IEC 62368-1

Edition 4.0 2023-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

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

IEC 62368-1:2023-05(en-fr)

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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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

This fourth edition cancels and replaces the third edition published in 2018. This edition constitutes a technical revision.

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

a) new table with requirements for external circuits;
b) revision of requirements for openings in fire enclosures;
c) revision of requirements for liquid filled components;
d) revision of battery charging requirements.

The text of this International Standard is based on the following documents:

Draft	Report on voting
108/800/FDIS	108/804/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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 clauses, subclauses and tables:

0.2.1, Clause 1, 3.3.8.1, 3.3.8.3, 4.1.15, 4.7.3, 5.4.2.3.2.4, 5.4.2.5, 5.4.5.1, 5.4.10.2.1, 5.4.10.2.2, 5.4.10.2.3, 5.5.2.1, 5.5.6, 5.6.4.2.1, 5.6.8, 5.7.6, 5.7.7.1, 8.5.4.2.3, 10.5.3, 10.6.1, F.3.3.4, F.3.3.6, Y.4.1, Y.4.5, Table 12, Table 13 and Table 38.

In this document, 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.

A comparison of terms introduced in this document that are different from other existing IEC documents is given in Annex W.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

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

NOTE Explanatory information related to IEC 62368-1 is contained in IEC TR 62368-2. It provides rationale together with explanatory information related to this document.

IMPORTANT – The "colour inside" logo on the cover page of this document 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 document.

0.2 Persons

0.2.1 General

This document describes **safeguards** for the protection of three kinds of persons: the **ordinary person**, the **instructed person**, and the **skilled person**. Unless otherwise specified in this document, the requirements for an **ordinary person** apply. This document assumes that a person will not intentionally create conditions or situations that could cause pain or injury.

NOTE 1 In Australia, the work conducted by an **instructed person** or **skilled person** can require formal licensing from regulatory authorities.

NOTE 2 In Germany, a person can only be regarded as an **instructed person** or a **skilled person** if certain legal requirements are fulfilled.

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 can possibly have access to the equipment or who could 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 can 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).

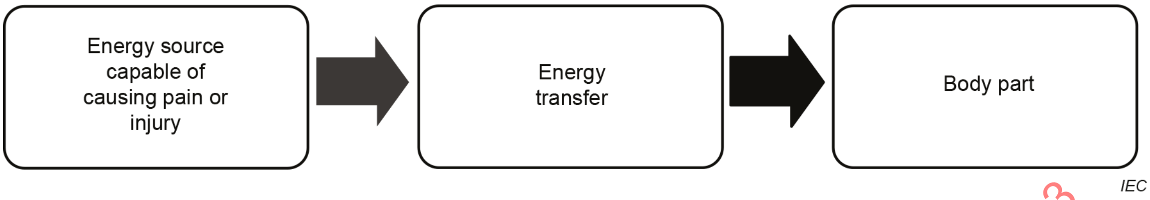

Figure 1 – Three block model for pain and injury

This safety standard specifies three classes of energy sources defined by magnitudes and durations of source parameters relative to the body responses to those electrical and thermal energy sources (see Table 1). Source parameters relative to responses to **combustible material**, mechanical energy sources and radiation energy sources are specified based on experience and basic safety standards.

Table 1 – Response to energy class

Energy source	Effect on the body	Effect on combustible materials
Class 1	Not painful, but can 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 can occur some considerable time after the transfer of energy to a body part. For example, it is possible that pain or injury from some chemical or physiological reaction does not manifest itself for days, weeks, months, or years.

0.4 Energy sources

Energy sources are addressed by this document, 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 unit, 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 can 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 can 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 can use energy sources that are non-electrical energy sources such as moving parts or chemicals. The energy in these other sources can be transferred to or from a body part, or can be transformed into other energy forms (for example, chemical energy can be converted to electrical energy through a **battery**, 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 document 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** can be a single element or a set of elements.

Generally, this document uses an order of preference for providing **safeguards** based on the requirements given in ISO/IEC Guide 51 as follows:

– **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 shall 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 **supplementary safeguard** providing **protective earthing** is located partly in the equipment and partly in the installation. The **supplementary safeguard** providing **protective earthing** is not effective until the equipment is connected to the **protective earthing** of the installation.

Requirements for **installation safeguards** are not addressed in this document. However, this document 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 document. However, this document 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 can 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 document. Each kind of behavioural **safeguard** is associated with a specific kind of person. An **instructional safeguard** is usually addressed to an **ordinary person**, but can 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**.

As an **equipment safeguard** provides protection for all persons, it is preferred above a behavioural **safeguard**. However, in certain situations a **precautionary safeguard** or a **skill safeguard** is accepted as a replacement of an **equipment safeguard**.

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** can 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 use 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 document but are assumed to be effective when the term **instructed person** is used.

During equipment servicing, it is possible that an **instructed person** will 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 exposure to class 2 energy sources.

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 document but are assumed to be effective when the term **skilled person** is used.

During equipment servicing, it is possible that a **skilled person** will 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 can be applicable. Such **safeguards** may 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 can 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.

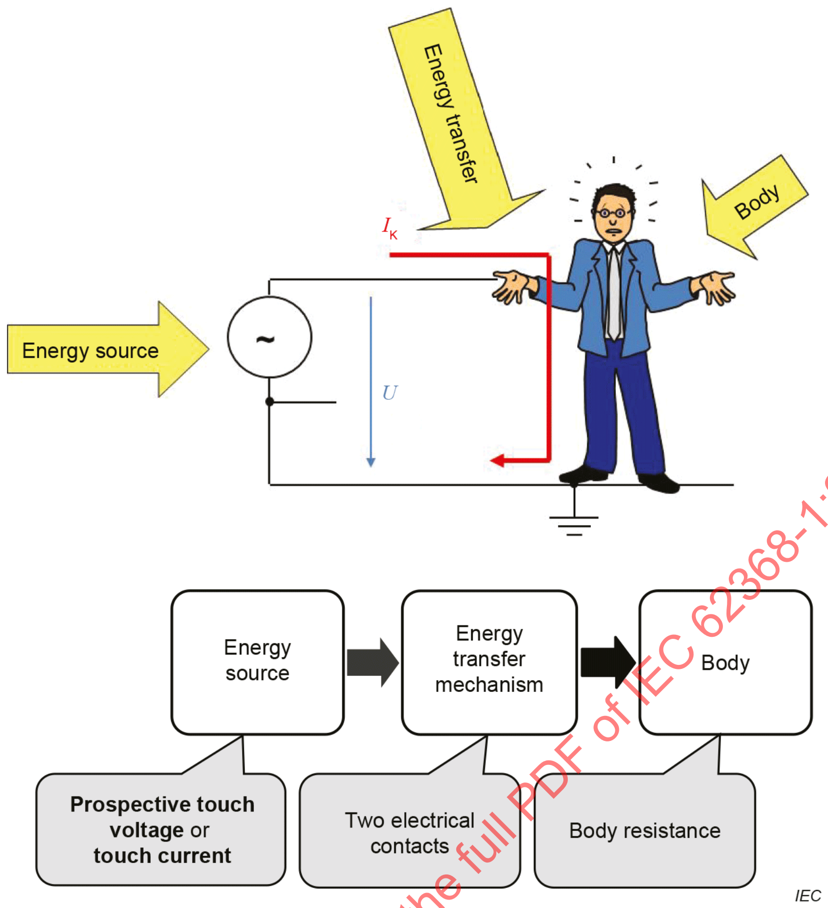

Figure 3 – Schematic and model for electrically-caused pain or injury

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

0.6.2 Models for protection against electrically-caused pain or injury

One or more **safeguards** are interposed between an electrical energy source capable of causing pain or injury and a body part to protect against electrically-caused pain or injury (see Figure 4).

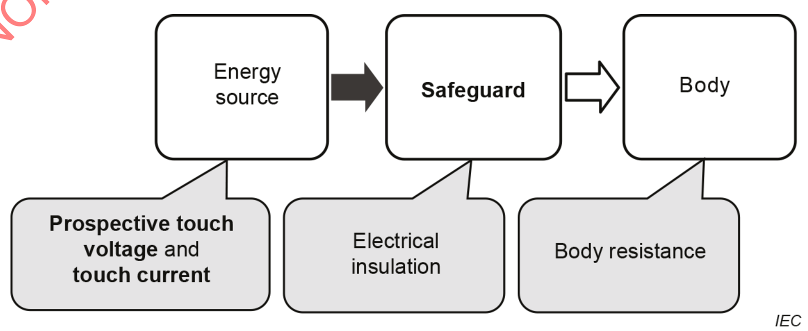

Figure 4 – Model for protection against electrically-caused pain or injury

Protection against electrically-caused pain is provided under **normal operating conditions** and **abnormal operating conditions**. For such protection, under **normal operating conditions** and **abnormal operating conditions**, a **basic safeguard** is 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**. For such protection, under **normal operating conditions** and **abnormal operating conditions**, both a **basic safeguard** and a **supplementary safeguard** are 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.

Another **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.

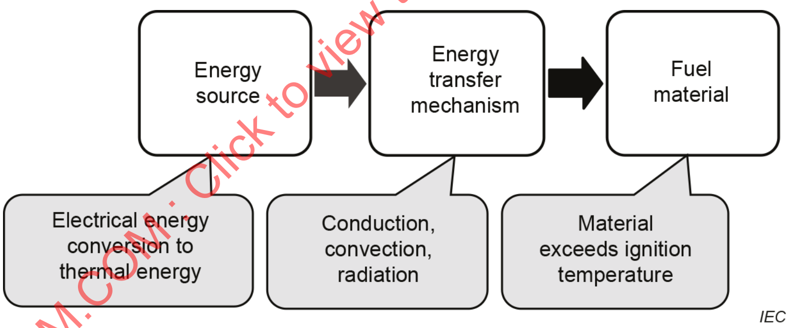

Figure 5 – Model for electrically-caused fire

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.

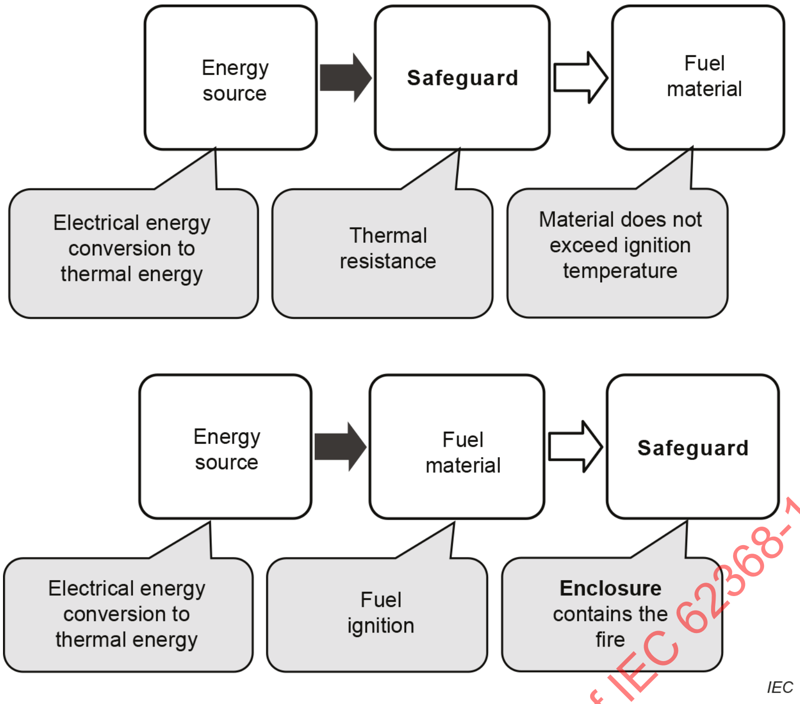

Figure 6 – Models for protection against fire

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 document. 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 trainings;
– 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 can 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.

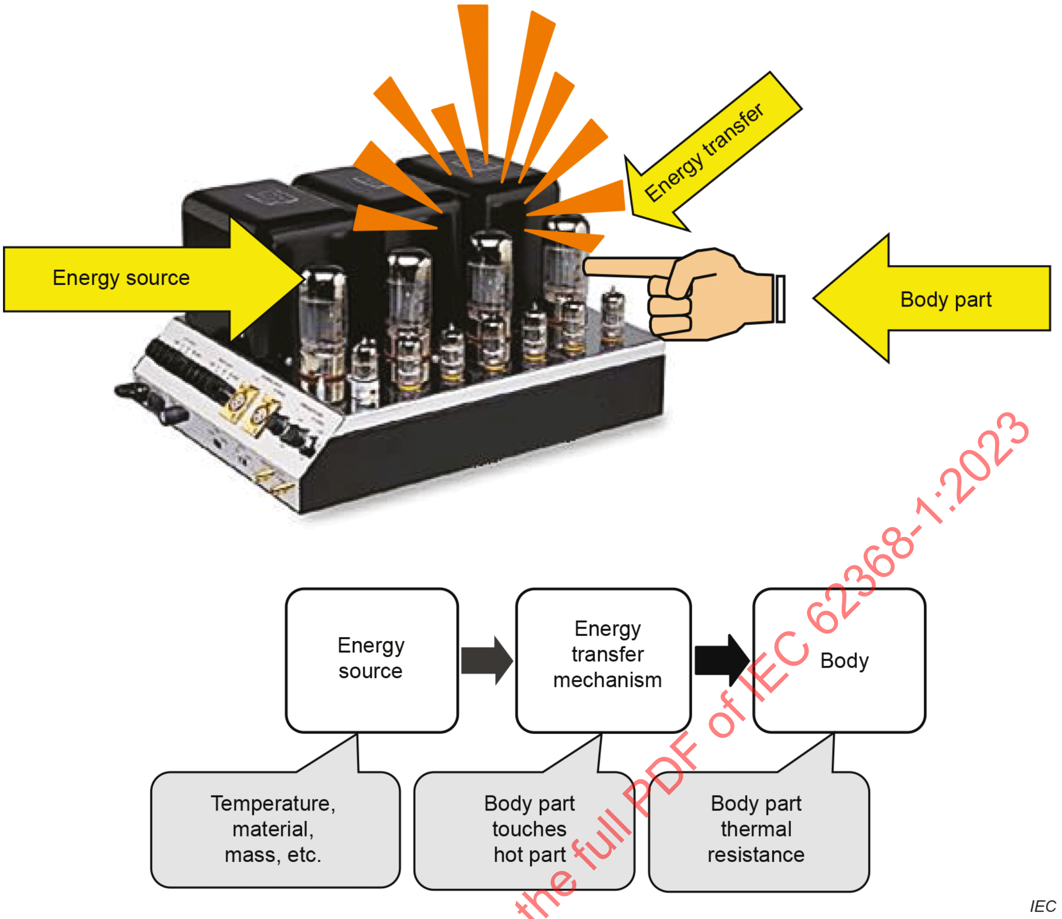

Figure 7 – Schematic and model for thermally-caused injury

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 can result in pain or injury (burn).

0.10.2 Models for protection against thermally-caused pain or injury

One or more **safeguards** are interposed between a thermal energy source capable of causing pain or injury and an **ordinary person** (see Figure 8).

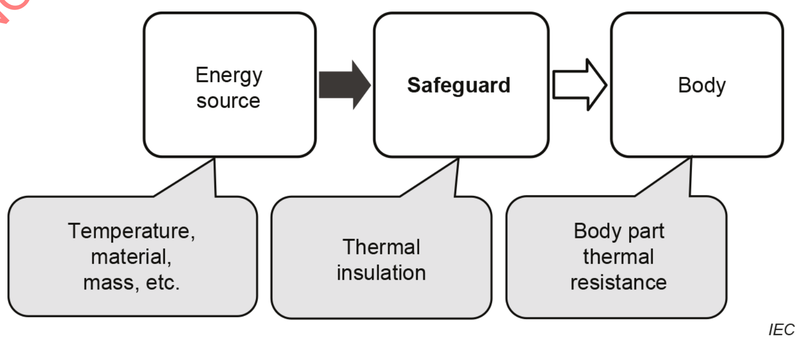

Figure 8 – Model for protection against thermally-caused injury

Under **normal operating conditions** and **abnormal operating conditions**, protection is used against thermally-cause pain. For such protection, a **basic safeguard** is interposed between a thermal energy source capable of causing pain and an **ordinary person**.

Under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**, protection is used against thermally-caused injury. For such protection, a **basic safeguard** and a **supplementary safeguard** are 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 can be an **instructional safeguard** identifying the hot parts and how to reduce the likelihood of injury. In some cases, a **basic safeguard** reduces the likelihood of a non-injurious thermal energy source from becoming a thermal energy source capable of causing pain or injury.

Examples of such **basic safeguards** are:

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

The **supplementary safeguard** against a thermal energy source capable of causing injury is thermal insulation 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 can 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 document 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
– auditory injury caused by over stimulation of the ear by excessive peaks or sustained loud sound, leading to physical or nerve damage; or
– X-radiation; or
– UV radiation.

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** can 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 level 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 document does not include requirements for performance or functional characteristics of equipment.

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

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

Explanatory information related to this document is contained in IEC TR 62368-2. It provides rationale together with explanatory information that can be helpful to apply to this document.

This document is also applicable to:

– components and **subassemblies** intended for incorporation in this equipment. Such components and **subassemblies** need not comply with every requirement of this document, provided that the complete equipment, incorporating such components and **subassemblies**, does comply;
– external power supply units intended to primarily supply equipment within the scope of this document;
– accessories intended to be used with equipment within the scope of this document;
– large equipment installed in **restricted access areas**. For equipment having large machinery aspects, additional requirements can apply; and
– equipment to be used in tropical regions.

This document also includes requirements for audio/video, information and communication technology equipment intended to be installed in an **outdoor location**. The requirements for **outdoor equipment** also apply, where relevant, to **outdoor enclosures** suitable for direct installation in the field and supplied for housing audio/video, information and communication technology equipment to be installed in an **outdoor location**. See Annex Y for specific construction requirements not covered elsewhere in this document.

This document harmonizes with IEC 61140 and gives consideration to the electrical installation by properly interfacing with the common safety aspects of the installation.

Each installation can have particular requirements. In addition, requirements for protection of the **outdoor equipment** against the effects of direct lightning strikes are not covered by this document.

NOTE 3 For information on this subject, see IEC 62305-1.

This document assumes a maximum altitude of 2 000 m unless otherwise specified by the manufacturer.

Additional requirements for equipment having the capability to supply or receive DC power over commonly used communication cables, such as USB or Ethernet (PoE), are given in IEC 62368-3. IEC 62368-3 does not apply to:

– equipment supplying or receiving power using proprietary connectors; or
– equipment using a proprietary protocol to enable the power transfer.

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

NOTE 4 In Australia, the work conducted by an **instructed person** or a **skilled person** can require formal licensing from regulatory authorities.

NOTE 5 In Germany, in many cases a person can only be regarded as an **instructed person** or a **skilled person** if certain legal requirements are fulfilled.

This document does not apply to:

– equipment with non-self-contained hazardous moving parts, such as robotic equipment;

  NOTE 6 For requirements related to robotic equipment in an industrial environment, see IEC 60204-1, IEC 60204-11, ISO 10218-1 and ISO 10218-2.

– personal care robots, including mobile servant robots, physical assistant robots, and person carrier robots;

  NOTE 7 For requirements related to personal care robots, see ISO 13482.

– power supply systems that are not an integral part of the equipment, such as motor-generator sets, **battery** backup systems and distribution transformers;
– equipment to be used in wet areas indoors.

This document does not address:

– manufacturing processes except for **routine tests**;
– injurious effects of gases released by thermal decomposition or combustion;
– disposal processes;
– effects of transport (other than as specified in this document);
– 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 use of the equipment in oxygen-enriched or **explosive** atmospheres;
– exposure to chemicals other than as specified in Clause 7;
– electrostatic discharge events;
– exposure to electromagnetic fields;
– environmental aspects; or
– requirements for functional safety, except for those related to **work cells**.

NOTE 8 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 are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

IEC 60038, *IEC standard voltages*

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

IEC 60068-2-11, *Basic environmental testing procedures – Part 2-11: Tests – Test Ka: Salt mist*

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

IEC 60073, *Basic and safety principles for man-machine interface, marking and identification – Coding principles for indicators and actuators*

IEC 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 60127-8, *Miniature fuses – Part 8: Fuse resistors with particular overcurrent protection*

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

IEC 60227-2:1997[1], *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V – Part 2: Test methods*
IEC 60227-2:1997/AMD1:2003

IEC 60243-1, *Electric strength of insulating materials – Test methods – Part 1: Tests at power frequencies*

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

IEC 60268-1:1985, *Sound system equipment – Part 1: General*
IEC 60268-1:1985/AMD1:1988
IEC 60268-1:1985/AMD2:1988

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

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

IEC 60317-0-7:2017, *Specifications for particular types of winding wires – Part 0-7: General requirements – Fully insulated (FIW) zero-defect enamelled round copper wire*

[1] This publication was withdrawn and replaced with IEC 63294:2021.

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

IEC 60317-56, *Specifications for particular types of winding wires – Part 56: Solderable fully insulated (FIW) zero-defect polyurethane enamelled round copper wire, class 180*

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 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 60384-14:2013, *Fixed capacitors for use in electronic equipment – Part 14: Sectional specification – Fixed capacitors for electromagnetic interference suppression and connection to the supply mains*
IEC 60384-14:2013/AMD1:2016

IEC 60417, *Graphical symbols for use on equipment*, available at http://www.graphical-symbols.info/equipment

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC 60664-1:2020, *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 60691:2015, *Thermal-links – Requirements and application guide*

IEC 60695-2-11, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products (GWEPT)*

IEC 60695-10-2, *Fire hazard testing – Part 10-2: Abnormal heat – Ball pressure test method*

IEC 60695-10-3, *Fire hazard testing – Part 10-3: Abnormal heat – Mould stress relief distortion test*

IEC 60695-11-5:2016, *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 60695-11-20:2015, *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 60728-11:2016, *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 60730-1:2022, *Automatic electrical controls – Part 1: General requirements*

IEC 60738-1:2022, *Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification*

IEC 60747-5-5:2020, *Semiconductor devices – Part 5-5: Optoelectronic devices – Photocouplers*

IEC 60825-1:2014, *Safety of laser products – Part 1: Equipment classification and requirements*

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

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 60851-3:2009/AMD1:2013
IEC 60851-3:2009/AMD2:2019

IEC 60851-5:2008, *Winding wires – Test methods – Part 5: Electrical properties*
IEC 60851-5:2008/AMD1:2011
IEC 60851-5:2008/AMD2:2019

IEC 60884-1, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*

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. and 20 A 125 V a.c.*

IEC 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-5-5, *Low-voltage switchgear and controlgear – Part 5-5: Control circuit devices and switching elements – Electrical emergency stop device with mechanical latching function*

IEC 60990:2016, *Methods of measurement of touch current and protective conductor current*

IEC 60998-1, *Connecting devices for low-voltage circuits for household and similar purposes – Part 1: General requirements*

IEC 60999-1, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm² up to 35 mm² (included)*

IEC 60999-2, *Connecting devices – Electrical copper conductors – Safety requirements for screw-type and screwless-type clamping units – Part 2: Particular requirements for clamping units for conductors above 35 mm² up to 300 mm² (included)*

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

IEC 61051-2:2021, *Varistors for use in electronic equipment – Part 2: Sectional specification for surge suppression varistors*

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

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

IEC 61058-1:2016, *Switches for appliances – Part 1: General requirements*

IEC 61204-7, *Low-voltage switch mode power supplies – Part 7: Safety requirements*

IEC 61260-1:2014, *Electroacoustics – Octave-band and fractional-octave-band filters – Part 1: Specifications*

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

IEC 61427 (all parts), *Secondary cells and batteries for renewable energy storage – 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 61558-1:2017, *Safety of transformers, reactors, power supply units and combinations thereof – Part 1: General requirements and tests*

IEC 61558-2-16, *Safety of transformers, reactors, power supply units and combinations thereof – Part 2-16: Particular requirements and tests for switch mode power supply units and transformers for switch mode power supply units for general applications*

IEC 61587-1:2022, *Mechanical structures for electrical and electronic equipment – Tests for IEC 60917 and IEC 60297 series – Part 1: Environmental requirements, test setups and safety aspects*

IEC 61643-11:2011, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

IEC 61643-331:2020, *Components for low-voltage surge protection – Part 331: Performance requirements and test methods for metal oxide varistors (MOV)*

IEC 61810-1:2015, *Electromechanical elementary relays – Part 1: General and safety requirements*
IEC 61810-1:2015/AMD1:2019

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 62061, *Safety of machinery – Functional safety of safety-related control systems*

IEC 62133-1, *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 – Part 1: Nickel systems*

IEC 62133-2:2017, *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 – Part 2: Lithium systems*
IEC 62133-2:2017/AMD1:2021

IEC 62230, *Electric cables – Spark-test method*

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

IEC 62440:2008, *Electric cables with a rated voltage not exceeding 450/750 V – Guide to use*

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

IEC 62471-5:2015, *Photobiological safety of lamps and lamp systems – Part 5: Image projectors*

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

IEC 62619:2022, *Secondary cells and batteries containing alkaline or other non-acid electrolytes – Safety requirements for secondary lithium cells and batteries, for use in industrial applications*

IEC 62821-1, *Electric cables - Halogen-free, low smoke, thermoplastic insulated and sheathed cables of rated voltages up to and including 450/750 V – Part 1: General requirements*

IEC 62821-2[2], *Electric cables - Halogen-free, low smoke, thermoplastic insulated and sheathed cables of rated voltages up to and including 450/750 V – Part 2: Test methods*

IEC 62821-3, *Electric cables - Halogen-free, low smoke, thermoplastic insulated and sheathed cables of rated voltages up to and including 450/750 V – Part 3: Flexible cables (cords)*

[2] This publication was withdrawn and replaced with IEC 63294:2021.

IEC 63010-1, *Halogen-free thermoplastic insulated and sheathed flexible cables of rated voltages up to and including 300/300 V – Part 1: General requirements and cables*

IEC 63010-2[3], *Halogen-free thermoplastic insulated and sheathed flexible cables of rated voltages up to and including 300/300 V – Part 2: Test methods*

IEC 63294:2021, *Test methods for electric cables with rated voltages up to and including 450/750 V*

ISO 37, *Rubber, vulcanized or thermoplastic – Determination of tensile stress-strain properties*

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 1798, *Flexible cellular polymeric materials – Determination of tensile strength and elongation at break*

ISO 1817:2022, *Rubber, vulcanized or thermoplastic – Determination of the effect of liquids*

ISO 2719, *Determination of flash point – Pensky-Martens closed cup method*

ISO 3679, *Determination of flash point – Method for flash no-flash and flash point by small scale closed cup tester*

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*

ISO 4892-2:2013, *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 – Registered symbols,* available at http://www.graphical-symbols.info/equipment

[3] This publication was withdrawn and replaced with IEC 63294:2021.

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs*

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*

ISO 13849-1, *Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design*

ISO 14993, *Corrosion of metals and alloys – Accelerated testing involving cyclic exposure to salt mist, "dry" and "wet" conditions*

ISO 21207, *Corrosion tests in artificial atmospheres – Accelerated corrosion tests involving alternate exposure to corrosion-promoting gases, neutral salt-spray and drying*

ISO 22479, *Corrosion of metals and alloys – Sulfur dioxide test in a humid atmosphere (fixed gas method)*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension*

ASTM D471-98, *Standard Test Method for Rubber Property – Effect of Liquids*

ASTM D3574, *Standard Test Methods for Flexible Cellular Materials – Slab, Bonded, and Molded Urethane Foams*

EN 50332-1:2013, *Sound system equipment: Headphones and earphones associated with personal music players – Maximum sound pressure level measurement methodology – Part 1: General method for "one package equipment"*

EN 50332-2, *Sound system equipment: Headphones and earphones associated with personal music players – Maximum sound pressure level measurement methodology – Part 2: Matching of sets with headphones if either or both are offered separately, or are offered as one package equipment but with standardised connectors between the two allowing to combine components of different manufacturers or different design*

EN 50332-3:2017, *Sound system equipment: Headphones and earphones associated with personal music players – Maximum sound pressure level measurement methodology – Part 3: Measurement method for sound dose management*

3 Terms, definitions and abbreviated terms

3.1 Energy source abbreviated terms

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

Abbreviation	Description	
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 abbreviated terms

Abbreviation	Description
AIT	auto ignition temperature
AWG	American wire gauge
CD	compact disc
CD ROM	compact disc read-only memory
CRT	cathode ray tube
CSD	**calculated sound dose**
CTI	comparative tracking index
dBFS	**digital signal level relative to full scale**
DVD	digital versatile disc
E	sound exposure
EIS	electrical insulation system
EUT	equipment under test
FIW	**fully insulated winding wire**
GDT	gas discharge tube
IC	integrated circuit
ICX	integrated circuit with X-capacitor function
IR	infrared
LED	light emitting diode
LEL	lower explosion limit
LFL	lower flammability limit
LFC	**liquid filled component**
LPS	limited power source
MEL	**momentary exposure level**
MOV	metal oxide varistor
NEMA	National Electrical Manufacturers Association
NiCd	nickel cadmium
PIS	**potential ignition source**
PMP	personal music player
PoE	power over Ethernet
PPE	personal protective equipment
PTC	positive temperature coefficient
PTI	proof tracking index
RC	resistor-capacitor
RG	risk group
Sb	antimony
SEL	**sound exposure level**
SRME	slide rail mounted equipment
TSS	thyristor surge suppressor
UPS	uninterruptible power supply
USB	universal serial bus
UV	ultraviolet
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.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

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 RMS values unless otherwise specified in this document.

5VA class material	3.3.4.2.1
5VB class material	3.3.4.2.2
abnormal operating condition	3.3.7.1
accessible	3.3.6.1
audio amplifier	3.3.1.1
arcing PIS	3.3.9.2
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3.3.1 Circuit terms

3.3.1.1
audio amplifier
amplifying device for audio signals intended to drive loudspeakers and headphones

3.3.1.2
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.

3.3.1.3
mains
AC or DC power distribution system (external to the equipment) that supplies operating power to the equipment

Note 1 to entry: **Mains** include public or private utilities and, unless otherwise specified in this document, equivalent sources such as motor-driven generators and uninterruptible power supplies.

Note 2 to entry: Powering **external circuits** by using communications cables and circuits that are isolated from the **mains** (for example, data, voice, PoE, USB, HDMI, Coaxial, RFT and similar circuits in Table 13) are not considered to be **mains**.

3.3.1.4
pink noise
stationary random signal having normal probability distribution of instantaneous values whose energy per unit bandwidth ($\Delta W/\Delta f$) is inversely proportional to frequency

Note 1 to entry: Unless otherwise stated, the mean value is zero.

Note 2 to entry: See E.2.1

3.3.2 Enclosure terms

3.3.2.1
electrical enclosure
enclosure intended as a **safeguard** against electrically-caused injury

[SOURCE: IEC 60050-195:2021, 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 60050-195:2021, 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

3.3.2.5
outdoor enclosure
enclosure that is intended to provide protection from specific conditions in an **outdoor location**

Note 1 to entry: An **outdoor enclosure** may also perform the functions of another **enclosure**, for example: a **fire enclosure**; an **electrical enclosure**; a **mechanical enclosure**.

Note 2 to entry: A separate cabinet or housing into which the equipment is placed may provide the function of an **outdoor enclosure**.

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
fixed equipment
equipment fastened to a support, or otherwise secured in a specific location by a means defined by the manufacturer in the installation instructions.

Note 1 to entry: Equipment that has a screw hole or other means to secure the equipment by an **ordinary person**, such as for securement to a table or for earthquake protection, is not considered to be **fixed equipment**.

Note 2 to entry: Typically, **fixed equipment** will be wall, ceiling or floor mounted.

[SOURCE: IEC 60050-826:2022, 826-16-07, modified — Addition of the requirement for defining the means in the installation instructions, and addition of notes to entry.]

3.3.3.3
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

3.3.3.4
movable equipment
equipment that is either:

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

3.3.3.5
outdoor equipment
equipment that is installed or exposed in an **outdoor location**, specified by the manufacturer to comply wholly or in part under specific conditions

Note 1 to entry: **Transportable equipment**, for example, a laptop or notebook computer, or a telephone, is not **outdoor equipment** unless specified by the manufacturer for continuous use in an **outdoor location**.

3.3.3.6
permanently connected equipment
equipment that can only be electrically connected to or disconnected from the **mains** by the use of a **tool**

3.3.3.7
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.

3.3.3.8
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.

3.3.3.9
professional equipment
equipment for use in trades, professions or industries and which is not intended for sale to the general public

[SOURCE: IEC 60050-161:1990, 161-05-05, modified — Note deleted.]

3.3.3.10
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**.

3.3.3.11
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 supply units.

3.3.3.12
wireless power transmitter
equipment that uses electromagnetic fields to transfer electrical power for charging **battery** operated hand-held **devices**

3.3.4 Flammability terms

3.3.4.1
combustible material
material that is capable of being ignited or burned

Note 1 to entry: All thermoplastic materials are considered capable of being ignited or burned 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 Electrical 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 60050-195:2021, 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
insulating liquid
insulating material consisting entirely of a liquid

[SOURCE: IEC 60050-212:2010, 212-11-04]

3.3.5.5
reinforced insulation
single insulation system that provides a degree of protection against electric shock equivalent to **double insulation**

3.3.5.6
solid insulation
insulation consisting entirely of solid material

[SOURCE: IEC 60050-212:2015, 212-11-02, modified — replacement of “insulating material” with “insulation” and replacement of “solid” with “solid material”.]

3.3.5.7
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
backfeed
condition in which a voltage or energy available within a **battery** backed up supply is fed back to any of the input terminals, either directly or by a leakage path while operating in the **stored energy mode** and with **mains** power not available

3.3.6.3
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.

3.3.6.4
coolant
a liquid or gas medium by means of which heat is transferred

[SOURCE: IEC 60050-441:1996, 411-44-02]

3.3.6.5
device
material element or assembly of such elements intended to perform a required function

Note 1 to entry: A **device** may form part of a larger system (for example, a server node installed in a rack system).

[SOURCE: IEC 60050-151:2001, 151-11-20, modified — Addition of the text within parenthesis in Note 1 to entry.]

3.3.6.6
disconnect device
means to electrically disconnect equipment from the **mains** that, in the open position, complies with the requirements specified for isolation

3.3.6.7
functional earthing
earthing a point or points in a system or in an installation or in equipment, for purposes other than electrical safety

[SOURCE: IEC 60050-195:2021, 195-01-13, modified — Addition of “a point or points in a system or in an installation or in equipment”.]

3.3.6.8
liquid cooling system
system that circulates and cools liquid used for decreasing the temperature of a **device**

[SOURCE: IEC 60050-851:2008, 851-14-48, modified — Replacement of “equipment of arc welding and allied processes” with “device”.]

3.3.6.9
liquid filled component
LFC
constituent part of a **device** which cannot be physically divided into smaller parts without losing its particular function and through which the **coolant** passes

EXAMPLE: Cold plate, tubing, fittings and interconnects.

[SOURCE: IEC 60050-151:2001, 151-11-21, modified — Replacement of the main term “component” with “liquid filled component”, addition of “through which the **coolant** passes” in the definition, and addition of examples.]

3.3.6.10
liquid filled component assembly
LFC assembly
set of components, at least one of which is a **liquid filled component**, assembled into a single unit

EXAMPLE: Assembly of cold plate, tubing, fittings and interconnects or any combination thereof.

[SOURCE: IEC 60050-904:2014, 904-01-08, modified — Replacement of the main term “electronic assembly” with “liquid filled component assembly”, and in the definition replacement of “an electronic component” with “a liquid filled component”.]

3.3.6.11
loudspeaker driver
transducer by which acoustic waves are obtained from electrical oscillation waves and designed to radiate acoustic power into the surrounding medium

3.3.6.12
modular liquid filled component
modular LFC
device which contains a **liquid filled component assembly** which relies on external connections to complete the **liquid cooling system**

EXAMPLE: Examples are cooling distribution unit or facility water system for operation.

3.3.6.13
non-detachable power supply cord
flexible power supply cord affixed to or assembled to the equipment and that cannot be removed from the equipment without the use of **tools**

3.3.6.14
outdoor location
location for equipment where protection from the weather and other outdoor influences provided by a building or other structure is limited or non-existent

3.3.6.15
pollution degree
numeral characterizing the expected pollution of the micro-environment

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

3.3.6.16
restricted access area
area **accessible** only to **skilled persons** and to **instructed persons** with the proper authorization

3.3.6.17
routine test
test to which each individual **device** is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEC 60664-1:2020, 3.1.42, modified — Replacement of "conformity test" with "test", replacement of "item" with "device", addition of "to ascertain whether it complies with certain criteria".]

3.3.6.18
sampling test
test on a number of **devices** taken at random from a batch

[SOURCE: IEC 60664-1:2020, 3.1.43]

3.3.6.19
self-contained LFC
device which contains a complete **liquid cooling system**

Note 1 to entry: A **self-contained LFC** comprising of multiple **modular LFCs** is considered a **modular LFC** with regards to G.15.

3.3.6.20
stored energy mode
stable mode of operation that a **battery** backed up supply attains under specified conditions

Note 1 to entry: In accordance with IEC 62040-1:2017, the specified conditions are as follows:

– AC input power is disconnected or is out of required tolerance;
– operating power and output power is supplied by the energy storage **device**;
– the load is within the specified rating of the **battery** backed up supply.

3.3.6.21
subassembly
unit assembled separately and designed to be incorporated with other units into a larger manufactured product and that cannot work independently from the final product

Note 1 to entry: A **subassembly** shall be regarded as a component in the final product.

3.3.6.22
tool
object that can be used to secure or release a screw, latch or similar fixing means

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

3.3.6.23
touch current
electric current through a human body when body parts touch two or more **accessible** parts or one **accessible** part and earth

3.3.6.24
type test
test on a representative sample with the objective of determining if, as designed and manufactured, it can meet the requirements of this document

3.3.6.25
work cell
space within the equipment of such size that a person can enter completely or partially (for example, entire limb or head) for servicing or operating the equipment and where mechanical hazards can be present

Note 1 to entry: A **work cell** can contain more than one compartment. A compartment can be used for either operational or service purposes.

Note 2 to entry: The equipment containing the **work cell** is typically installed within a **restricted access area**.

3.3.6.26
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** can be introduced by the equipment or by a person.

Note 3 to entry: An **abnormal operating condition** can 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 the test frequency at the onset of clipping on either one or both peaks

Note 1 to entry: See Annex E.

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 specified in this document, the most severe conditions of normal use are the most unfavourable default values as specified in Clause B.2.

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

3.3.7.5
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.

3.3.7.6
rated load impedance
impedance or resistance, as declared by the manufacturer, by which an output circuit should be terminated

3.3.7.7
reasonably foreseeable misuse
use of a product, process or service in a way not intended by the supplier, but which can 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 51:2014, 3.7, modified – In the definition, "product or system" has been replaced by "product, process or service". The Notes to entry have been replaced.]

3.3.7.8
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

3.3.7.9
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.

Note 2 to entry: In Germany, in many cases, a person can only be regarded as an **instructed person** if certain legal requirements are fulfilled.

3.3.8.2
ordinary person
person who is neither a **skilled person** nor an **instructed person**

[SOURCE: IEC 60050-826:2022, 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

Note 1 to entry: In Germany, in many cases, a person can only be regarded as a **skilled person** if certain legal requirements are fulfilled.

[SOURCE: IEC 60050-826:2022, 826-18-01, modified – The definition has been made applicable to all types of hazards, and a new Note 1 to entry has been added.]

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
PIS where an arc can 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 can occur in conductive patterns on printed boards is considered to be within the scope of this definition.

3.3.9.3
resistive PIS
PIS where a component can ignite due to excessive power dissipation

Note 1 to entry: An electronic protection circuit or additional constructional measures may be used to prevent a location from becoming a **resistive PIS**.

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 60664-1:2020, 3.1.17]

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
backfeed safeguard
control scheme that reduces the risk of electric shock due to backfeed

3.3.11.2
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

3.3.11.3
double safeguard
safeguard comprising both a **basic safeguard** and a **supplementary safeguard**

3.3.11.4
equipment safeguard
safeguard that is a physical part of the equipment

3.3.11.5
installation safeguard
safeguard that is a physical part of a man-made installation

3.3.11.6
instructional safeguard
instruction invoking specified behaviour

3.3.11.7
personal safeguard
personal protective equipment that is worn on the body and that reduces exposure to an energy source

Note 1 to entry: Examples are shields, goggles, gloves, aprons, face masks or breathing apparatus.

3.3.11.8
precautionary safeguard
instructed person behaviour to avoid contact with or exposure to a class 2 energy source based on supervision or instructions given by a **skilled person**

3.3.11.9
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.

3.3.11.10
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 60050-195:2021, 195-02-09, modified — Addition of an example in the definition, and new Note 1 to entry.]

3.3.11.11
protective earthing
earthing a point or points in a system or in an installation or in equipment for purposes of electrical safety

[SOURCE: IEC 60050-195:2021, 195-01-11, modified — Addition of " a point or points in a system or in an installation or in equipment".]

3.3.11.12
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**

3.3.11.13
reinforced safeguard
single **safeguard** that is effective under:

– **normal operating conditions**;
– **abnormal operating conditions**; and
– **single fault conditions**

3.3.11.14
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 Clause 0.5 for further explanation of a **safeguard**.

3.3.11.15
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.

3.3.11.16
skill safeguard
skilled person behaviour to avoid contact with or exposure to a class 2 or class 3 energy source based on education and experience

3.3.11.17
supplementary safeguard
safeguard applied in addition to the **basic safeguard** that is or becomes operational in the event of failure of the **basic safeguard**

3.3.12 Spacings

3.3.12.1
clearance
shortest distance in air between two conductive parts

[SOURCE: IEC 60664-1:2020, 3.1.4]

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

[SOURCE: IEC 60664-1:2020, 3.1.5, modified – In the definition, "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
DC 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
prospective touch voltage
voltage between simultaneously **accessible** conductive parts or between one **accessible** conductive part and earth when those conductive parts are not being touched

[SOURCE: IEC 60050-195:2021, 195-05-09, modified – In the definition, "or between one **accessible** conductive part and earth" has been added, and “by a human being or livestock” has been deleted.]

3.3.14.4
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".

3.3.14.5
required withstand voltage
peak voltage that the insulation under consideration is required to withstand

3.3.14.6
RMS working voltage
true RMS value of the **working voltage**

Note 1 to entry: True RMS value of the **working voltage** includes any DC component of the waveform.

Note 2 to entry: The resultant RMS value of a waveform having an AC RMS voltage A and a DC component voltage B is given by the following formula:

$$\text{RMS value} = (A^2 + B^2)^{1/2}$$

3.3.14.7
temporary overvoltage
overvoltage at **mains** power frequency of relatively long duration

3.3.14.8
working voltage
voltage across any particular insulation while the equipment is supplied at **rated voltage** or any voltage in the **rated voltage range** under **normal operating conditions**

Note 1 to entry: External transient voltages are disregarded.

Note 2 to entry: Recurring peak voltages are disregarded.

3.3.15 Classes of equipment with respect to protection from electric shock

3.3.15.1
class I equipment
equipment with **basic insulation** used as a **basic safeguard**, and with protective bonding and **protective earthing** used as a **supplementary safeguard**

Note 1 to entry: **Class I equipment** may be provided with **class II construction**.

[SOURCE: IEC 60050-851:2008, 851-15-10, modified – The definition has been adapted to the **safeguard** principle; new Note 1 to entry.]

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

Note 1 to entry: Air filters are not considered to be **consumable materials**.

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 one or more **cells** ready for use as a source of electrical energy characterized by its voltage, size, terminal arrangement, capacity and rate capability

Note 1 to entry: A **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 or button cell battery
small, single **cell battery** having a diameter greater than its height

3.3.17.4
highest specified charging temperature
highest surface temperature on the **cells** within the **battery** specified by the manufacturer during charging of a secondary **battery**

Note 1 to entry: It is 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 the **battery** supplier.

3.3.17.5
lowest specified charging temperature
lowest surface temperature on the **cells** within the **battery** specified by the manufacturer during charging of a secondary **battery**

Note 1 to entry: It is 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 the **battery** supplier.

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

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

3.3.17.8
secondary lithium battery
battery that incorporates one or more secondary lithium **cells**

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 metal or alloy **battery**.

3.3.18 FIW terms

3.3.18.1
fully insulated winding wire
FIW
polyurethane enamelled round copper wire, class 180

Note 1 to entry: The insulating properties are in accordance with IEC 60317-0-7, IEC 60317-56 and IEC 60851-5:2008. These standards also refer to this type of wire as "zero-defect wire", which they define as "winding wire that exhibits no electrical discontinuities when tested under specific conditions".

Note 2 to entry: The term "zero-defect wire" is commonly used to refer to **FIW**.

3.3.18.2
grade of FIW
range of overall diameter of a wire (FIW3 to FIW9)

3.3.19 Sound exposure

3.3.19.1
calculated sound dose
CSD
one week rolling estimate of **sound exposure** expressed as a percentage of the maximum regarded as safe

Note 1 to entry: See B.4 of EN 50332-3:2017 for additional information.

3.3.19.2
momentary exposure level
MEL
metric for estimating 1 s **sound exposure** level from a specific test signal applied to both channels, based on EN 50332-1:2013, 4.2

Note 1 to entry: **MEL** is measured in dB(A).

Note 2 to entry: See B.3 of EN 50332-3:2017 for additional information.

3.3.19.3
sound exposure
E
A-weighted sound pressure (p) squared and integrated over a stated period of time, T

$$E = \int_0^T p(t)^2 \mathrm{d}t$$

Note 1 to entry: The SI unit is Pa^2 s.

3.3.19.4
sound exposure level
SEL
logarithmic measure of **sound exposure** relative to a reference value, E_0

$$\mathrm{SEL} = 10 \log_{10}\left(\frac{E}{E_0}\right)$$

Note 1 to entry: **SEL** is measured in dB(A).

Note 2 to entry: The reference value E_0 is typically the 1 kHz threshold of hearing in humans.

Note 3 to entry: See B.4 of EN 50332-3:2017 for additional information.

3.3.19.5
digital signal level relative to full scale
dBFS
level of a DC-free 997 Hz sine wave whose undithered positive peak value is positive digital full scale, leaving the code corresponding to negative digital full scale unused

Note 1 to entry: Levels reported in **dBFS** are always RMS.

Note 2 to entry: It is invalid to use **dBFS** for non-RMS levels. Because the definition of full scale is based on a sine wave, the level of signals with a crest factor lower than that of a sine wave may exceed 0 **dBFS**. In particular, square-wave signals can reach +3,01 **dBFS**.

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.

Classification is used throughout the document to clearly identify the energy sources, the number of required **safeguards** and the requirements for each **safeguard**.

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

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 document 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 ratings;

– 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 document, 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 document, as part of the equipment, and to the applicable tests of the component standard, under the conditions occurring in the equipment;

– where components are used in circuits not in accordance with their specified ratings, the components shall be subjected to the applicable tests of the component standard, under the conditions occurring in the equipment. The number of samples required for test is, in general, the same as required by the component 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** as specified in Clause B.2, **abnormal operating conditions** as specified in Clause B.3, and **single fault conditions** as specified in Clause B.4, **safeguards** are provided to reduce the likelihood of injury or, in the case of fire, property damage. General test conditions are given in Clause B.1.

Parts of equipment that could cause injury shall be provided with **safeguards** in accordance with 4.3.

When the manufacturer specifies the use of a **tool** by an **ordinary person** or an **instructed person** to gain access to an area, class 2 and class 3 energy sources shall not be **accessible**. This includes energy sources contained in all other compartments within that area when using the same **tool**, except:

– for **ordinary person** servicing, class 2 energy sources in accordance with 4.3.2.3, where an **instructional safeguard** is shall be provided in accordance with Clause F.5, except that element 3 is optional; or

– for **instructed persons**, class 2 energy sources in accordance with 4.3.3.2.

Compliance is checked by inspection and by the relevant tests.

4.1.4 Equipment installation

Except as given in 4.1.6, equipment evaluation according to this document shall take into account manufacturer's instructions with regard to installation, relocation, servicing and operation, as applicable.

Outdoor enclosures providing a **safeguard** function shall comply with Annex Y. **Outdoor equipment** and **outdoor enclosures** shall be suitable for use at any temperature in the range specified by the manufacturer. If not specified by the manufacturer, the range shall be taken as:

– minimum ambient temperature: –33 °C;

– maximum ambient temperature: +40 °C.

Compliance is checked by inspection and by evaluation of the data provided by the manufacturer.

NOTE 1 The temperature values are based on IEC 60721-3-4, Class 4K2. These temperatures do not take into account severe environments (for example, extremely cold or extremely warm), nor do they include provision for heating by radiation from the sun (solar loading).

NOTE 2 Attention is drawn to IEC 61587-1 for additional information on performance levels C1, C2 and C3.

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 document, the equipment shall provide **safeguards** not less than that generally afforded by this document 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. However, if equipment has means for fixing in place by an **ordinary person**, such as the provision of screw holes for direct attachment to a mounting surface or through the use of brackets or the like, either provided with the equipment or readily available in the market, all likely positions of orientation of the equipment shall be taken into account, including the possibility of mounting to a non-vertical surface regardless of the installation or user instructions that are provided by the manufacturer.

In addition, for **transportable equipment**, all orientations of transport shall be taken into account.

4.1.7 Choice of criteria

Where this document 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 Liquids, refrigerants and liquid filled components (LFCs)

Unless specified as an **insulating liquid**, liquids shall be treated as electrically conductive materials.

For equipment using refrigerants, see IEC 60335-2-40 and IEC 61010-2-011.

Constructions and test requirements for pressurized **LFCs** used inside the equipment, where an injury can occur within the meaning of this document due to leaks of the liquid in the **LFC**, shall comply with Clause G.15. However, Clause G.15 does not apply to any of the following:

– an **LFC** that is sealed but open to the atmosphere in the equipment;
– components containing small amounts of liquids not likely to cause any injury (for example, liquid crystal displays, electrolytic capacitors, liquid cooling heat pipes, etc.);
– wet **cell batteries** (for wet **cell batteries**, see Annex M);
– an **LFC** and its associated parts that comply with P.3.3.

4.1.9 Electrical measuring instruments

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

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

Measurements shall be made with a measuring instrument whose input impedance has a negligible influence on the measurement. Unless otherwise stated, the measuring instrument used to measure voltage shall have a minimum impedance of 1 MΩ.

4.1.10 Temperature measurements

Unless otherwise specified in this document, where the result of a test is likely to depend upon the ambient temperature, the manufacturer's specified ambient temperature range of the equipment shall be taken into account. When performing the test at a specific ambient temperature (T_{amb}), extrapolation (above and below) the results of the test may be used to consider the impact of the specified ambient temperature range 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**. Temperature measurements are made in accordance with B.1.5.

4.1.11 Steady state conditions

Steady state conditions are conditions when temperature stability is considered to exist (see B.1.5).

4.1.12 Hierarchy of safeguards

Safeguards that are required for **ordinary persons** are acceptable, but are not always required for **instructed persons** and **skilled persons**. Likewise, **safeguards** that are required for **instructed persons** are acceptable, but are not always 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**, are given in specific clauses.

4.1.13 Examples mentioned in this document

Where examples are given in this document, 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 document 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 in this document, 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.

4.2.2 Class 2 energy source

Unless otherwise specified in this document, 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**, and **single fault 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, as given in 4.2.4.

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.

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**.

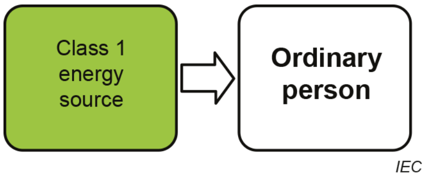


Figure 9 – Model for protection of an ordinary person against a class 1 energy source

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).

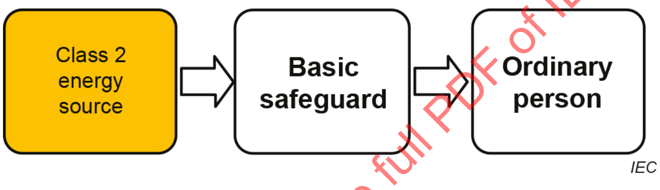


Figure 10 – Model for protection of an ordinary person against a class 2 energy source

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.

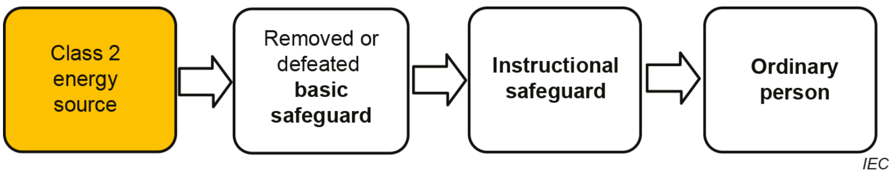


Figure 11 – Model for protection of an ordinary person against a class 2 energy source during ordinary person servicing conditions

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

Unless otherwise specified in this document,

– 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).

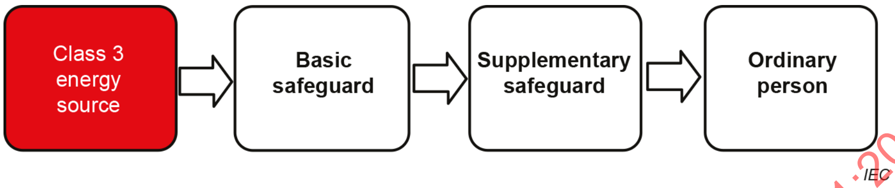


Figure 12 – Model for protection of an ordinary person against a class 3 energy source

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).

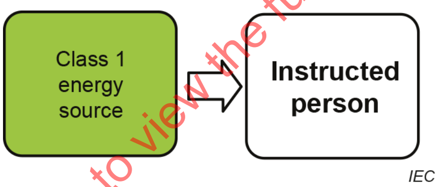


Figure 13 – Model for protection of an instructed person against a class 1 energy source

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 in this document,

– 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).

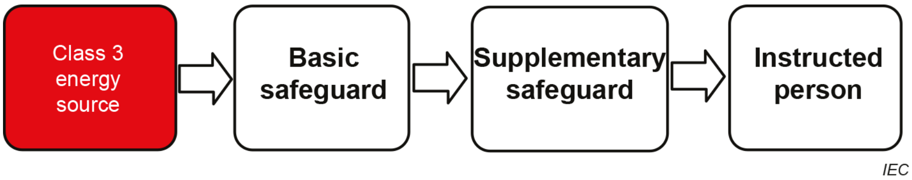


Figure 15 – Model for protection of an instructed person against a class 3 energy source

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).

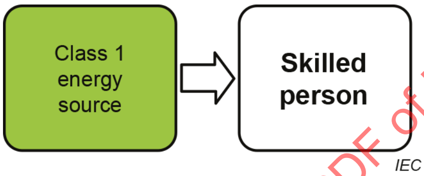


Figure 16 – Model for protection of a skilled person against a class 1 energy source

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**.

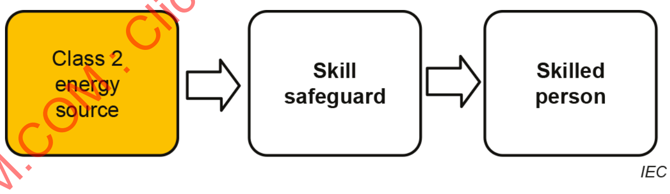


Figure 17 – Model for protection of a skilled person against a class 2 energy source

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 in this document (for example, see 8.5.4), 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**.

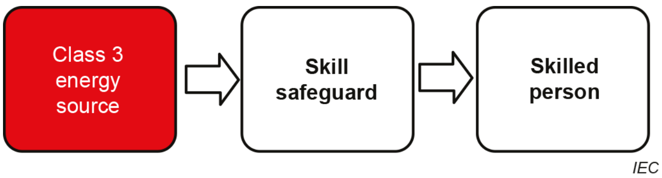


Figure 18 – Model for protection of a skilled person against a class 3 energy source

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).

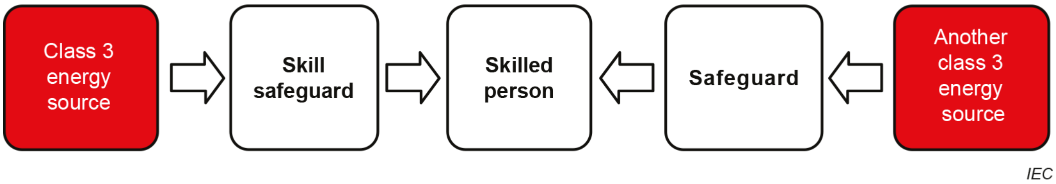


Figure 19 – Model for protection of a skilled person against class 3 energy sources during equipment servicing conditions

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 document 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 Safeguard robustness

4.4.3.1 General

Where a solid **safeguard** (for example, an **enclosure**, barrier, **solid insulation**, earthed conductive part, 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 4.4.3.2 to 4.4.3.10.

A solid **safeguard** made of thermoplastic material that is not **accessible** shall pass the stress relief test of 4.4.3.8.

For a **safeguard** that is **accessible** after opening an external **enclosure**, see 4.4.3.5.

Requirements for:

– adhesion of metallized coatings; and
– adhesives securing parts serving as **safeguards**; and
– parts that can defeat a **safeguard** if an adhesive fails,

are specified in Clause P.4.

Unless specified otherwise, the tests are performed in the most unfavourable direction.

4.4.3.2 Steady force tests

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

– **transportable equipment**; or
– **hand-held equipment**; or
– **direct plug-in equipment**

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

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

All other **enclosures** or barriers that are **accessible** and that are 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.

This subclause does not apply to glass. Requirements for glass are given in 4.4.3.6.

4.4.3.3 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 that requires removal of the paper shredder to empty the container.

– desk-top equipment having a mass of 7 kg or less that is intended for use with any one of the following:
  • a cord-connected telephone handset; or
  • another cord-connected hand-held accessory with an acoustic function; or
  • a headset.

4.4.3.4 Impact tests

All equipment, other than that specified in 4.4.3.3, 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 4.4.3.6.

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

4.4.3.5 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.

4.4.3.6 Glass impact tests

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

– platen glass used on copiers, scanners and the like, where the glass has been subjected to the steady force test of Clause T.3 and is provided with a cover or **device** to protect the platen glass;
– CRTs: requirements for CRTs are given in Annex U;
– glass that is laminated or has a construction such that glass particles do not separate from each other if the glass is broken.

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

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.

4.4.3.7 Glass fixation test

Laminated glass used as a **safeguard** that prevents access to class 3 energy sources other than PS3 shall be subjected to the following fixation tests:

– a glass impact test as given in Clause T.9 with an impact of 1 J applied three times; and
– a push/pull test with 10 N applied in the centre of the glass in the least favourable direction.

NOTE To perform the test, any suitable method may be used, such as using suction handles or gluing a support to the glass.

4.4.3.8 Thermoplastic material tests

If a **safeguard** is of moulded or formed 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.

4.4.3.9 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 or **enclosure** shall comply with the mechanical strength test specified in Annex T, as applicable.

4.4.3.10 Compliance criteria

During and after the tests of 4.4.3.2 to 4.4.3.9:

– *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.*

4.4.4 Displacement of a safeguard by an insulating liquid

If an **insulating liquid** displaces air comprising a **safeguard**:

– the requirements of 5.4.12 and 6.4.9 apply to the **insulating liquid**; and
– the requirements of 5.4.2 and 5.4.3 apply to the equipment both with and without the **insulating liquid** present.

Partial or total loss of the **insulating liquid** shall be considered an **abnormal operating condition** of the equipment.

If the power supplied to parts immersed in **insulating liquid** is disconnected in the event of partial or total loss of the **insulating liquid**, the requirements of 6.4.2 to 6.4.8 do not apply for the immersed parts. An example of such a disconnect system is a float switch system complying with Annex K.

NOTE The use of **insulating liquids** to replace a **basic insulation**, a **supplementary insulation** or a **reinforced insulation** is not covered by the requirements of this document.

4.4.5 Safety interlocks

Unless otherwise specified in this document, if a **safety interlock** is used as a **safeguard** for protection against:

– a class 2 or a class 3 energy source for an **ordinary person**; or
– a class 3 energy source for an **instructed person**,

the **safety interlock** shall comply with Annex K.

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 injury and the equipment shall comply with the relevant parts of this document.

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 and conductive parts

4.6.1 Requirements

Conductors and conductive parts shall be positioned 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 and of the conductive parts shall be such that, if a conductor or a conductive part becomes loose or detached, the conductor and the conductive part cannot defeat a **safeguard**, such as reducing **clearances** or **creepage distances** below the values specified in 5.4.2 and 5.4.3.

EXAMPLE Examples of conductive parts are screws, nuts, washers, springs or similar parts.

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 the test of Clause T.2 applied 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 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 Equipment containing coin or button cell batteries

4.8.1 General

These requirements apply to equipment and remote controls that:

– are likely to be **accessible** to children; and
– include one or more **coin or button cell batteries** with a diameter of 32 mm or less.

These requirements do not apply to:

– **professional equipment**;
– equipment for use in locations where it is unlikely that children will be present;
– equipment for which it is unlikely that the **coin or button cell battery** will be removed by children due to location of the **battery** within the equipment; in such cases, 4.8.2 still applies;
– equipment containing **coin or button cell batteries** that are soldered in place.

4.8.2 Instructional safeguard

Equipment containing one or more **coin or 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 text
– element 3: the following or equivalent text

[The remote control supplied with] This product contains a coin or button cell battery. If the coin or 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 **coin or button cell battery** compartment, door or cover shall be designed to reduce the possibility of children removing the **coin or button cell battery**. The following are considered acceptable:

- if a **tool**, such as a screwdriver or coin, is required to open or remove the **coin or button cell battery** compartment, door or cover, any of the following constructions may be used:
  - if one or more screws or similar fasteners is used to secure the compartment, door or cover, a minimum of two full rotations of the screw or fastener are required to open or remove the **coin or button cell battery** compartment, door or cover. The screw or fastener shall be captive to the **coin or button cell battery** compartment, door, cover, or to the equipment; or
  - for a cover which is required to be rotated to be opened, a minimum torque of 0,5 Nm shall be required to unlock the cover and start its rotation. A minimum rotation of 90 ° shall be required to remove the cover; or
  - for a cover which is secured by one or more latches, a minimum torque of 0,5 Nm is required to release the latches.
- if no **tool** is required to remove the **coin or button cell battery** compartment door or cover, either of the following shall apply for opening by hand:
  - the application of a minimum of two different and interdependent movements; or
  - the application of simultaneous movements to engage two mechanisms requiring the use of multiple fingers.

Compliance is checked by inspection and the applicable measurements for acceptable constructions and by the tests of 4.8.4 with the compliance criteria of 4.8.5.

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 or 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 or cover is secured by one or more screws, the screws are loosened and then tightened applying a continuous linear torque according to Table 36, using a suitable screwdriver, spanner or key. The screws shall 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 or cover shall be subjected to three impacts in a direction perpendicular to the **battery** compartment door or 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 or covers.*

4.8.4.6 Crush test

*Hand-held remote control **devices** shall 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 selfsupported. A crushing force of 330 N ± 5 N is applied to the exposed top and bottom surfaces of remote control **devices** placed in a stable condition by a flat rigid surface measuring approximately 100 mm by 250 mm for a period of 10 s.*

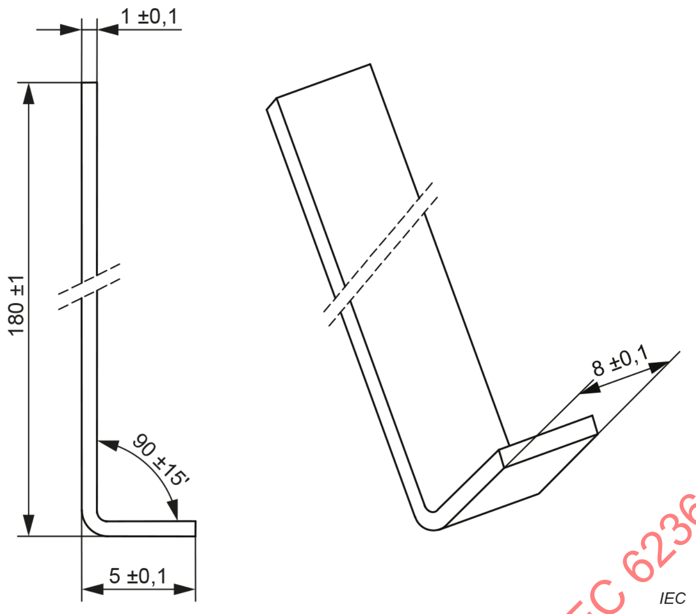
4.8.5 Compliance criteria

*Compliance is checked by applying a force of 30 N ± 1 N for 10 s to the **battery** compartment door or cover by the straight unjointed version of the test probe of Figure V.1 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 or 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.*

Dimensions in millimetres



Material: steel

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 an ES3 circuit to **accessible** conductive parts; or
– bridging within PS3 circuits, unless they are protected by the control fire spread method in 6.4.6,

top and side openings above ES3 and PS3 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.

4.10 Components requirements

4.10.1 Disconnect device

Equipment connected to the **mains** shall be provided with a **disconnect device** in accordance with Annex L.

4.10.2 Switches and relays

Switches and relays located in a PS3 circuit or used as a **safeguard** shall comply with Clause G.1 or Clause G.2 respectively.

4.10.3 Mains power supply cords

Power supply cords for connection to the **mains** shall comply with Clause G.7. A power supply cord for connection to the **mains** is not considered to be external wiring.

4.10.4 Batteries and their protection circuits

Batteries and their protection circuits shall comply with Annex M.

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 fault conditions** of a **basic safeguard** or of a **supplementary safeguard**.

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

NOTE For accessibility requirements, see 5.3.1.

5.2.1.2 ES2

ES2 is a class 2 electrical energy source where:

– both the voltage and the current exceed the limits for ES1; and
– under
  - **normal operating conditions**, and
  - **abnormal operating conditions**, and
  - **single fault conditions**,

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

NOTE For accessibility requirements, see 5.3.1.

5.2.1.3 ES3

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

A neutral conductor is a class 3 electrical energy source.

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.

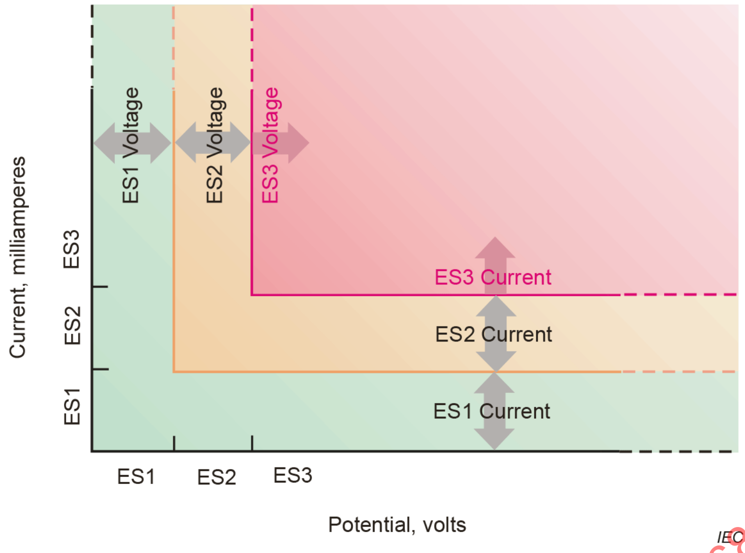


Figure 21 – Illustration showing ES limits for voltage and current

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.

The classification of **external circuits** is done by using their normal operating voltage or current, disregarding the communication or data signals, except for ringing signals (see 5.2.2.6) and for audio signals (see 5.2.2.7).

5.2.2.2 Steady state voltage and current limits

An electrical energy source classification is determined from the AC or **DC voltage** and the maximum current under each of the **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.

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

Energy source	ES1 limits		ES2 limits		ES3
	Voltage	**Current** [a, c, d]	**Voltage**	**Current** [b, c, e]	
DC [c]	60 V	2 mA	120 V	25 mA	> ES2
AC up to 1 kHz	U_{RMS} = 30 V U_{peak} = 42,4 V	I_{RMS} = 0,5 mA I_{peak} = 0,707 mA	U_{RMS} = 50 V U_{peak} = 70,7 V	I_{RMS} = 5 mA I_{peak} = 7,07 mA	
AC > 1 kHz up to 100 kHz	$U_{\text{RMS}} = (30 + 0{,}4f)\text{V}$ $U_{\text{peak}} = (42{,}4 + 0{,}4\sqrt{2}$		$U_{\text{RMS}} = (50 + 0{,}9f)\text{ V}$ $U_{\text{peak}} = (70{,}7 + 0{,}9\sqrt{2}f$		
AC above 100 kHz	U_{RMS} = 70 V U_{peak} = 99 V		U_{RMS} = 140 V U_{peak} = 198 V		
Combined AC and DC [f]	$\frac{U_{\text{DC}}(\text{V})}{60} + \frac{U_{\text{AC RMS}}(\text{V})}{U_{\text{RMS limit}}} \le 1$ $\frac{U_{\text{DC}}(\text{V})}{60} + \frac{U_{\text{AC peak}}(\text{V})}{U_{\text{peak limit}}} \le 1$	$\frac{I_{\text{DC}}(\text{mA})}{2} + \frac{I_{\text{AC RMS}}(\text{mA})}{0{,}5} \le 1$ $\frac{I_{\text{DC}}(\text{mA})}{2} + \frac{I_{\text{AC peak}}(\text{mA})}{0{,}707} \le 1$	See Figure 23	See Figure 22	
As an alternative to the requirements above, the values below can be used for purely sinusoidal waveforms					
Energy source	**ES1 limits**		**ES2 limits**		**ES3**
	Current [a, c] RMS		**Current** [b, c] RMS		
AC up to 1 kHz	0,5 mA		5 mA		> ES2
AC > 1 kHz up to 100 kHz	$I_{\text{RMS}} = (0{,}5\,f)\text{mA}$ [d]		$I_{\text{RMS}} = (5 \text{ x } 0{,}95\,f)\text{mA}$ [e]		
AC above 100 kHz	50 mA [d]		100 mA [e]		

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

See 5.7 for measurement of **prospective touch voltage** and **touch current**.

Electric shock current limits are taken from IEC 60479-1 and IEC 60479-2.

f is in kHz

[a] Current is measured using the measuring network specified in Figure 4 of IEC 60990:2016.

[b] Current is measured using the measuring network specified in Figure 5 of IEC 60990:2016.

[c] For sinusoidal waveforms and DC, 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.

[f] $U_{\text{RMS limit}}$ is determined from the RMS voltage limit corresponding to the applicable frequency, and $U_{\text{peak limit}}$ is determined from the peak voltage limit corresponding to the applicable frequency.

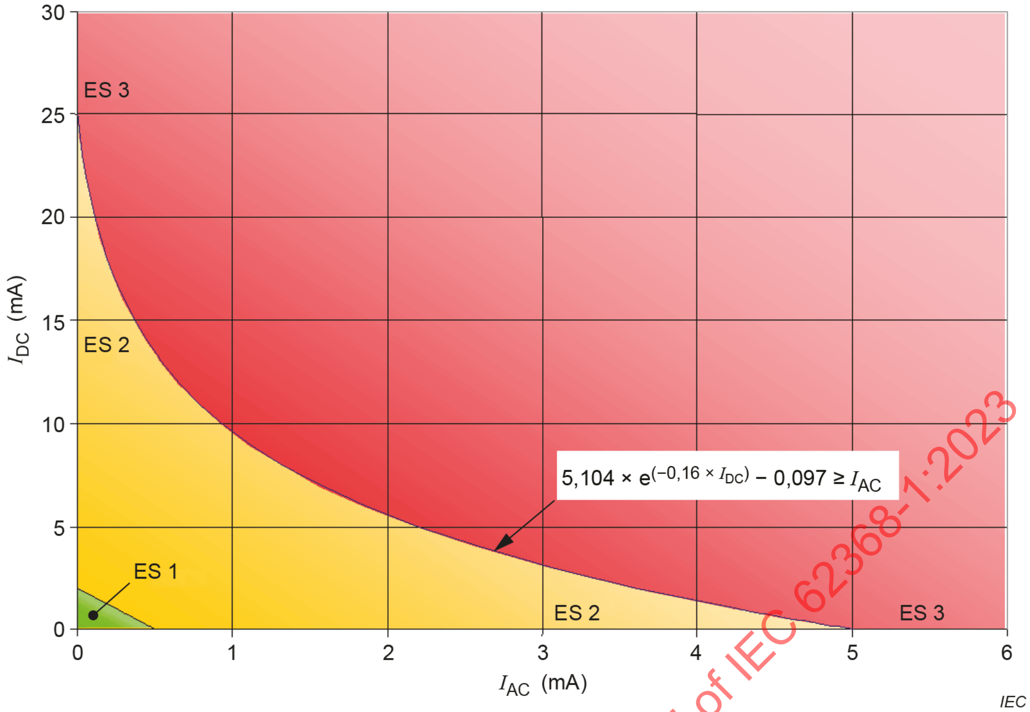


Figure 22 – Maximum values for combined AC current and DC current

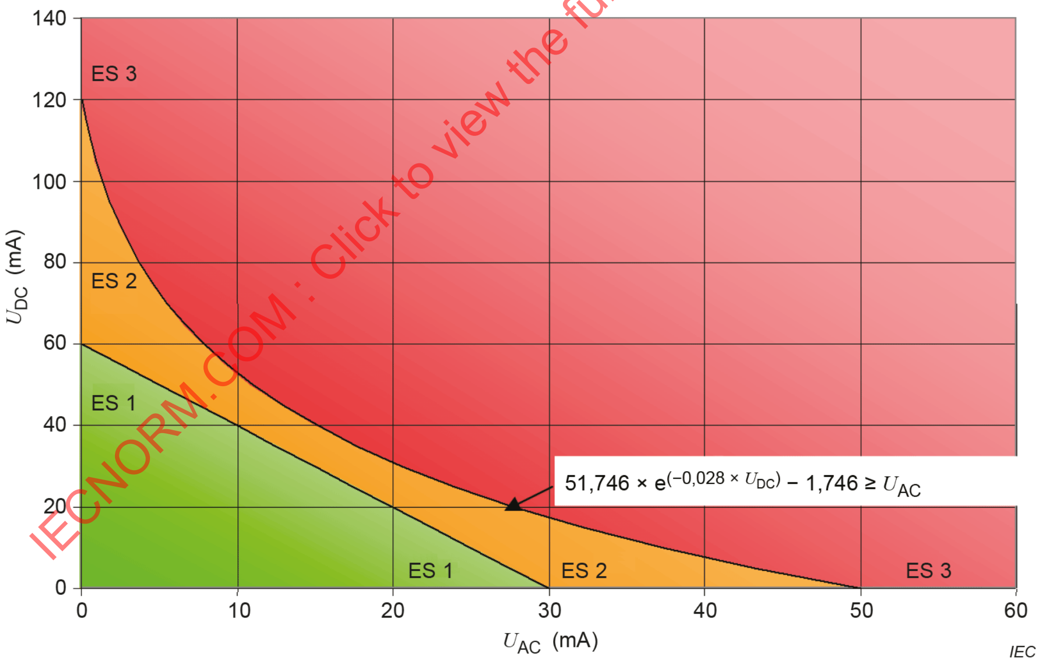


Figure 23 – Maximum values for combined AC voltage and DC voltage

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_{peak} V	ES2 U_{peak} V	ES3 U_{peak} V
300 or greater	60	120	> ES2
170	75	150	
91	100	200	
61	125	250	
41	150	300	
28	200	400	
18	250	500	
12	350	700	
8,0	500	1 000	
4,0	1 000	2 000	
1,6	2 500	5 000	
0,8	5 000	10 000	
0,4	10 000	20 000	
0,2	20 000	40 000	
0,133 or less	30 000	60 000	
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 Figure 22 and Table 10 of IEC 60479-1:2018.

NOTE 2 These single pulses do not include transient voltages.

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	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, either the lower ES2 value of U_{peak} 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, either the shortest time duration can 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	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, either the lower ES2 value of I_{peak} 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, either the value of the shortest time duration 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. 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 pulse off times less than 3 s, the peak values of 5.2.2.2 apply. For longer durations, the values of 5.2.2.4 apply.

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 to be ES2.

5.2.2.7 Audio signals

For electrical energy sources that are audio signals, the limits are specified in Clause E.1.

5.3 Protection against electrical energy sources

5.3.1 General

Safeguard requirements between **accessible** parts and ES2/ES3 **mains** are given in 4.3.

Accessible ES1 or ES2 circuits shall have a **double safeguard** or **reinforced safeguard** to an ES3 source directly connected to the **mains**.

In addition, for ES2/ES3 circuits that are not ES2/ES3 **mains**, the following applies:

– under **single fault conditions** in the circuit between the ES2/ES3 circuits not directly connected to the **mains** and **accessible** ES1 circuits, the current or voltage levels shall not exceed the ES1 limits; and

– under **single fault conditions** in the circuit between the ES2/ES3 circuits not directly connected to the **mains** and **accessible** ES2 circuits, the current or voltage levels shall not exceed the ES2 limits.

NOTE Examples for this construction are:

– with an ES3 **mains**, a rectifier in the insulated (secondary) circuit in a switch mode power supply in which multiple components are present;

– for construction with an ES2 **mains**, a telecommunication office/access equipment where the ES2 **mains** and ES1 circuits are earthed;

– for a construction with ES2 circuits derived from ES1 circuit, a DC / DC converter in the insulated (secondary) circuits of an indoor foreign exchange station (FXS) telephone interface at ES2 levels (derived from ES1 circuits) in which multiple components are present.

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).

For a **battery** backed up supply capable of backfeeding to the input AC terminals, see 5.8.

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 bare parts of **outdoor equipment** that are **accessible** to an **ordinary person** in their intended **outdoor location,** the following shall not be **accessible**:

– bare parts exceeding 0,5 times ES1 voltage 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

– bare parts exceeding ES1 voltage limits under **single fault conditions** of a **basic safeguard** or of a **supplementary safeguard** (see 5.2.1.1).

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 (DC or peak AC) that is equal to the test voltage for **basic insulation** in Table 26 corresponding to the peak of the **working voltage**; or
b) have a minimum distance according to Table 8.

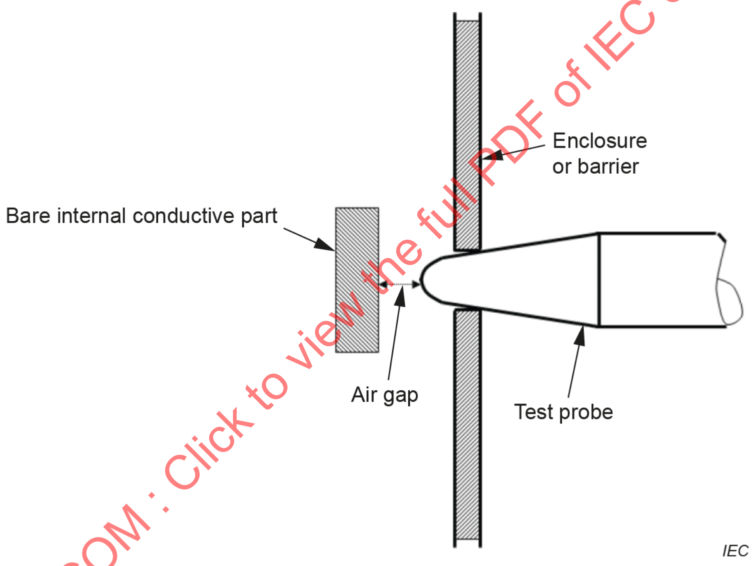


Figure 24 – Contact requirements to bare internal conductive parts

Table 8 – Minimum air gap distance

Voltage	**Air gap distance** mm	
V peak or DC 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.

For equipment intended to be used more than 2 000 m above sea level, the values in this table are multiplied by the multiplication factor for the desired altitude according to Table 16.

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 in accordance with 4.1.2 are not required 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; and

– by an **instructed person** shall not result in contact with ES3.

For audio signal voltages, see Table E.1 for the 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 according to 4.4.3.

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 9.

For maximum temperatures below or equal to 100 °C, no declared insulation system is required. An undeclared EIS is considered to be Class 105 (A).

5.4.1.4.2 Test method

Insulating material temperatures are measured in accordance with B.1.5.

*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.

5.4.1.4.3 Compliance criteria

The temperature of the electrical insulation material or EIS shall not exceed the limits in Table 9.

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

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

Table 9 – 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 **pollution degrees** of the operating or micro-environment for products covered by this document 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 document.

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, 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 can 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 can 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 AC waveform, the pulse width is determined by measuring the time difference between the peaks of the AC 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 across the other insulation;

f) when the **working voltage** is determined by measurement, the input voltage 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 a circuit isolated from the **mains**,

   shall be taken as 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 **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** shall be taken as less than 30 kHz. The **working voltage** to determine minimum **creepage distances** is the voltage measured after the ignition of the lamp.

5.4.1.8.2 RMS working voltage

In determining the **RMS 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 **RMS working voltages**.

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**.

Compliance is checked by examination of the Vicat test or ball pressure data from the material manufacturer. If the data is not available, compliance is checked by either the Vicat test of 5.4.1.10.2 or by the ball pressure test of 5.4.1.10.3.

5.4.1.10.2 Vicat test

*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 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 $(T - T_{amb} + T_{ma} + 15\ °C) \pm 2\ °C$ *(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.*

5.4.2 Clearances

5.4.2.1 General requirements

Clearances shall be so dimensioned to reduce the likelihood of breakdown due to:

– **temporary overvoltages**; and
– transient voltages that can enter the equipment; and
– recurring peak voltages and their related frequencies that are generated within the equipment.

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 after any linear interpolation, but before rounding up, and before any other multiplication factors are applied as stated in Table 10, Table 11, Table 14 and Table 15.

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 **normal operating conditions**, 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.
– Procedure 2: Determine **clearances** according to 5.4.2.3. 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.

For overvoltage category II, **clearances** in circuits connected to an AC **mains** not exceeding 420 V peak (300 V RMS) may be determined per Annex X as an alternative.

5.4.2.2 Procedure 1 for determining clearance

To determine the voltage to be used in Table 10 and Table 11, the highest voltage of the following is used as applicable:

– the peak value of the **working voltage** across the **clearance**;
– the recurring peak voltages, if any, across the **clearance**;

– for circuits connected to the AC **mains**: the **temporary overvoltage**, which is taken as 2 000 V peak if the nominal AC **mains** system voltage does not exceed 250 V and is taken as 2 500 V peak if the nominal AC **mains** system voltage exceeds 250 V but does not exceed 600 V.

  Alternatively, the **temporary overvoltage** may be determined in accordance with 5.4.3.2 of IEC 60664-1:2020 at the discretion of the manufacturer, in which case the reference to "solid insulation" in 5.4.3.2 of IEC 60664-1:2020 is replaced by "clearances". Moreover, the short term value equal to U_n + 1 200 V is taken as the voltage for use in Table 10.

  NOTE U_n is the nominal line-to-neutral voltage of the neutral-earthed supply system.

This voltage shall be used to determine the **clearance** as follows:

– **clearance** values of Table 10 for circuits with fundamental frequencies up to 30 kHz; or
– **clearance** values of Table 11 for circuits with fundamental frequencies higher than 30 kHz; or
– the highest **clearance** values of Table 10 and Table 11 for circuits where both frequencies lower than 30 kHz and higher than 30 kHz are present.

Table 10 – Minimum clearances for voltages with frequencies up to 30 kHz

<table>
<tr><th rowspan="3">Voltage up to and including
Peak</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. 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 11 – Minimum clearances for voltages with frequencies above 30 kHz

Voltage up to and including Peak	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. 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 2 for determining clearance

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 may be determined based on their origin, or may 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.

Outdoor equipment connected to the **mains** shall be suitable for the highest **mains transient voltage** expected in the installation location.

Consideration shall be given to the following:

– the prospective fault current of the supply to **outdoor equipment** can be higher than for indoor equipment, see IEC 60364-4-43; and

– the **mains transient voltage** for **outdoor equipment** can be higher than for indoor equipment.

Components within **outdoor equipment** that reduce the **mains transient voltage** or the prospective fault current shall comply with the requirements of the IEC 61643 series.

NOTE 1 The overvoltage category of **outdoor equipment** is normally considered to be one of the following:

– if powered via the normal building installation wiring, overvoltage category II;

– if powered directly from the **mains** distribution system, overvoltage category III;

– if at, or in the proximity of, the origin of the electrical installation, overvoltage category IV.

NOTE 2 For further information regarding protection from overvoltages, see IEC 60364-5-53.

Compliance is checked by inspection of the equipment, the installation instructions and, where necessary, by the applicable component tests specified in IEC 61643 (all parts).

5.4.2.3.2.2 Determining AC mains transient voltages

For equipment to be supplied from the AC **mains**, the value of the **mains transient voltage** depends on the overvoltage category and the AC **mains** voltage and is given in Table 12. In general, **clearances** in equipment intended to be connected to the AC **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 either external or internal to the equipment. When provided external to the equipment, the installation instructions shall state the need for such external protection.

Table 12 – Mains transient voltages

Nominal voltage of the supply system [a] based on IEC 60038		AC mains voltage up to and including [a c]	Mains transient voltage [b]			
			Overvoltage category			
Three-phase V RMS	Single phase V RMS	V RMS	I V peak	II V peak	III V peak	IV V peak
		50	330	500	800	1 500
		100	500	800	1 500	2 500
120/208	120/240	150	800	1 500	2 500	4 000
230/400 277/480		300	1 500	2 500	4 000	6 000
400/690		600	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 AC **mains** supply voltage is the line-to-line voltage. In all other cases, where there is a neutral conductor, it is the line-to-neutral voltage.

[b] The **mains transient voltage** is always one of the values in the table. Interpolation is not permitted.

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

5.4.2.3.2.3 Determining DC mains transient voltages

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

– if the DC power distribution system is earthed at a single point, the transient voltage is taken to be 500 V peak; or

– if the DC 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 may be at the source of the DC power distribution system or at the equipment location, or both (see ITU-T Recommendation K.27).

– if the cabling associated with the DC 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 DC 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 DC power is derived.

If the DC 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.

When determining the DC **mains transient voltage**, the installation and the source of the DC **mains** shall be taken into account. If these are not known, the **mains transient voltage** on the DC **mains** supply for an **outdoor equipment** shall be taken as 1,5 kV.

If the DC power distribution system is not within the same building, the manufacturer shall declare the **mains transient voltage** on the DC **mains** supply in the installation instructions. The declared **mains transient voltage** shall take into account the conditions mentioned above and shall as a minimum correspond to the overvoltage category of the equipment (see Annex I).

5.4.2.3.2.4 Determining external circuit transient voltages

The applicable value of the transient voltage that can occur on an **external circuit** shall be determined using Table 13. 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 13, the known value shall be used.

NOTE 1 Australia has published its overvoltage limits in 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 13. In installations where transient voltages presented to the equipment are expected to exceed the values specified in Table 13, additional measures such as surge suppression can be applicable.

NOTE 3 In Europe, the requirement for interconnection with an **external circuit** is in addition given in EN 50491-3:2009.

Table 13 – External circuit ID assignment and associated transient voltages

ID	Cable type	Additional conditions	Transient voltages
1a	Symmetrical paired[a] conductors – shielded or single ended paired[a] or unpaired conductors – outdoor aerial or buried exposure (for example, outdoor telecommunications cables).	The building or structure containing the equipment has equipotential bonding or not. Assumes primary protection is installed. "Network Environment 1"	1 500 V 10/700 µs (see IEC 61000-4-5 and ITU-T K (all parts))
1b	Symmetrical paired[a] conductors or single ended paired[a] or unpaired conductors – shielded or unshielded, typically short outdoor or stays within a structure. Typically less than 300 m.	The building or structure containing the equipment has equipotential bonding or not. Assumes primary protection is installed. "Network Environment 1"	1 500 V 1,2/50 µs (see IEC 61000-4-5 and ITU-T K (all parts))
1c	Symmetrical paired[a] conductors or single ended paired[a] or unpaired conductors – shielded or unshielded, short interconnection lines or circuits between equipment not connected to building wiring. The cable can be connected to an outdoor antenna. Typically less than 10 m.	The building or structure containing the equipment has equipotential bonding or not. "Network Environment 0"	Transient voltages are negligible and are therefore disregarded[b]
2	Any other conductors paired[a] or unpaired with short direct inter-connection lines or circuits. Typically less than 10 m.	The building, structure or equipment has equipotential bonding or not. Primary protection can be installed. "Network Environment 0"	Transient voltages are negligible and are therefore disregarded
3a	Coaxial cable distribution network where cables might exit a building or structure where exposure to AC mains or larger electrical transients are possible. Typically this deployment is > 30 m to remote equipment or tall outdoor antennas.	Powered or unpowered circuits. No primary protection or isolation devices installed inside the equipment being evaluated; or no primary protector/isolation device is specified to be installed externally to the equipment; or the coaxial cable entering the building/structure is not likely to be reliably earthed at the building entrance. "Network Environment 1"	4 000 V 1,2/50 µs (earthed applications);or 4 000 V 10/700 µs (unearthed applications) Voltage is center conductor to shield/earth/conductive exposed parts and shield to earth/other conductive parts
3b	Coaxial cable in the coaxial cable distribution network that is used primarily indoors or for short connections to outdoor equipment or antennas. Typically this deployment is < 30 m to remote indoor equipment or rooftop or short outdoor antennas where transient exposure is minimal.	Powered or unpowered circuits. Examples: coaxial interconnections between residential or business equipment within a building/structure. Or coaxial cable connects from a TV, cable TV or satellite set top box or similar equipment to an outdoor antenna. "Network Environment 1"	Transient voltages are negligible and are therefore disregarded[b]
3c	Coaxial cable used for equipment interconnection and totally indoors. Typically this deployment is < 10 m where transient exposure is unlikely.	"Network Environment 0"	Transient voltages are negligible and are therefore disregarded.

If the external circuit transient voltages are known to be higher than indicated above, the known value shall be used. For guidance see IEC 61000-4-5 and ITU-T K (all parts).

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 traction systems) are controlled by installation practices. Such practices are application dependent and are not dealt with by this document.

For a shielded cable to affect a reduction in transients, the shield shall be continuous, earthed at both ends.

Network Environment 0 (see IEC TR 62102) is an **external circuit** with a low likelihood of any significant electrical transients and overvoltages. It is considered to be in a Network Environment 0 if any of the following conditions apply to all parts of that network:

a) the **external circuit** connection is consistent with the definition of Installation Class 0 "Well-protected electrical environment, often within a special room" or of Installation Class 1 "Partly protected electrical environment" based on IEC 61000-4-5;

b) the **external circuit** connection between equipment is not run on building wiring and is ≤ 10 m in length;

c) the **external circuit** connection is an installation or maintenance port not connected during normal use;

d) the **external circuit** connection is intended and documented to be between ports where the equipment is located in (or on) the same cabinet, frame, rack, wall, table etc, or directly adjacent to each other by a very short distance.

Network Environment 1 is an **external circuit** that does not meet the requirements for Network Environment 0.

NOTE 1 Home appliances like audio, video and multimedia products are addressed by ID 1c, 3a, 3b and 3c.

NOTE 2 In Norway and Sweden, the cable shield on coaxial cables is normally not earthed at the building entrance (see Note 1 in 5.7.7.1). For installation conditions, see IEC 60728-11.

[a] A paired conductor includes a twisted pair.

[b] These cables are not subject to any transients but those connected to an outdoor antenna can 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 5.4.5.2.

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** or to any **external circuit**. Only surge suppressors internal to the equipment in circuits connected to the **mains** are disconnected. If the equipment is intended to be used with a separate power supply unit, 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 relevant point.

a) Transient voltages from an AC **mains**

The impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μs impulses equal to the AC **mains transient voltages** between 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 DC **mains**

The impulse test generator circuit 2 of Table D.1 is used to generate 1,2/50 μs impulses equal to the DC **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 13 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 the main **protective earthing** terminal through a **protective bonding conductor**, the **required withstand voltage** may be one overvoltage category lower or one AC **mains** voltage lower in Table 12. For an AC **mains** up to and including 50 V RMS, no adjustments are made.
- In a circuit isolated from the **mains** supplied by a DC 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 **DC voltage** of the source, or the peak of the **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 of the **working voltage**.

5.4.2.3.4 Determining clearances using required withstand voltage

Each **clearance** shall comply with the relevant value of Table 14.

Table 14 – 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 DC
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 shall be rounded up to the next higher specified increment. 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 AC voltage or a **DC 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 15. Five impulses of each polarity are applied with an interval of at least 1 s between pulses.

The AC voltage test is conducted using a sinusoidal voltage with a peak value as specified in Table 15 and is applied for 5 s.

*The **DC voltage** test is conducted using a **DC voltage** specified in Table 15 and applied for 5 s in a single polarity.*

Table 15 – 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 AC or DC)
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** after which this calculated test voltage is rounded up to the next higher 0,01 kV increment.

If the EUT fails the AC or DC test, the impulse withstand voltage test shall be used.

If the test is conducted at an altitude of 200 m or more above sea level, Table F.6 of IEC 60664-1:2020 may be used, in which case linear interpolation between 200 m and 500 m altitudes and between the corresponding impulse test voltages of Table F.6 of IEC 60664-1:2020 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 and designed to be used more than 2 000 m above sea level, the minimum **clearances** in Table 10, Table 11 and Table 14 and the electric strength test voltages in Table 15 are multiplied by the multiplication factor for the desired altitude according to Table 16.

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 16 – 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 according to 4.4.3.

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, and*
  - *the relevant electric strength test shall be applied, and*
  - *for the glass 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 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 be based on the **RMS working voltage** and comply with Table 17. **Creepage distances** for **basic insulation** and **supplementary insulation** for frequencies greater than 30 kHz and up to 400 kHz shall be based on the peak of the working voltage and comply with Table 18.

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

NOTE **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**.

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.

If the minimum **creepage distance** derived from Table 17 or Table 18 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 17 or Table 18.

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 4.4.3;*
– *for the glass impact 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 ≤ CTI
Material Group II	400 ≤ CTI < 600
Material Group IIIa	175 ≤ CTI < 400
Material Group IIIb	100 ≤ CTI < 175

The material group shall be checked by evaluating 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 can be included in a group if its PTI established by these tests is equal to, or greater than, the lower value of the comparative tracking index (CTI) specified for the group.

5.4.3.4 Compliance criteria

Compliance is checked by measurement taking into account Annex O, Annex T according to 4.4.3 and Annex V.

A ***creepage distance*** *may be split into several portions of different materials and/or have different* ***pollution degrees*** *if one of the* ***creepage distances*** *is dimensioned to withstand the total voltage or if the total distance is dimensioned according to the material having the lowest comparative tracking index (CTI) and the highest* ***pollution degree****.*

Table 17 – Minimum creepage distances for basic insulation and supplementary insulation in mm

RMS working voltage up to and including	Pollution degree						
	1 [a]	2			3		
	Material group						
V	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 **RMS working voltage** above 630 V.

Table 18 – Minimum values of creepage distances (in mm) for frequencies higher than 30 kHz and up to 400 kHz

Peak voltage kV	30 kHz < f ≤ 100 kHz	100 kHz < f ≤ 200 kHz	200 kHz < f ≤ 400 kHz
0,1	0,016 7	0,02	0,025
0,2	0,042	0,043	0,05
0,3	0,083	0,09	0,09
0,4	0,125	0,13	0,15
0,5	0,183	0,19	0,25
0,6	0,267	0,27	0,4
0,7	0,358	0,38	0,68
0,8	0,45	0,55	1,1
0,9	0,525	0,82	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 of 1,4 shall be used.

Linear interpolation may be used, the result being rounded up to the next significant digit.

The data given in this Table 18 does not take into account the influence of tracking phenomena. For that purpose, Table 17 shall be taken into account. Therefore, if values in Table 18 are smaller than those in Table 17, the values of Table 17 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. When the **solid insulation** is exposed to frequencies above 30 kHz, the requirements of 5.4.4.9 also apply.

Solid insulation shall not break down due to:

– overvoltages, including transients, that enter the equipment, and peak voltages that can be generated within the equipment; and
– pinholes in thin layers of insulation.

Enamelled 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 impact 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 5.4.9.2; 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 can 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 may 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 can be made of different 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 19 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 19.

Table 19 – 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

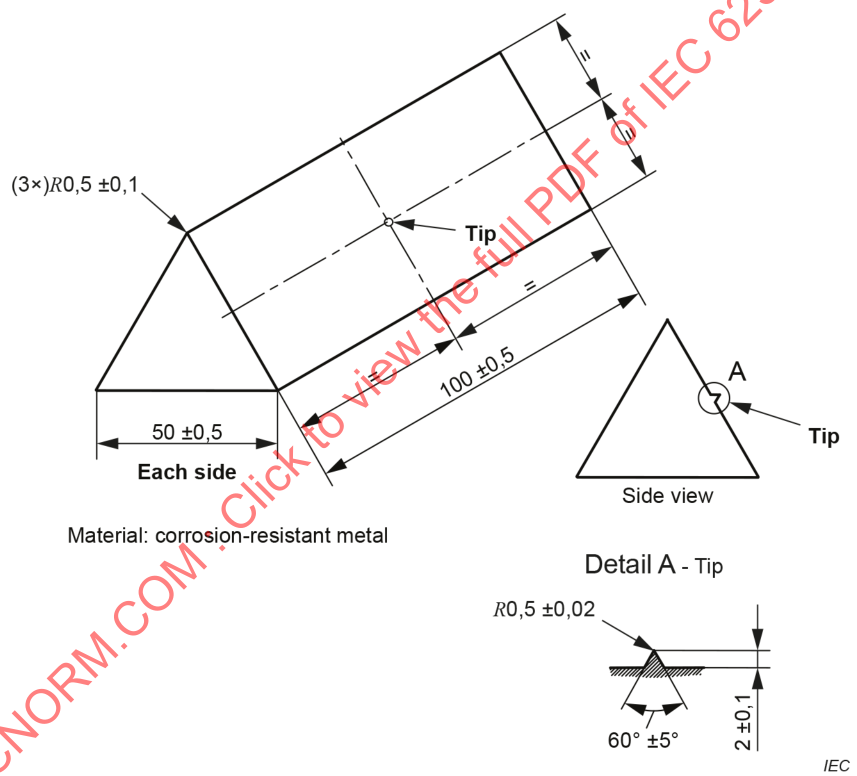


Figure 25 – Mandrel

Dimensions in millimetres

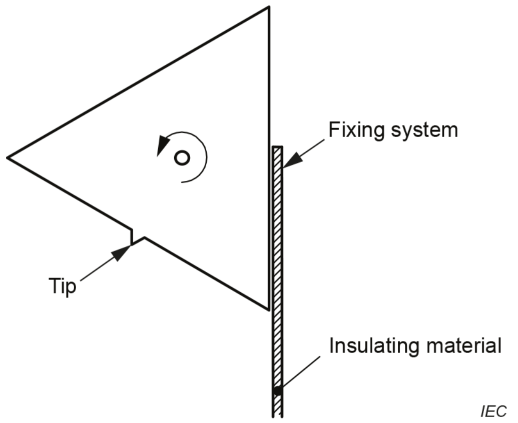
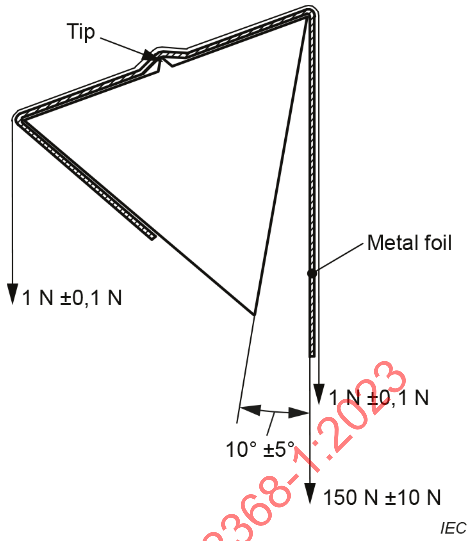


Figure 26 – Initial position of mandrel



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

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 with a thickness of 0,035 mm ± 0,005 mm and 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 18 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

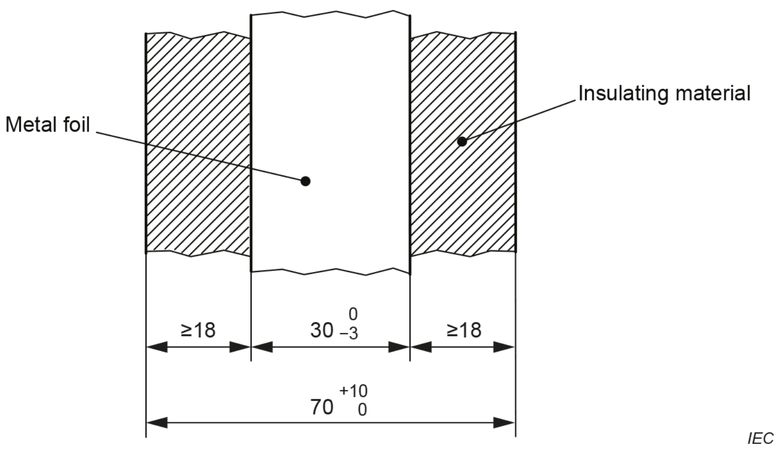


Figure 28 – Position of metal foil on insulating material

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 RMS, 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 (RMS) for the insulating material. One of the following methods shall be used to determine the value of E_P:
  - the value declared by the manufacturer based on material manufacturer's data; or
  - the value from Table 20; or
  - the value based on the test specified in IEC 60243-1.

  The manufacturer is responsible for determining the value.
– Determine the reduction factor K_R for the breakdown electric field strength of the insulating material at the applicable frequency from Table 21 or Table 22. If the material is not one listed in Table 21 or Table 22, use the average reduction factor in the last row of Table 21 or Table 22 as applicable.
– Determine the value of the breakdown electric field strength at the applicable frequency E_F by multiplying the value E_P with the reduction factor K_R.

$$E_F = E_P \times K_R$$

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

$$V_W = E_F \times d$$

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

$$V_W > 1{,}2 \times V_{PW} / 1{,}41$$

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

$$V_W > 1{,}2 \times 2 \times V_{PW} / 1{,}41$$

As an alternative to the above, the electric strength test according to 5.4.9.1 may be applied except that the **mains** frequency test voltage shall be as follows:

– for **basic insulation**: $1{,}2 \times V_{PW} / K_R$

– for **reinforced insulation**: $1{,}2 \times 2 \times V_{PW} / K_R$

There shall be no breakdown.

Table 20 – 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] [4]	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] [5]	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 EP value of 0,75 mm thickness may be used for all thicknesses.

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

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

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

4 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 can be used if they can be shown to lead to the same results.

5 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 can be used if they can be shown to lead to the same results.

Table 21 – 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 22 – 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 **mains** and antenna terminals; and
– between **mains** and **external circuits** providing non-**mains** supply voltages to other equipment having antenna terminals

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;
– equipment with only antenna terminals intended for connection to an indoor antenna only.

NOTE In China, connection of the CATV to the main **protective earthing** terminal of equipment is not permitted.

5.4.5.2 Test method

*The sample is subjected to 50 discharges from the antenna interface test generator (circuit 3) of Clause D.2, at not more than 12 discharges per minute, with U_c equal to 10 kV. The equipment shall be placed on an insulating surface. The antenna interface test generator output shall be connected to the antenna terminals connected together and to the **mains** terminals connected together. If the equipment has **external circuits** providing non-**mains** supply voltages to other equipment having antenna terminals, the test is repeated with the generator connected to the **mains** terminals connected together and the **external circuit** terminals connected together. The equipment is not energized during these tests.*

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 DC.

The equipment complies with the requirement if the insulation resistance measured after 1 min is not less than the values given in Table 23.

Table 23 – 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 24.

Table 24 – Distance through insulation of internal wiring

Working voltage in case of failure of basic insulation		Minimum distance through insulation
V peak or DC	V RMS (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 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 in this document, 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 in this document, 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 25 using the **required withstand voltage** (based on transient voltages from the AC **mains** or DC **mains** or from **external circuits**).*
- *Method 2: Determine the test voltage according to Table 26 using the peak of the **working voltage** or the recurring peak voltages, whichever is higher.*
- *Method 3: Determine the test voltage according to Table 27 using the nominal AC **mains** voltage (to cover **temporary overvoltages**).*

The insulation is subjected to the highest test voltage as follows:

- *by applying an AC voltage of substantially sine-wave form having a frequency of 50 Hz or 60 Hz; or*
- *by applying a **DC voltage** for the time specified below.*

*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).*

Where necessary, the insulation is tested with a 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) and the capacitors can affect the test results, DC test voltages shall be used.

*Components providing a DC 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 can 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 25 – Test voltages for electric strength tests based on transient voltages

Required withstand voltage up to and including	**Test voltage for basic insulation or supplementary insulation**	**Test voltage for reinforced insulation**
kV peak	kV peak or DC	
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 × 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.		

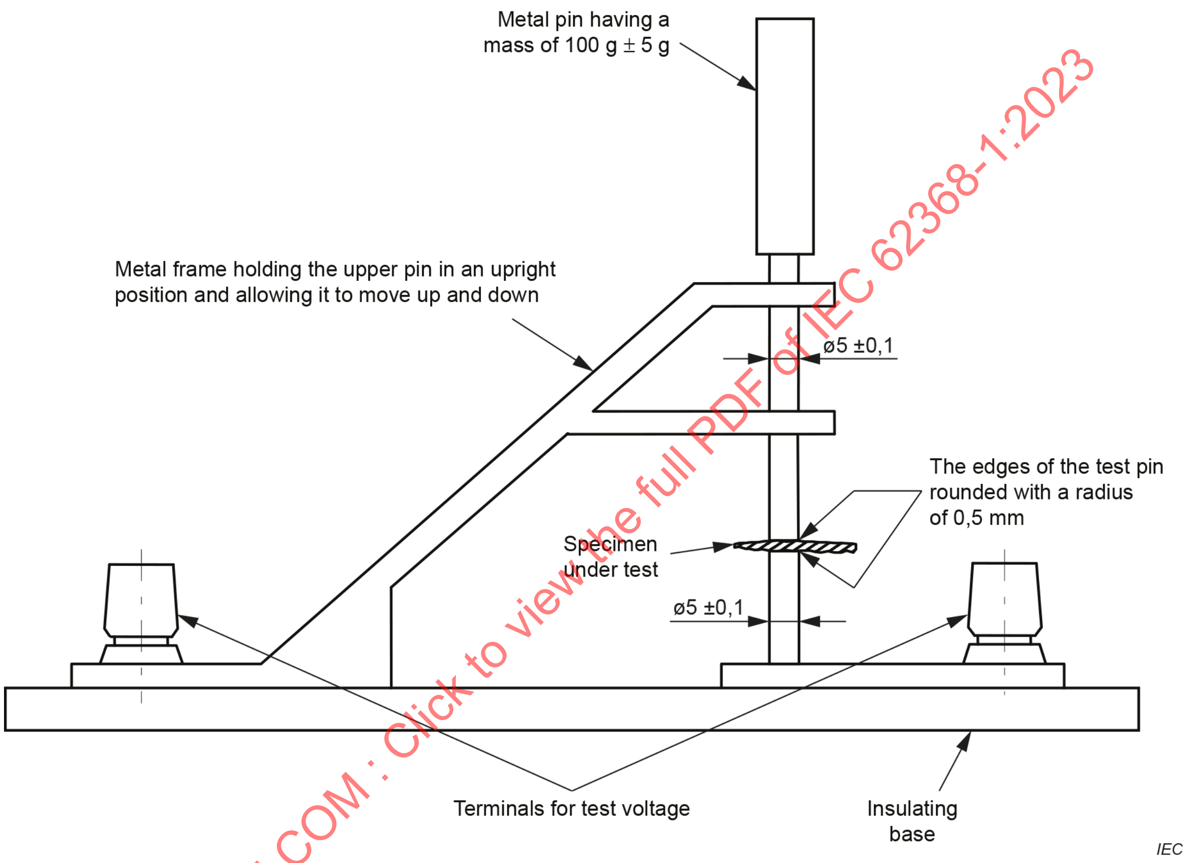
Table 26 – Test voltages for electric strength tests based on the peak of the working voltages and recurring peak voltages

Voltage up to and including	**Test voltage for basic insulation or supplementary insulation**	**Test voltage for reinforced insulation**
kV peak	kV peak or DC	
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 × U_P [a]	1,6 × U_P [a]
Linear interpolation may be used between the nearest two points.		
[a] U_P is any voltage higher than 12 kV.		

Table 27 – 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 RMS	kV peak or DC	
Up to and including 250	2	4
Over 250 up to and including 600	2,5	5

Dimensions in millimetres



NOTE When applying the test fixture, ensure that the specimen sample diameter is of sufficient size to prevent breakdown around the edges.

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

Where required, ***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 **Routine testing** for equipment is specified in IEC 62911.

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 the circuitry intended to be connected to **external circuits** with a transient as indicated in Table 13, ID 1a, 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 circuitry intended to be connected to an **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).

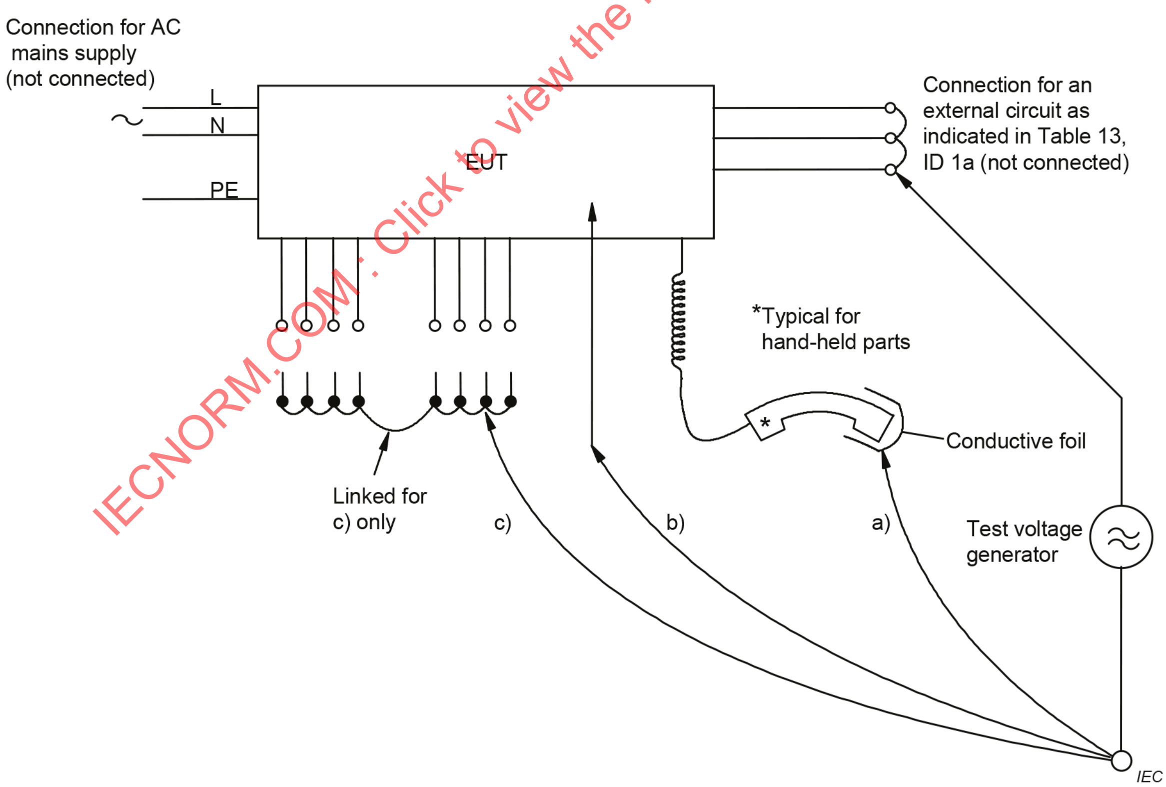


Figure 30 – Application points of test voltage

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.

NOTE In Australia, the tests of both 5.4.10.2.2 and 5.4.10.2.3 apply.

During the test:

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

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

Table 28 – Test values for electric strength tests

Parts	Impulse test (see Annex D)		Steady state test
	U_c	Test generator	
Parts indicated in 5.4.10.1 a) [a]	2,5 kV	circuit 1	1,5 kV
Parts indicated in 5.4.10.1 b) and c) [b]	1,5 kV	circuit 1 [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 as given in Table 28. The interval between successive impulses is 60 s. U_c is the value to which the capacitor shall be charged.

NOTE In Australia, a value of U_c = 7,0 kV is used for hand-held telephones and for headsets and 2,5 kV for other equipment in 5.4.10.1 a). The 7 kV impulse simulates lightning surges on typical rural and semi-rural network lines.

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 28.

NOTE In Australia, the steady state test voltage is 3 kV for 5.4.10.1 a), and 1,5 kV for 5.4.10.1 b) and c). These values have been determined considering the low frequency induced voltages from the power supply distribution system.

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 28, footnote [c], 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 DC or, if surge suppressors are left in place, a DC test voltage that is 10 % less than the surge suppressor operating or striking voltage. The insulation resistance shall not be less than 2 MW.*

5.4.11 Separation between external circuits and earth

5.4.11.1 General

These requirements apply only to equipment with **external circuits** intended for connection to building wiring that is expected to leave the environment in which it is located.

These requirements do not apply to any of the following:

– **permanently connected equipment**;

– **pluggable equipment type B**;

– **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**;

– **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.

Surge suppressors that bridge the separation between ES1 or ES2 circuitry intended to be connected to **external circuits** and earth shall have a minimum rated operating voltage U_{op} (for example, the sparkover voltage of a gas discharge tube) of:

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

where:

U_{peak} is one of the following values:

– for equipment intended to be installed in an area where the nominal voltage of the AC **mains** exceeds 130 V: 360 V;

– for all other equipment: 180 V.

ΔU_{sp} is the negative tolerance of the rated operating voltage due to variations in the surge suppressor production, obtained by subtracting the minimum rated operating voltage from the nominal rated operating voltage. If this is not specified by the surge suppressor manufacturer, ΔU_{sp} shall be taken as 10 % of the rated operating voltage of the surge suppressor.

ΔU_{sa} is the change of the rated operating voltage due to the surge suppressor ageing over the expected life of the equipment, obtained by subtracting the minimum operating voltage after ageing from the rated operating voltage. If this is not specified by the surge suppressor manufacturer, ΔU_{sa} shall be taken as 10 % of the rated operating voltage of the surge suppressor.

(ΔU_{sp} + ΔU_{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 with a test voltage according to Table 25 for ***basic insulation*** *or* ***supplementary insulation*** *based on the* ***required withstand voltage*** *for the* ***mains*** *voltage of the equipment.*

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 AC ***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 DC* ***mains****, the test is performed with a voltage equal to the highest nominal voltage of the AC* ***mains*** *in the region where the equipment shall 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.

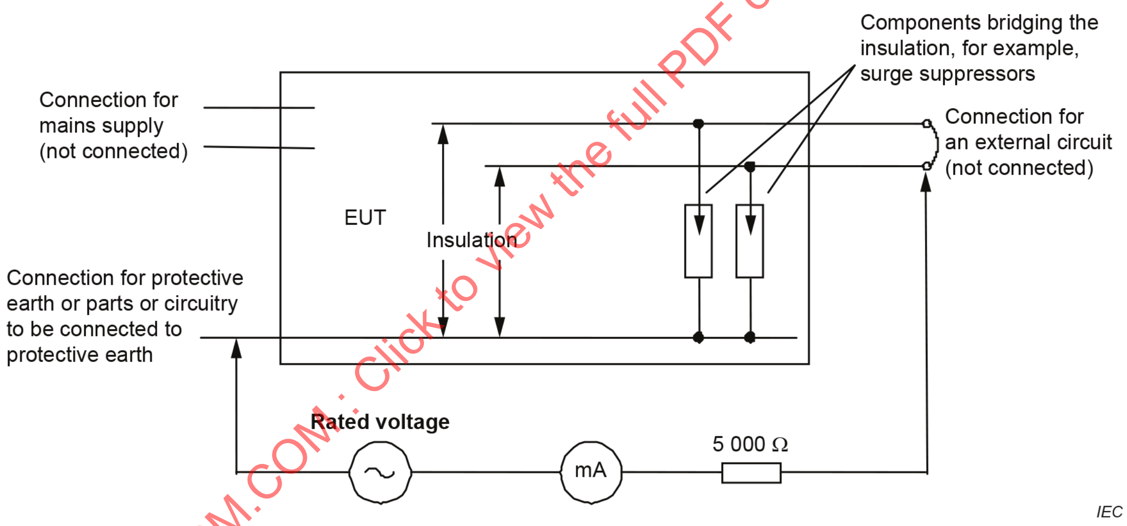


Figure 31 – Test for separation between an external circuit and earth

5.4.12 Insulating liquid

5.4.12.1 General requirements

An **insulating liquid** used as a **safeguard** shall not break down due to overvoltages, including transients, that enter the equipment, and peak voltages that could be generated within the equipment.

The **insulating liquid** shall comply with 5.4.12.2 and 5.4.12.3. The container for the **insulating liquid** shall comply with 5.4.12.4.

5.4.12.2 Electric strength of an insulating liquid

The electric strength of the **insulating liquid** shall comply with the electric strength test in 5.4.9 with the **insulating liquid** in the equipment.

5.4.12.3 Compatibility of an insulating liquid

The **insulating liquid** shall not react with or otherwise deteriorate **safeguards**, such as:

– **solid insulation;** or

– the **insulating liquid** itself.

*For **insulating liquids** with a thermal classification of IEC 60085 Class 105 (A), compliance is checked by operating the immersed equipment for 60 days followed by an electric strength test in accordance with 5.4.9. There shall be no breakdown and there shall be no visible damage or deformation of the other immersed **equipment safeguards**.*

For higher thermal classes the requirements of 5.4.1.4.3 are applicable.

5.4.12.4 Container for insulating liquid

The container for the **insulating liquid** shall be provided with a means of pressure relief if there is a closed vessel.

The **insulating liquid** container shall comply with G.15.2.1 for a closed vessel.

For an **insulating liquid** that is also considered to be a **hazardous substance**, the container shall also comply with the requirements of 7.2.

Compliance is checked by the relevant tests.

5.5 Components as safeguards

5.5.1 General

A component is considered a **safeguard** if the classification of the energy source increases due to a failure of the component.

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

– comply with all the applicable requirements for that **safeguard**; and

– be used within its ratings.

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 can consist of discrete components.

Capacitors and RC units with one or multiple capacitors shall comply with Clause G.11. However, the requirements of Clause G.11 do not apply to a capacitor and RC unit used as a **basic safeguard** between any of the following:

– ES3 isolated from the **mains** and protective earth;

– ES2 and protective earth;

– ES2 and ES1;

which 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 and G.11.3 do not need to be tested.

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 distribution system used, capacitors are required to be rated for the applicable line-to-line voltage (230 V).

Class X capacitors can 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 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 5 s after disconnection of the connector for **pluggable equipment type B** and 2 s after disconnection of any other 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**.

A resistor or a group of resistors used as a **safeguard** against capacitor discharge is not subjected to simulated **single fault conditions** if the resistor or the group of resistors complies with 5.5.6.

If an IC that includes a capacitor discharge function (ICX) is used to comply with the above:

– the **accessible** voltage (for example, at the **mains** connector) shall not exceed the limits given above under a **single fault condition** of an ICX or of any one component in the associated capacitor discharge circuit; 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 unfavourable position. The disconnection of the connector (start of discharge time) shall be done at the moment when the input capacitor 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 following resistor applications shall comply with the relevant tests as indicated in Table 29:

– a single resistor used as a **reinforced safeguard** or for bridging **reinforced insulation**;

– a resistor or a group of resistors serving as a **safeguard** between a circuit connected to the **mains** and a circuit intended to be connected to coaxial cable;

– resistors serving as a capacitor discharge **safeguard**.

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 the relevant requirements of Clause G.10.

In addition, resistors that bridge **basic insulation**, **supplementary insulation** or **reinforced insulation** shall comply with each of the following:

– 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);

– 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 the relevant requirements of Clause G.10.

Table 29 – Overview of tests for resistor applications

Resistor application	Conditioning	Resistor test	Voltage surge test	Impulse test	Overload test
	G.10.2	G.10.3	G.10.4	G.10.5	G.10.6
Reinforced safeguard or bridging **reinforced insulation**	X	X			
Between a **mains** connected circuit and a coaxial cable	X		X	X	
Capacitor discharge **safeguard**	X				X

5.5.7 Surge suppressors

Where a varistor is used between a **mains** circuit at ES3 voltage and **protective earthing**:

– the earth connection shall comply with 5.6.7; and

– the varistor shall comply with Clause G.8.

Where a varistor is used between line and neutral or between lines, it shall comply with Clause G.8.

Where surge suppression is used between the **mains** and **protective earthing**, 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** with a test voltage according to Table 26 and Table 27; 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 surge suppressors are MOVs, varistors and GDTs. A varistor is sometimes referred to as a VDR or a metal oxide varistor (MOV).

NOTE 2 In **class II equipment**, surge suppressors are sometimes used between the **mains** and an **external circuit** as defined in Table 13, ID 1a, 1b and 1c to protect internal circuits from a lightning surge. Information related to the use of surge suppressors for such purposes is given in IEC TR 62368-2:20—, Annex A.

The above requirements do not apply to surge suppressors connected to reliable earthing (see 5.6.7).

NOTE 3 It is not a requirement of this document that surge suppressors comply with any particular component standard. However, attention is drawn to the IEC 61643 and IEC 61051 series of standards, in particular:

– IEC 61051-2 (surge suppression varistors)

– IEC 61643-21 (surge protective devices connected to telecommunications and signalling networks)

– IEC 61643-311 (gas discharge tubes)

– IEC 61643-321 (avalanche breakdown diodes)

– IEC 61643-331 (metal oxide varistors)

– IEC 61643-341 (thyristor surge suppressors TSS).

NOTE 4 Surge suppressors between an **external circuit** and earth are not considered to be a **safeguard**. Requirements for those surge suppressors are covered in 5.4.11.2.

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 voltage 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;

– equipment connected to a reliable earthing in accordance with 5.6.7.

The combination of the insulation with the resistor is tested after conditioning any resistor in parallel with this insulation, either alone or combined with this insulation, according to G.10.2 as follows:

– *for equipment intended to be connected to a coaxial cable connected to an outdoor antenna, the voltage surge test of G.10.4; or*

– *for equipment intended to be connected to another coaxial cable, the impulse test of G.10.5; or*

– *for equipment intended to be connected to both an outdoor antenna and other coaxial connections, the voltage surge test of G.10.4 and the impulse test of G.10.5.*

When G.10.5 requires only a 4 kV impulse test, this 4 kV impulse test is not required if the insulation complies with the electric strength test in accordance with 5.4.9.1 with a minimum of 4 kV peak or DC.

The resistor may be removed during the tests. After the tests, the insulation shall comply with 5.4.5.3.

5.5.9 Safeguards for socket-outlets in outdoor equipment

A residual current protective **device** (RCD) with rated residual operating current not exceeding 30 mA shall be used in the **mains** supply to socket-outlets intended for general use.

The RCD shall be an integral part of the **outdoor equipment** or shall be part of the building installation. If the RCD is not an integral part of the equipment, the instructions shall provide the installation requirements for the RCD.

Compliance is checked by inspection.

5.6 Protective conductor

5.6.1 General

Under **normal operating conditions**, a **protective conductor** can 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** can 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 a **protective conductor**.

A **protective conductor** termination shall be made such that it is not likely to be loosened during servicing, other than servicing of the actual conductor itself. A single terminal can be used to connect multiple **protective bonding conductors**. A **protective earthing conductor** termination shall not serve as a means to secure any component or part other than a **protective bonding conductor**.

A single wiring terminal of the screw or stud type can be used to secure both the **protective earthing conductor** and the **protective bonding conductor** in equipment having a **non-detachable power supply cord**. In this case, the wiring termination of the **protective earthing conductor** shall be separated by a nut from that of the **protective bonding conductor**. The **protective earthing conductor** shall be on the bottom of the stack, so that it is the last connection disturbed.

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, can be transparent;

– a **protective bonding conductor** in assemblies such as ribbon cables, bus bars, printed wiring, etc., can be of any colour provided that no misinterpretation of the use of the conductor is likely to arise.

For **functional earthing** conductors, the colour combination green-and-yellow shall not be used, except for multipurpose preassembled components (for example, multi-conductor cables or EMC filters).

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.7.

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 DC **mains**, the **protective earthing** connection can be provided by a separate terminal.

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

– be included in and protected by a sheathed power supply cord that complies with G.7.1 and which is not lighter than heavy duty as specified in Annex C of IEC 62440:2008; or

– 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 3 For **mains** power supply cords, see also Clause G.7.

NOTE 4 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.7 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.7; or

– if either the **rated current** of the equipment or the **protective current rating** of the circuit exceeds 25 A, with the minimum conductor sizes in Table 31; or

– if both the **rated current** of the equipment and the **protective current rating** of the circuit do not exceed 25 A; either

  • with the minimum conductor sizes in Table 31; or

  • with the limited short-circuit test of Annex R; or

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

If the **rated current** of the equipment is not declared by the manufacturer, it is the calculated value of the **rated power** divided by **rated voltage**.

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 Gauge 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.

NOTE 4 In France, in certain cases, the **protective current rating** of the circuit supplied from the **mains** is taken as 20 A instead of 16 A.

– 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.

5.6.4.2.4 Current limiting and overcurrent protective devices

A current limiting **device** (a PTC **device**) or an 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.

5.6.4.3 Compliance criteria

Compliance is checked by inspection and measurement of the ***protective bonding conductor*** *sizes in accordance with Table 31, Table G.7, or the test of Annex R as applicable.*

5.6.5 Terminals for protective conductors

5.6.5.1 Requirements

Equipment required to have **protective earthing** shall have a main **protective earthing** terminal. For equipment with a detachable power supply cord, the earthing terminal in the appliance inlet is regarded as the main **protective earthing** terminal.

Terminals for connecting **protective earthing conductors** shall:

– comply with the minimum terminal sizes in Table 32 for all pillar, stud or screw type terminals; or

– be suitable as a **protective earthing** connection according to the relevant IEC standard in accordance with 4.1.2 and pass the test of 5.6.6.

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

– the minimum terminal sizes in Table 32 for all pillar, stud or screw type terminals; or

– be suitable as a **protective earthing** connection according to the IEC standard relevant for the terminal in accordance with 4.1.2 and pass the test of 5.6.6; or

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

– if both the **rated current** of the equipment and the **protective current rating** of the circuit do 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;

  or

– 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.7)**	**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.7 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, evaluation of compliance with the relevant terminal IEC standard in accordance with 4.1.2, 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.7 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 AC or DC 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 AC **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 DC* ***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*** *does not exceed 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*** *exceeds 25 A, the voltage drop over the protective bonding system shall not exceed 2,5 V.*

5.6.7 Reliable connection of a protective earthing conductor

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**; and
  • has instructions for the installation of that conductor to building earth by a **skilled person**.

For equipment connected to an **external circuit**, 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**; and
– has instructions for the installation of that conductor to building earth by a **skilled person**.

5.6.8 Functional earthing

If a **protective earthing conductor** in the **mains** power supply cord is only used for establishing **functional earthing**:

– the requirements for conductor size as given in G.7.2 apply to the earthing conductor of the **mains** power supply cord; and
– the marking for **class II equipment** with **functional earthing** shall be used as specified in F.3.6.2: and

– the appliance inlet, if used, shall comply with the **creepage distance** and **clearance** requirements for **double insulation** or **reinforced insulation**.

NOTE 1 Some appliance inlets for **class I equipment** do not have sufficient insulation to serve as **double insulation** or **reinforced insulation** between the phases and the **protective earthing** terminal. Equipment using such an inlet is not considered to be **class II equipment**.

NOTE 2 In Norway, equipment connected with an earthed **mains** plug is classified as **class I equipment**. See the marking requirement in the country note to 4.1.15. The symbol IEC 60417-6092 (2013-03), as specified in F.3.6.2, is accepted.

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 supplied 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 Figure 4 and Figure 5 respectively in IEC 60990:2016 shall indicate peak voltage. If the **touch current** waveform is sinusoidal, an RMS 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 60990:2016.

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 1 Systems of interconnected equipment are specified in more detail in Annex A of IEC 60990:2016.

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. The EUT operates normally during this test.

5.7.4 Unearthed accessible parts

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, 5.4 and 6.2.1 of IEC 60990:2016.

Under **single fault conditions** of a relevant **basic safeguard** or a **supplementary safeguard**, including 6.2.2.2 of IEC 60990:2016, 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 60990:2016.

For an **accessible** non-conductive part, the test is made with a metal foil as specified in 5.2.1 of IEC 60990:2016.

5.7.5 Earthed accessible conductive parts

At least one earthed **accessible** conductive part shall be tested for **touch current** following supply connection faults in accordance with 6.1 and 6.2.2 of IEC 60990:2016, except 6.2.2.8. Except as permitted in 5.7.6, the **touch current** shall not exceed the ES2 limits in 5.2.2.2.

Subclause 6.2.2.3 of IEC 60990:2016 does not apply to equipment with a switch or other **disconnect device** that disconnects all poles of the supply.

NOTE An appliance coupler is an example of a **disconnect device**.

5.7.6 Requirements when touch current exceeds ES2 limits

Where the **touch current** exceeds the ES2 limits in 5.2.2.2 under the supply fault conditions specified in 6.2.2.2 of IEC 60990:2016, all of the following conditions apply:

– the **protective conductor current** measured according to Clause 8 of IEC 60990:2016 shall not exceed 5 % of the input current measured under **normal operating conditions**;
– the construction of the **protective earthing conductor** circuit and its connections shall have:
  - a **protective earthing conductor** serving as a **reinforced safeguard** as specified in 5.6.3 or two independent **protective earthing conductors** serving as a **double safeguard**, and
  - a reliable connection to **protective earthing** as specified in 5.6.7;
– the manufacturer shall indicate the value of the **protective conductor current** in the installation instructions if the current exceeds 10 mA;
– 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 elements of the **instructional safeguard** that are required to be placed on the equipment shall be affixed to the equipment adjacent to the equipment supply connection.

5.7.7 Prospective touch voltage and touch current associated with external circuits

5.7.7.1 Touch current from coaxial cables

If the equipment is connected to **external circuits** with a coaxial cable and if such connection is likely to create a hazard, the manufacturer shall provide instructions to connect the shield of the coaxial cable to the building earth in accordance with 6.2 g) and 6.2 l) of IEC 60728-11:2016.

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 can be provided by a retailer, for example.

The user manual shall have the following or similar information in Norwegian and Swedish language respectively, depending on which 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 IEC 60728-11)".

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."

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 RMS, 50 Hz or 60 Hz, for 1 min.

5.7.7.2 Prospective touch voltage and touch current associated with paired conductor cables

For circuits intended to be connected to **external circuits** such as those described in ID 1a, 1b, 1c and 2 of Table 13:

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

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

The above requirements do not apply if the corresponding **external circuits** are 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.

NOTE For other power distribution systems, see IEC 60990:2016.

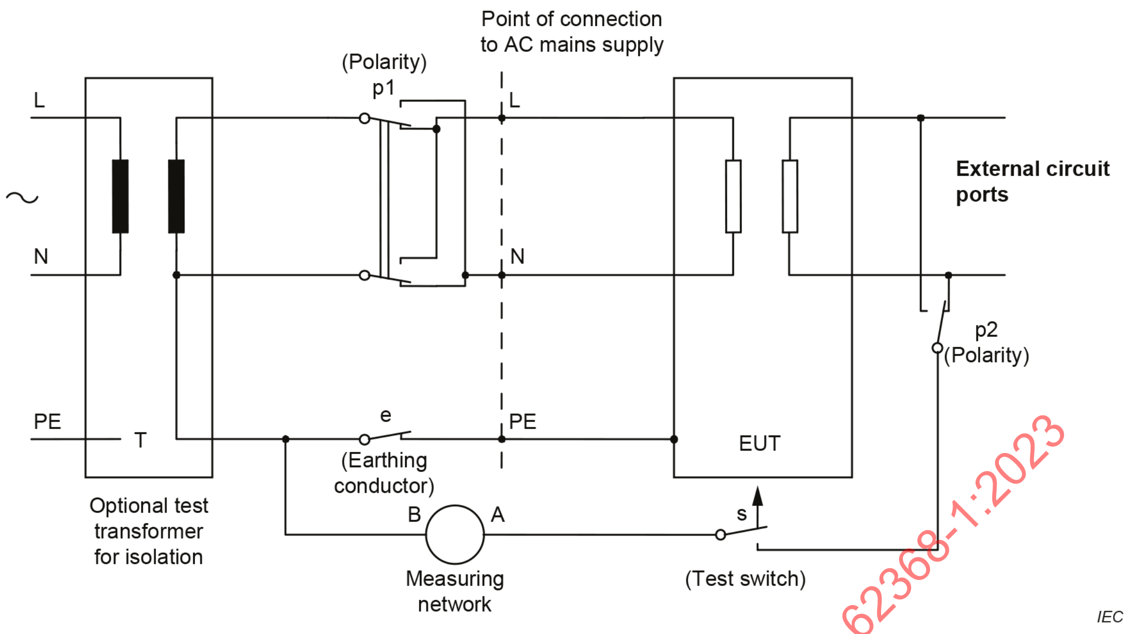


Figure 32 – Test circuit for touch current of single-phase equipment

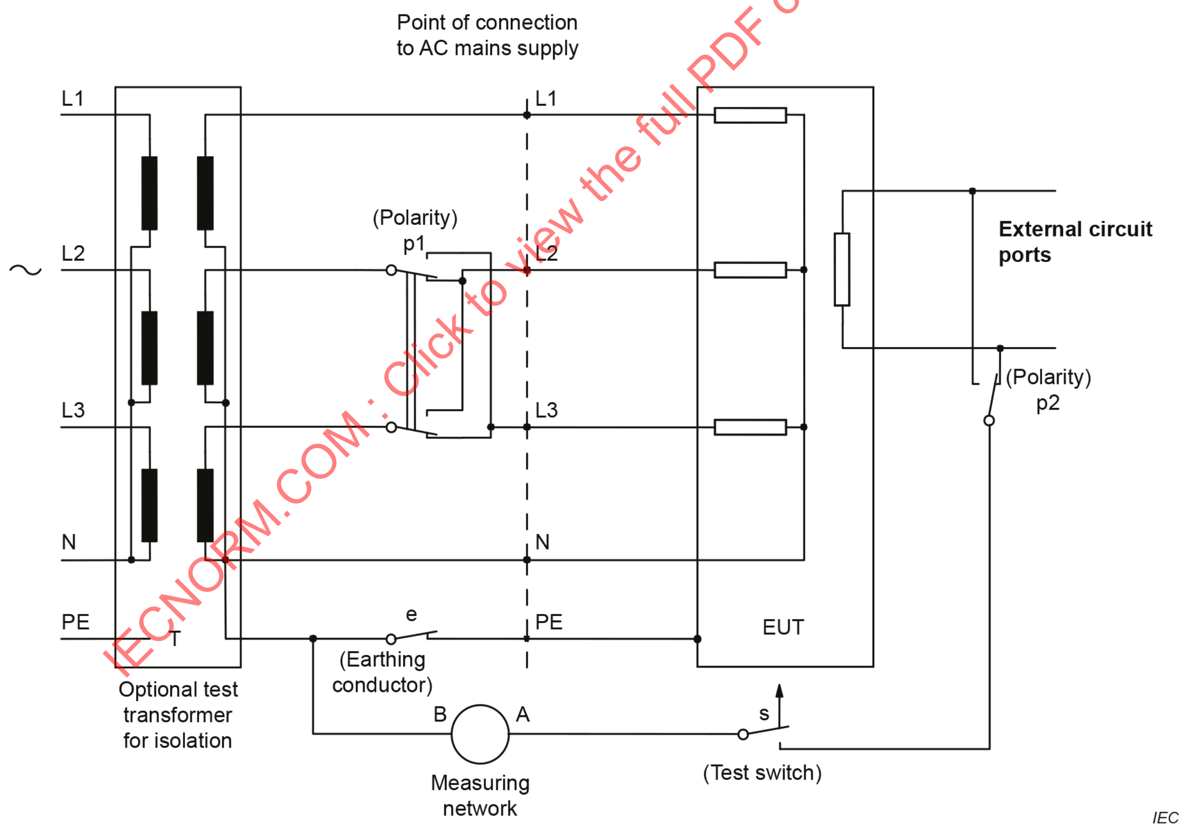


Figure 33 – Test circuit for touch current of three-phase equipment

5.7.8 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 intended to be connected to an **external circuit** such as described in Table 13, ID 1a, 1b, 1c, 2, 3a, 3b and 3c.

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 an **external circuit**;

– $S(I_1)$: summation of **touch current** received from all other equipment via an **external circuit**;

– I_2: **touch current** due to the **mains** of the equipment.

It shall be assumed that each circuit of the equipment connected to an **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 connected to an earthed **external circuit**

For equipment in which each circuit that can be connected to an **external circuit** is connected to a terminal for the **protective earthing conductor** of the equipment, the following 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 5.7.6 and Clause F.3.

2) Such equipment shall comply with 5.7.6. The value of I_2 shall be used to calculate the 5 % input current limit per phase specified in 5.7.6.

3) The sum of $S(I_1)$ and I_2 shall comply with the ES2 limits of Table 4.

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 60990:2016, Figure 5, or any other instrument giving the same results. A source (for example, a capacitively coupled AC source of the same line frequency and phase as the AC **mains**) is applied to each **external circuit** and adjusted 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 connected to an unearthed **external circuit**

If each circuit of the equipment that can be connected to an **external circuit** does not have a common connection, the **touch current** for each circuit shall not exceed the ES2 limits of Table 4.

If all circuits of the equipment that can be connected to an **external circuit** or any groups of such ports have a common connection, the total **touch current** from each common connection shall not exceed the ES2 limits of Table 4.

Compliance with item b) is checked by inspection and, if there are common connection points and the sum of $\mathrm{S}(I_1)$ and I_2 *exceeds the ES2 limits of Table 4, by the following test.*

A capacitively coupled AC source of the same frequency and phase as the AC ***mains*** is applied to each circuit of the equipment that can be connected to an ***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 circuit. Common connection points are tested in accordance with 5.7.3, whether or not the points are ***accessible***.

5.8 Backfeed safeguard in battery backed up supplies

A **battery** backed up supply that is an integral part of the equipment and is capable of backfeeding shall prevent greater than ES1 from being present on the **mains** terminals after interruption of the **mains** power.

No hazard shall exist at the **mains** terminals when measured 1 s after de-energization of the **mains** for **pluggable type A equipment**, 5 s for **pluggable type B equipment** or 15 s for **permanently connected equipment** using the measurement instruments described in 5.7.2. Where the measured open-circuit voltage does not exceed the ES1 limits, the **touch current** does not need to be measured.

Compliance is checked by inspection of the equipment and the relevant circuit diagram, by measurement and by ***single fault conditions*** *in accordance with B.4.*

NOTE 1 For standards related to **battery** backed up power supply systems that are not an integral part of the equipment, see standards related to UPS, such as IEC 62040-1. For transfer switches, see IEC 62310-1:2005.

NOTE 2 See also the explanatory information in IEC TR 62368-2.

When an air gap is employed as a **backfeed safeguard**, the requirements of 5.4.2 for **clearances** and 5.4.3 for **creepage distances** apply in addition to the following:

– subject to confirmation from the manufacturer, the **battery** backed up supply output, in **stored energy mode** can be considered a transient free circuit of Overvoltage Category I;
– the **clearances** and **creepage distances** shall comply with the requirements for **pollution degree** 2 or higher if expected in the intended installation location;
– **reinforced insulation** shall be applied between the unit output and the unit input if during **stored energy mode** of operation not all input poles are isolated by the **backfeed safeguard device**. In all other cases, **basic insulation** shall be applied.

Compliance is checked by inspection.

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 and potential ignition sources

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 can 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** can be created 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 in the load circuit (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 load 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);*

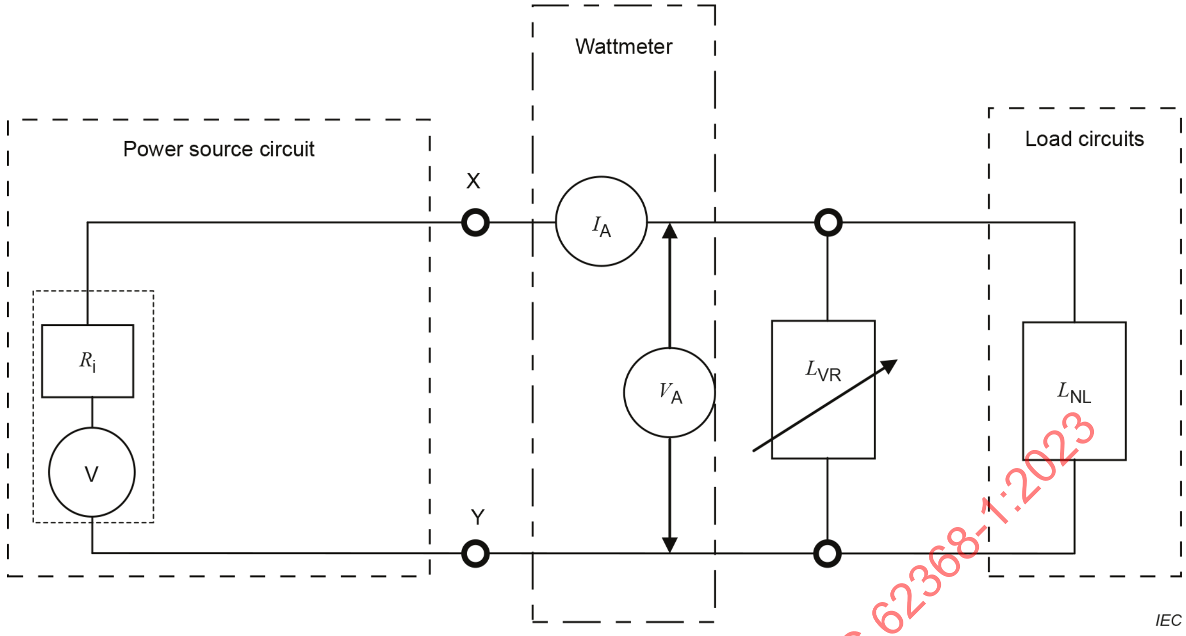
– *connect a variable resistor, L_{VR}, as shown;*

– *adjust the variable resistor, L_{VR}, until the power source delivers the maximum power in a steady state 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 **device** or circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting **device** or circuit operated.*

When evaluating accessories connected via cables to the equipment, the impedance of the cable should 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 load 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.*
- *Equipment containing* ***audio amplifiers*** *shall also be tested under* ***abnormal operating conditions*** *as specified in Clause E.3.2.*
- *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.*

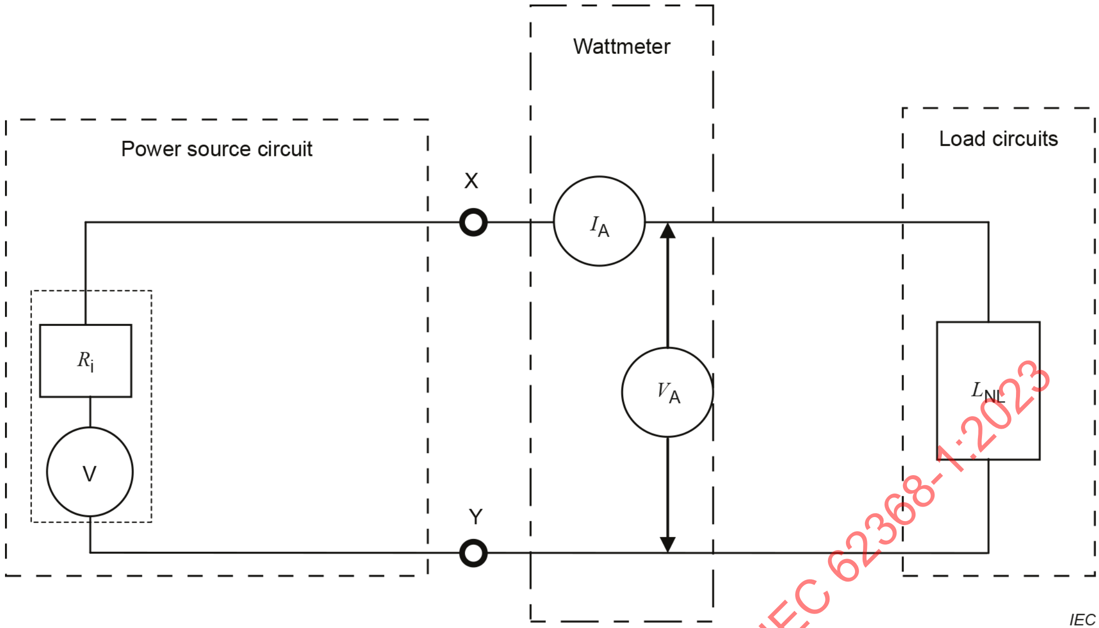
If an overcurrent protective ***device*** *operates during the test, the measurement shall be repeated at 125 % of the current rating of the overcurrent protective* ***device****.*

If a power limiting ***device*** *or circuit operates during the test, the measurement shall be repeated at a point just below the current at which the power limiting* ***device*** *or 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 may be used 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.

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.

Circuits that have previously been evaluated and comply with Annex Q are considered not to be higher than PS2. All **safeguards** and requirements for PS2 apply.

NOTE Such circuits were typically tested according to IEC 60950-1.

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).

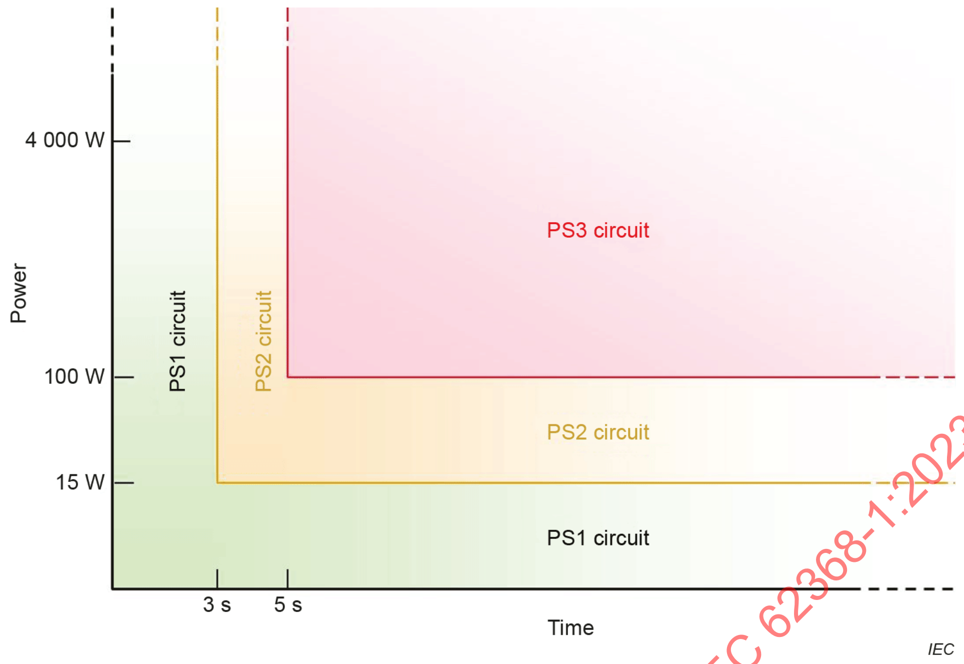


Figure 36 – Illustration of power source classification

6.2.3 Classification of potential ignition sources

6.2.3.1 Arcing PIS

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) AC or DC; and

– the product of the peak of the open-circuit voltage (V_p) and the measured RMS 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 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** may 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.

However, the manufacturer may declare any location to be an **arcing PIS** without testing.

6.2.3.2 Resistive PIS

A **resistive PIS** is any part in a PS2 or PS3 circuit that, under **normal operating conditions**, **abnormal operating conditions** or **single fault conditions**, dissipates more than 15 W for longer than 30 s.

For the method "Control fire spread", with the exception of **secondary lithium batteries**, components and current carrying parts in a PS2 circuit are considered not to be a **resistive PIS**.

For the method "Control fire spread", components and current carrying parts in a PS3 circuit are considered to be a **resistive PIS**.

A **resistive PIS** is considered not to exist in a PS1 because of the limits of the power source.

However, the manufacturer may declare any location to be a **resistive PIS** without testing.

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 document currently does not contain requirements for flammable dust or liquids other than for **insulating liquids**.

– **combustible materials** for components and other parts (including **electrical enclosures**, **mechanical enclosures** and decorative parts) not inside a **fire enclosure** shall comply with:

  - **HB75 class material** if the thinnest significant thickness of this material is < 3 mm; or
  - **HB40 class material** if the thinnest significant thickness of this material is ≥ 3 mm; or
  - **HBF class foamed material**; or
  - shall pass the glow-wire test at 550 °C according to IEC 60695-2-11.

  These requirements do not apply to any of the following:

  - parts with a volume not exceeding 1 750 mm^3;
  - parts with a mass of **combustible material** of less than 4 g;
  - supplies, **consumable materials**, media and recording materials;
  - **loudspeaker drivers** and **loudspeaker driver** assemblies;
  - grille covering material, cloth, and reticulated foam that comply with S.6;

- parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics;
- 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.1.5 for details on thermal equilibrium.

*Temperature limiting **basic safeguards** that comply with the applicable requirements of this document 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 parts of the same equipment.

– **Reduce the likelihood of ignition:** Equipment is so designed that under **single fault conditions** no part shall have sustained flaming. This method may 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** ($V_{mains} \times I_{max}$) 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 may 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 considered not to be capable of providing 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 Requirements

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) shall be reduced by using the following **supplementary safeguards** as applicable:

NOTE For PS3 circuits where the available power exceeds 4 000 W, see 6.4.6.

– an **arcing PIS** or a **resistive PIS** shall be separated as specified in 6.4.7;

– an **arcing PIS** or a **resistive PIS** shall be separated from **combustible material** that is located on an **accessible** outer surface of the equipment. If there are openings within the restricted volume (see Figure 37), ignition shall not occur during **single fault conditions;**

– protective **devices** acting as a **safeguard** shall comply with G.3.1 to G.3.4 or the relevant IEC component standards;

– motors and transformers shall comply with G.5.3, G.5.4 or the relevant IEC component standard;

– varistors shall comply with G.8.2; and

– components associated with the **mains** shall comply with the relevant IEC component standards and the requirements of other parts of this document.

In addition, the tests of 6.4.3.2 apply.

EXAMPLES Components associated with the **mains** include the power supply cord, appliance couplers, EMC filtering components, switches, etc.

6.4.3.2 Test method

The conditions of Clause B.4, that are possible causes for ignition, are applied in turn. A consequential fault can 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 monitored continuously until thermal equilibrium has been attained.*

*If a conductor opens during a simulated **single fault condition**, this opened 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.1.5 for details on thermal equilibrium.

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.*

6.4.3.3 Compliance criteria

Compliance is checked by inspection, tests and measurements. See B.4.8 for compliance criteria.

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 be capable of providing enough energy to result in materials reaching ignition temperatures.

6.4.5 Control of fire spread in PS2 circuits

6.4.5.1 General

This subclause 6.4.5 defines the **safeguard** methods that can be used to control the spread of fire.

6.4.5.2 Requirements

Fire spread in PS2 circuits shall be controlled by applying the following **supplementary safeguards**.

Conductors, **devices**, components, parts and materials shall comply with the following:

– printed boards shall be made of **V-1 class material** or **VTM-1 class material**; and
– wire insulation and tubing shall comply with 6.5.1, and
– motors shall comply with G.5.4, and
– transformers shall comply with G.5.3, and
– supplies, consumable materials, media and recording materials, and parts that are required to have particular properties in order to perform intended functions, such as synthetic rubber rollers, ink tubes and material requiring optical characteristics shall comply with one of the following:
  - be made of **HB class material**; or
  - shall not ignite during **single fault conditions** in a PS2 circuit; or
  - have a minimum distance of 13 mm from a PS2 circuit.

NOTE A PS2 circuit can consist of components, printed board traces, wires or similar.

All other components in a PS2 circuit, except for **loudspeaker drivers** and **loudspeaker driver** assemblies, shall comply with one of the following:

– be mounted on **V-1 class material** or **VTM-1 class material**;
– be made of **V-2 class material**, **VTM-2 class material** or **HF-2 class foamed material**;
– comply with the requirements of Clause S.1;
– have a volume not exceeding 1 750 mm^3;

– have a mass of **combustible material** of less than 4 g;
– comply with the flammability requirements of the relevant IEC component standard;
– be in a sealed **enclosure** of 0,06 m^3 or less, consisting totally of non-**combustible material** and having no ventilation openings.

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**,
  - comply with the flammability requirements of the relevant IEC component standard,
  - comply with the requirements of Clause S.1,
  - be mounted on material made of **V-1 class material** or **VTM-1 class material** and be of a volume not exceeding 1 750 mm^3 or have a mass of **combustible material** of less than 4 g;
– by providing a **fire enclosure** as specified in 6.4.8;
– varistors located less than 13 mm from an **enclosure** and that are made of **combustible material** shall comply with G.8.2.

Within the **fire enclosure**, **combustible materials** that do not comply with the flammability requirements for PS2 or PS3 circuits 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 any of the following:

– parts with a volume not exceeding 1 750 mm^3;
– parts with a mass of **combustible material** of less than 4 g;
– 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, ink tubes and material requiring optical characteristics;
– gears, cams, belts, bearings and other parts that would contribute negligible fuel to a fire, including, labels, mounting feet, key caps, knobs and the like;
– tubing for air or fluid systems, containers for powders or liquids and foamed plastic parts, provided that they are of **HB75 class material** if the thinnest significant thickness of the material is < 3 mm, or **HB40 class material** if the thinnest significant thickness of the material is ≥ 3 mm, or **HBF class foamed material** or pass the glow-wire test at 550 °C according to IEC 60695-2-11.

A **fire enclosure** is not necessary for any of the following components and materials:

– wire insulation and tubing complying with 6.5.1;
– 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, Clause G.4 and Clause G.7;
– **loudspeaker drivers** and **loudspeaker driver** assemblies;
– 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

When required, the minimum separation requirements between a **PIS** and **combustible materials**, in order to reduce the likelihood of sustained flaming or spread of fire, can be achieved by either separation by distance (6.4.7.2) or separation by a fire barrier (6.4.7.3).

Additional requirements for a **fire enclosure** or a fire barrier of **combustible material** located within 13 mm of an **arcing PIS** or 5 mm of a **resistive PIS** are given in 6.4.8.4.

These requirements do not apply to **loudspeaker drivers** and **loudspeaker driver** assemblies.

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 and Figure 38.

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**.

Dimensions in millimetres

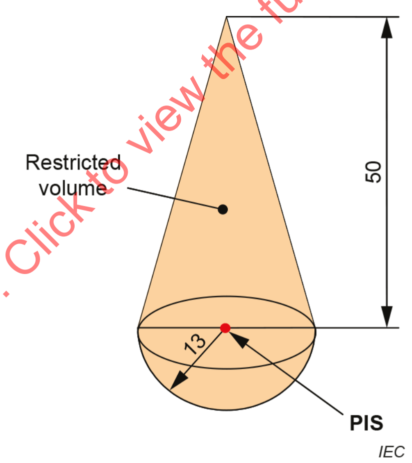
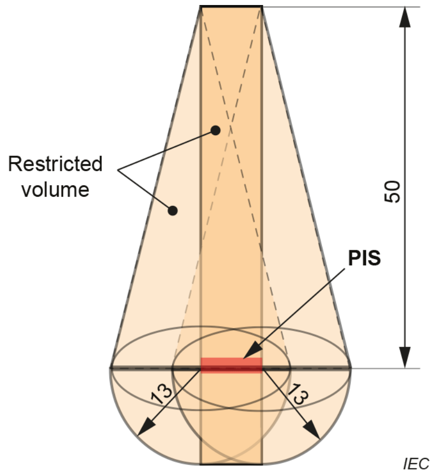


Figure 37 – Minimum separation requirements from a PIS

Dimensions in millimetres



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 distance between a **PIS** and **combustible materials** is less than specified in Figure 37 and Figure 38 as applicable, the **combustible materials** shall:

– have a volume not exceeding 1 750 mm^3; or
– have a mass of **combustible material** of less than 4 g; or
– comply with:
  - the flammability 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. The flame application times 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 39).

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 may 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 of 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, components shall meet the flammability requirements of the relevant component standard and no other materials rated less than **V-1 class material** shall be mounted on the same side of a printed board as the **resistive PIS**; and
– 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.

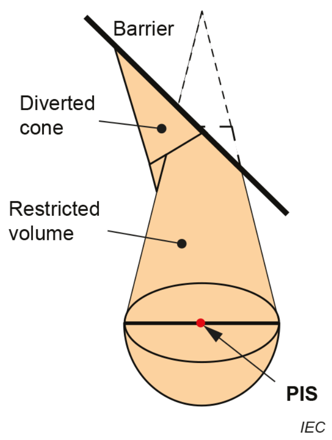


Figure 39a – Illustration showing an angled barrier

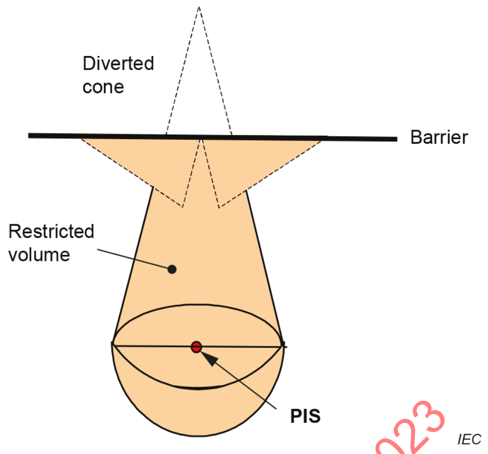


Figure 39b – Illustration showing a horizontal barrier

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 given in 6.4.8.4, the distance of the barrier from the **PIS** is not significant.

Figure 39 – 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, except where 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; or
– be made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or
– be made of **V-1 class material**.

For circuits where the available power exceeds 4 000 W, a **fire enclosure** shall:

- comply with the requirements of Clause S.5; or
- be made of non-**combustible material** (for example, metal, glass, ceramic, etc.); or
- be made of **5VA class material** or **5VB class material**.

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. Where the equipment has two or more **normal operating condition** orientations, opening properties apply to each possible orientation.

Determination of top openings, side openings and bottom openings shall be done in accordance with Figure 40, taking into account all possible orientations of use (see also 4.1.6).

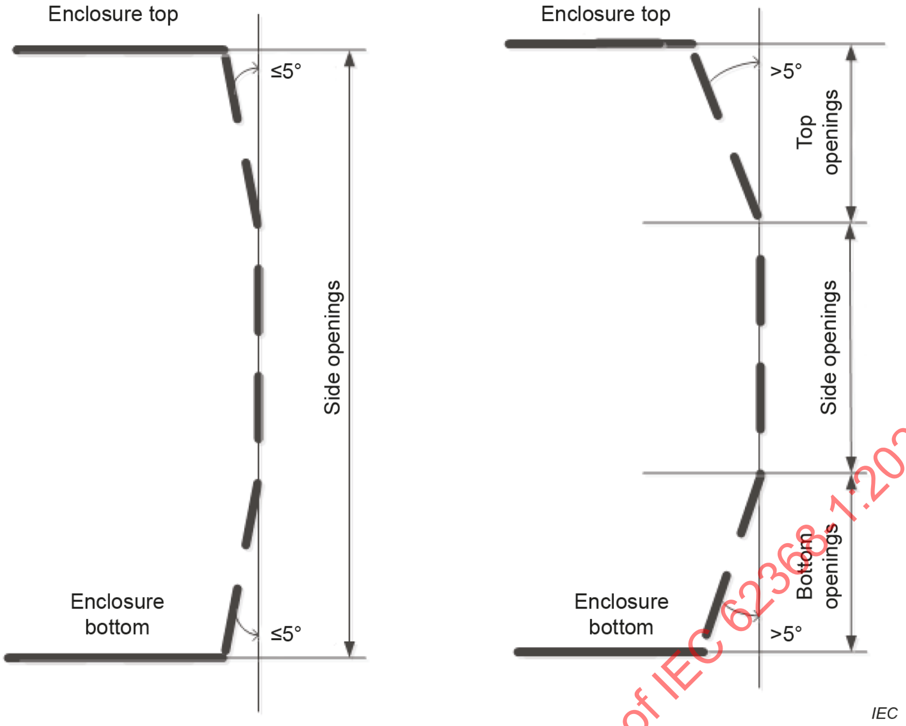


Figure 40 – Determination of top, bottom and side openings

6.4.8.3.2 Fire barrier dimensions

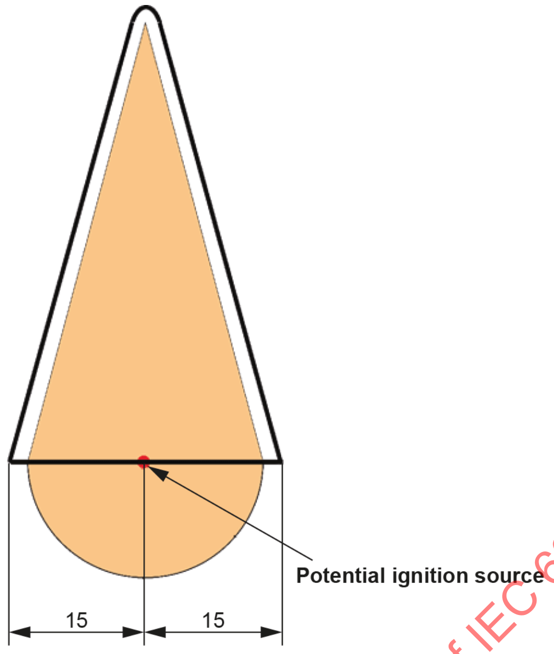
The edges of the fire barriers shall extend beyond the restricted volume (see Figure 39).

6.4.8.3.3 Top openings and top opening properties

Top opening properties of a **fire enclosure** shall apply to openings on a horizontal surface or any surface with an inclination of more than 5 degrees from vertical (see Figure 40) above a **PIS** located in a PS3 circuit as shown in Figure 41. Top opening properties of a fire barrier shall apply to openings above a **PIS** located in a PS3 circuit as shown in Figure 41.

Top openings that fall within the volume of the fire cone with an addition of 2 mm space as defined in Figure 41 shall comply with Clause S.2.

Dimensions in millimetres



NOTE Dimensions of the fire cone are identical to those of 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*

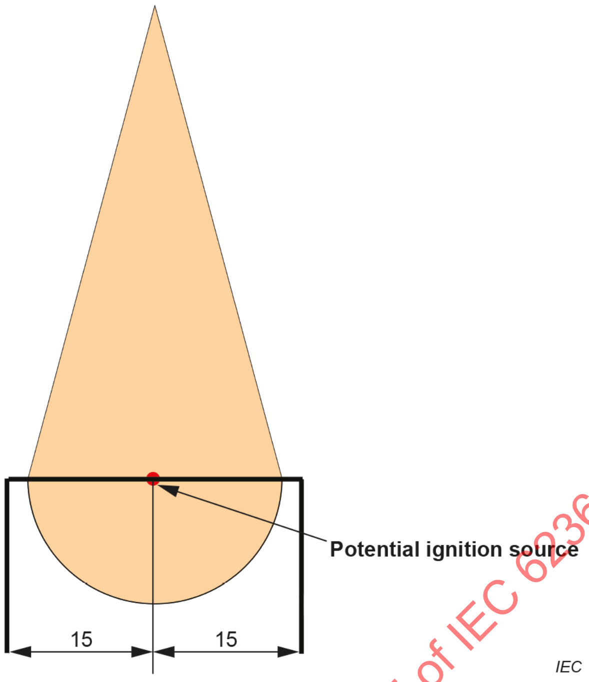
– *1 mm in width regardless of length.*

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 on a horizontal surface or any other surface with an inclination of more than 5 degrees from the vertical (see Figure 40) below a **PIS** located in a PS3 circuit as shown in Figure 42. Openings on other surfaces below a **PIS** located in a PS3 circuit shall be considered side openings and 6.4.8.3.5 applies.

Bottom openings are those openings below a **PIS** located in a PS3 circuit and within 30 mm diameter cylinder extending indefinitely below the **PIS**. With respect to the **potential ignition source**, bottom openings are any openings within the volume of the fire cone with an addition of 2 mm space.

Dimensions in millimetres



NOTE Dimensions of the fire cone are identical to those of 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) comply with a baffle plate construction as illustrated in Figure 43.

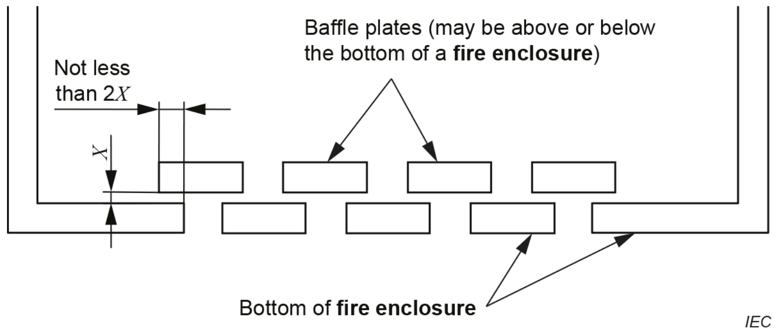


Figure 43 – Baffle plate construction

For **professional equipment** intended for use in environments where **combustible materials** are unlikely to be adjacent to the product (for example, in data centers and server rooms), extended bottom surfaces are considered to be a suitable **fire enclosure** as illustrated in Figure 44 if the bottom surface complies with 6.4.8.3.4.

Dimensions in millimetres

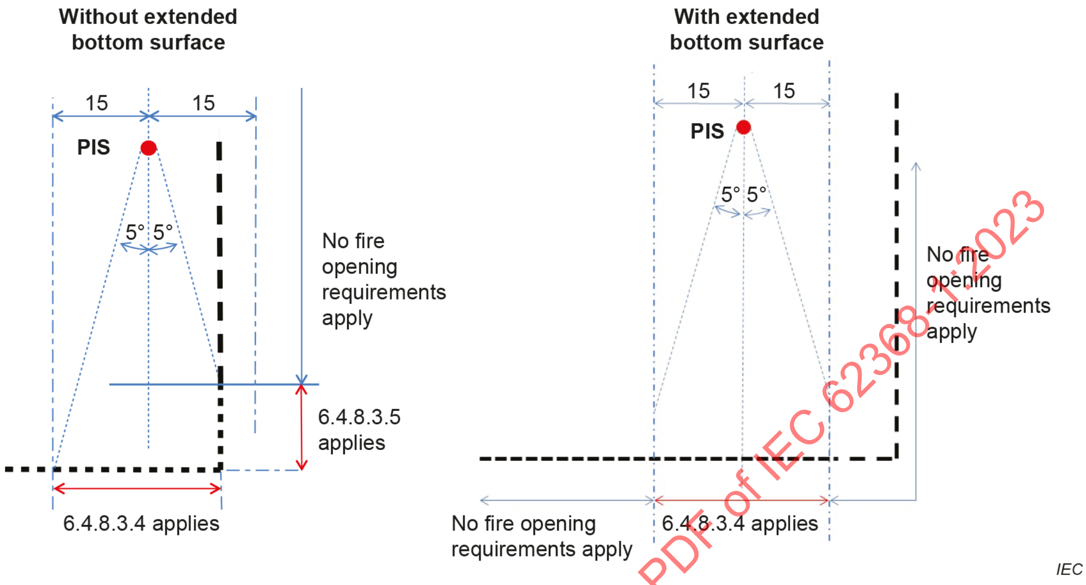


Figure 44 – Application of bottom opening requirements

Fixed equipment intended to be floor standing on a non-combustible surface does not require a **fire enclosure** bottom. Such equipment shall be marked 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: "RISK OF FIRE" or equivalent text

– element 3: optional

– element 4: "Install only on concrete or other non-combustible surface" or equivalent text

6.4.8.3.5 Side openings and side opening properties

Side opening properties of a **fire enclosure** and a fire barrier shall apply to openings that are on a vertical (± 5 °) side surface.

Where a portion of the side of a **fire enclosure** falls within the area indicated by the 5 ° angle in Figure 46, the limitations in 6.4.8.3.4 on sizes of openings in bottoms of **fire enclosures** also apply to this portion of the side.

Side openings that comply with the maximum dimensions as illustrated in Figure 45 are considered to meet the requirements of this subclause without further consideration.

NOTE In this case, the thickness of the side **enclosure** opening acts as a bottom **enclosure** and is sufficient to prevent escape of fire debris (molten metal or burning material).

Thickness of materials to be considered during 5° rule application

- y = maximum side opening vertical dimension
- t = thickness of side **enclosure** material
- d = maximum bottom opening size as specified in 6.4.8.3.4

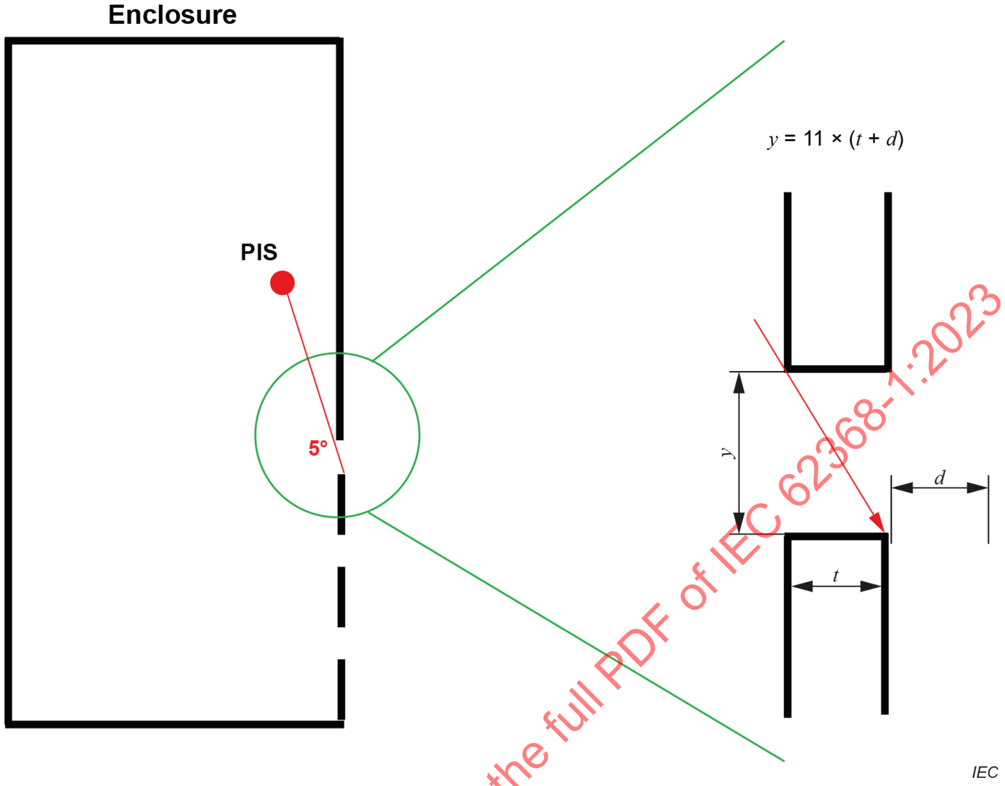
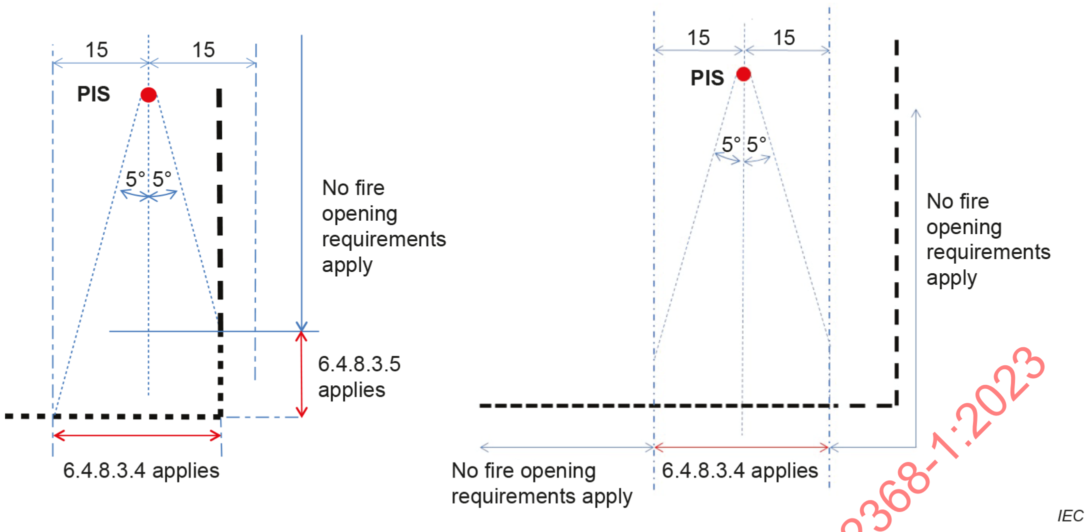


Figure 45 – Application of bottom opening properties to side enclosure material thickness

*Compliance is checked by inspection and measurement. Except for that portion of the side of a **fire enclosure** that is subject to the requirements of 6.4.8.3.5 (see above paragraphs), there are no other considerations for side openings.*

NOTE Limitations affecting the size of side openings are contained in other clauses of this document.

Dimensions in millimetres



The **PIS** can be either a point, a component or a trace on a printed board.

Figure 46 – PIS trajectory downwards

6.4.8.3.6 Integrity of a fire enclosure

If part of a **fire enclosure** consists of a door or cover that can be opened by an **ordinary person**, the door or cover shall comply with requirements a), b), or c):

a) the door or cover shall be interlocked and comply with the **safety interlock** requirements in Annex K.

b) a door or cover, intended to be routinely opened by the **ordinary person**, shall comply with both of the following conditions:
   - it shall not be removable from other parts of the **fire enclosure** by the **ordinary person**; and
   - it shall be provided with a means to keep it closed during **normal operating conditions**.

c) a door or cover intended only for occasional use by the **ordinary person**, such as for the installation of accessories, may be removable provided that instructions for correct removal and reinstallation of the door or cover are given in accordance with F.4.

6.4.8.3.7 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. Conditions 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** is made of **V-0 class material**; or

– the fire barrier is made of **V-0 class material** or **VTM-0 class material**.

6.4.9 Flammability of an insulating liquid

An **insulating liquid**:

- shall have an auto ignition temperature not less than 300 °C as determined in accordance with ISO 871 or similar national standard (for example ASTM E659-84); and
- shall not flash; or shall have a flashpoint higher than 135 °C determined in accordance with ISO 2719 using Pensky-Martens closed cup method (or a national standard, for example ASTM D93); or by the Small Scale closed cup method in accordance with ISO 3679 (or national standards, for example ASTM D3828 and ASTM D3278).

The temperature of components in contact with the **insulating liquid** shall not exceed the flashpoint of the **insulating liquid**.

Compliance is checked by the available data or by inspection and tests as applicable.

6.5 Internal and external wiring

6.5.1 General requirements

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

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.

NOTE Wire complying with UL 2556 VW-1 is considered to comply with these requirements.

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.

6.5.2 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 **normal operating conditions** or external load conditions. 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 to **external circuits** shall have their output power limited to values that reduce the likelihood of ignition within building wiring during **normal operating conditions** and external fault conditions.

External circuits, such as those described in Table 13, ID 1a, 1b, 1c and 2, shall have the current limited to 1,3 A RMS or DC when they are intended to provide power over a paired conductor cable having a minimum wire diameter of 0,4 mm.

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 by test, inspection and by the requirements of Annex Q.

6.5.3 Internal wiring for socket-outlets

Internal wiring for socket-outlets or appliance outlets providing **mains** power to other equipment shall have a nominal cross-sectional area at least as specified in Table G.7, including the condition of footnote [a].

Compliance is checked by inspection.

6.6 Safeguards against fire due to the connection of additional equipment

The power delivered via communication ports to connected equipment or accessories shall be limited to PS2, unless it is likely that the connected equipment or accessories also comply with 6.3, 6.4 and 6.5.

This requirement does not apply to the audio output of **audio amplifiers**.

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

NOTE 2 The classification of other possible **hazardous substances** not addressed in Clause 7 is not covered by this document. In many regions of the world different legislation applies, such as Restriction of Hazardous Substances Directive (RoHS) and Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).

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 4.4.3, 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 or personal protective equipment (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.

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 34.

Table 34 – 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 can be painful	Can cause injury [c]
2	Moving parts	Does not cause pain or injury [b]	Does not cause injury [b] but can be painful	Can cause injury [c]
3a	Plastic fan blades [a] See Figure 48	$\frac{N}{15\,000}+\frac{K}{2\,400}\leq 1$	$\frac{N}{44\,000}+\frac{K}{7\,200}\leq 1$	> MS2
3b	Other fan blades [a] See Figure 47	$\frac{N}{15\,000}+\frac{K}{2\,400}\leq 1$	$\frac{N}{22\,000}+\frac{K}{3\,600}\leq 1$	> MS2
4	Loosening, exploding or imploding parts	NA	NA	See [d]
5	Equipment mass [f]	≤ 7 kg	≤ 25 kg	> 25 kg
6	Wall/ceiling or other structure mount [f]	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, according to experience and/or basic safety standards, a doctor or hospital emergency attention is not needed.

[c] The phrase "Can cause injury" means that, according to experience and/or basic safety standards, a medical doctor or hospital emergency attention can 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 may only be used if the manufacturer's instructions state that the equipment is only suitable for mounting at heights ≤ 2 m.

[f] Mass of supplies, **consumable materials**, media or the like that can be contained in the equipment shall be included in the calculation of the equipment mass. The additional mass of such items is determined by the manufacturer.

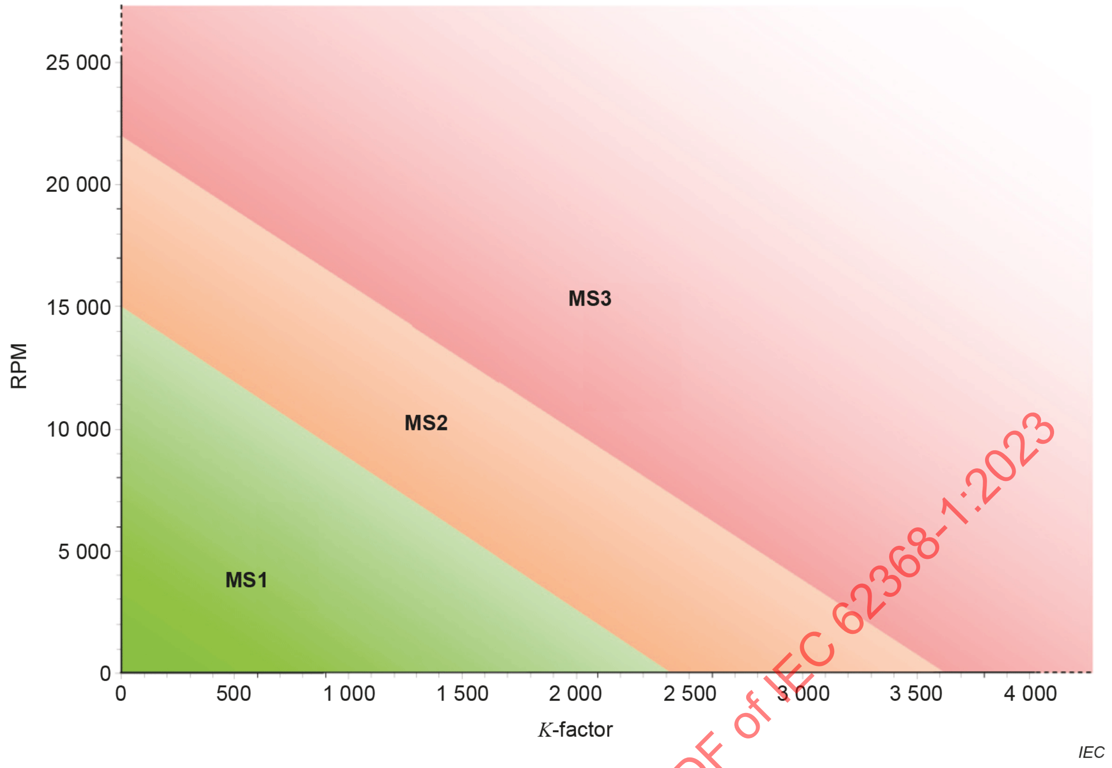


Figure 47 – Limits for moving fan blades made of non-plastic materials

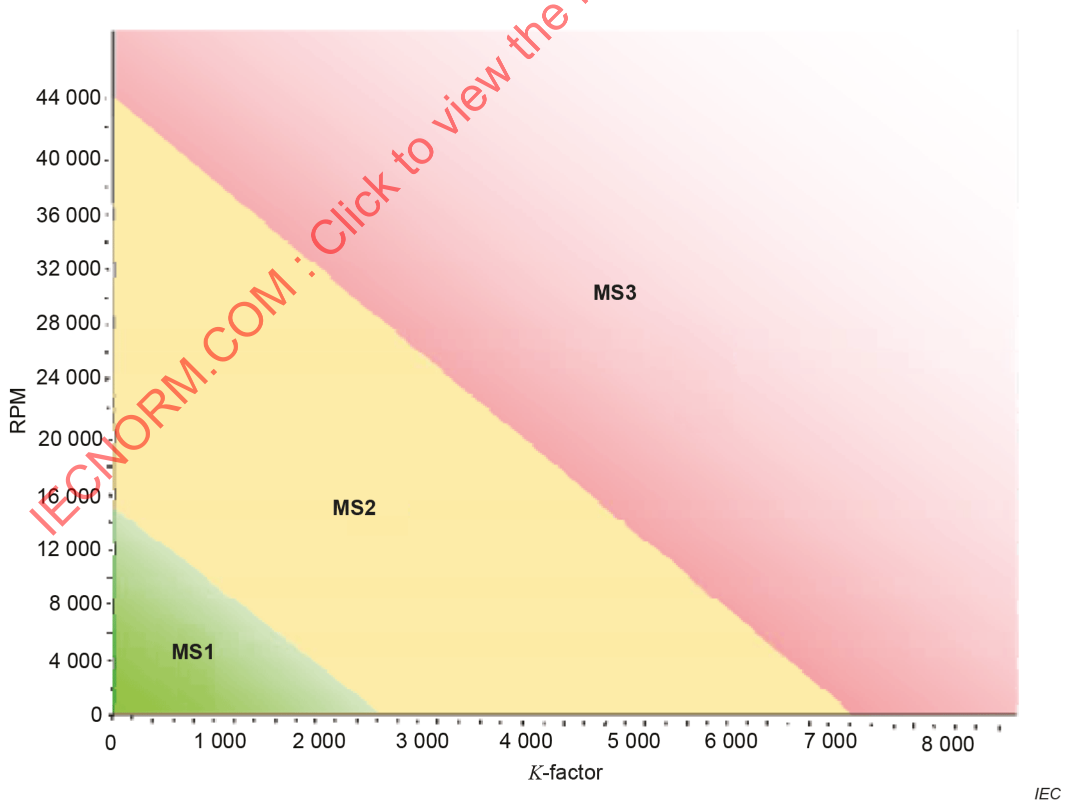


Figure 48 – Limits for moving fan blades made of plastic materials

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 34, line 1.

Where a sharp edge or corner classified as MS2 or MS3 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 can start moving due to unexpected resetting of a control **device**) are specified below.

Plastic fan blades are classified according to Table 34, line 3a. Other fan blades are classified according to Table 34, line 3b. Other moving parts are classified according to Table 34, 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 document may 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**, the energy of the moving part shall be reduced to MS1 before the part is **accessible**.

Unless otherwise specified in this document, 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**, the moving part shall be guarded as much as practicable and an **instructional safeguard** as given in 8.5.2 shall be used.

If a moving MS3 part is required to be **accessible** for the function of the equipment 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
– a manually activated stopping **device** shall be clearly visible and placed in a prominent position within 750 mm of the MS3 part.

  Components of the manually activated stopping **device** shall be of an electromechanical type. A manually activated stopping **device** may consist of:

  • a switch complying with IEC 61058-1 and that meets the requirements of Annex K and that is provided with a latching type mechanism meeting the requirements of IEC 60947-5-5, or
  • an emergency stop **device** in accordance with IEC 60947-5-5.

Restarting of the mechanical system shall only be possible by initiating a start control procedure after the manually activated stopping **device** has been manually reset.

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),

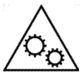
shall have an **instructional safeguard** as given in 8.5.2. Unless the moving part is arranged, located, enclosed or guarded in such a way that the possibility of contact with the moving parts is unlikely, a stopping **device** shall be placed in a clearly visible and prominent position within 750 mm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

8.5.4.1 General

Clause 8.5.4 applies to large self-contained equipment installed in **restricted access areas** (for example, a data centre), typically of such a size that a person can enter completely, or can insert a complete limb or head into areas containing hazardous moving parts and where a person is expected to enter the area to service or operate the equipment.

Equipment covered by this paragraph are automated information mass storage and retrieval systems that use integral hazardous moving parts for the handling of recorded media (for example, tape cartridges, tape cassettes, optical discs, etc.) and similar functions and large printers.

8.5.4.2 Equipment containing work cells with MS3 parts

8.5.4.2.1 Protection of persons in the work cell

During **normal operating conditions**, no MS3 moving parts shall be **accessible** at the outer **enclosure** of a **work cell.**

The equipment shall be provided with **safeguards** to reduce the risk of injury due to MS3 moving parts in the **work cell**. Other class 3 energy sources within a **work cell** shall not be **accessible** under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**.

EXAMPLES **Safeguards** include interlocks, barriers and awareness signals, together with designated procedures and training.

NOTE 1 Some authorities can require installation of fire detection and extinguishing systems in **work cells**.

Access to a **work cell** or any of its compartments shall be protected by either of the following methods:

– Method 1 – **Safety interlock** method. No key or **tool** is needed to gain entry to the **work cell**. **Safety interlocks** meeting the requirements of Annex K shall be provided to prevent access to the **work cell** while power is available to the MS3 moving parts in that compartment. Power to the MS3 moving parts shall not be restored until the doors are closed and latched. Opening of the interlocked access door into any compartment of a **work cell** containing MS3 moving parts, or an access door between a compartment containing MS3 moving parts and one that has been disabled, shall automatically initiate disconnection of the supply to such parts, and to reduce to a class 2 energy source within 2 s for an **instructed person** or a **skilled 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.
– Method 2 – Key or **tool** method. A key or **tool** shall be required to gain and control access to the **work cell**, and access to the **work cell** shall be prevented while power is available to the MS3 moving parts in that **work cell**. The operating and servicing instructions, as appropriate, shall specify that the key or **tool** must be carried by the person while in the **work cell**. When the **work cell** can be entered completely closing of the door without the key or **tool** shall not result in the equipment being restarted automatically.

  NOTE 2 The key or **tool** may be used as the means to remove power before access to the **work cell** or compartment.

Except as permitted in 8.5.4.2.2, it shall not be possible to start or restart the system until all relevant access doors are closed and latched.

Where it is possible to enter a **work cell** completely, an automatically activated mechanical interlock shall be provided so that the door cannot be closed inadvertently if this closure would allow the equipment to be restarted. It shall be possible to open any door from inside the **work cell** without the use of a key or **tool**. The means of opening the door from inside the **work cell** shall be readily identifiable and visible, whether the door is open or closed, irrespective of the operating status of the equipment.

Compliance is checked by inspection.

During servicing of the equipment, there can be a need to energize the equipment to allow for alignment, etc. In such cases, under **single fault conditions** or **abnormal operating conditions**, adequate means shall be provided to limit the movement of the parts so that they do not become MS3, such as by extended travel or by having parts detach and be ejected from the moving assembly. Such means shall be capable of limiting these moving parts to less than MS3 under rated load, maximum speed conditions and at maximum extension.

Compliance is checked by inspection, and, if necessary, by the tests of B.3 and B.4. The ***enclosure*** *or compartment separation barriers shall contain any part that can become detached during the test.*

8.5.4.2.2 Access protection override

8.5.4.2.2.1 General

If it is necessary for a **skilled person** to override a protective mechanisim such as a **safety interlock** for access to a **work cell** or compartment, an override system complying with Clause K.4 shall be provided. In addition, when an override system is used, an emergency stop system shall be provided in accordance with 8.5.4.2.3, and shall comply with the operational endurance requirements of 8.5.4.2.4.

Compliance is checked by inspection.

8.5.4.2.2.2 Visual indicator

A set of two or more bright flashing indicators complying with IEC 60073 shall operate under the following conditions:

a) for a **work cell** or compartment that can be entered completely to indicate the equipment is being restored to normal operation and motion is pending; or

b) for any equipment when the interlock is overridden and drive power is available to MS3 moving parts.

The indicators shall be readily visible at any point within the **work cell** or relevant compartment and at the point of entry. For condition a), the indicators shall operate for a minimum of 10 s prior to movement of a MS3 moving part along the most significant axis. If condition a) can occur while condition b) is in effect, there shall be a change of light sequencing such that the change in status will be obvious to persons in or at the point of entry to the **work cell**.

NOTE The most significant axis is the one with the longest travel distance. This is usually the horizontal (X) axis.

Compliance is checked by inspection and test.

8.5.4.2.3 Emergency stop system

This subclause only applies if a **safety interlock** override is provided as specified in 8.5.4.2.2.

An emergency stop system shall override all other controls, remove drive power from MS3 moving parts and employ automatic braking, if necessary, to cause all these moving parts to stop within a reasonable time period such that a level 3 hazard cannot be contacted.

Components of the emergency stop system shall be of an electromechanical type. An emergency stop control may consist of:

– a switch complying with IEC 61058-1 and that meets the requirements of Annex K and that is provided with a latching type mechanism meeting the requirements of IEC 60947-5-5, or equivalent; or

– an emergency stop **device** in accordance with IEC 60947-5-5.

NOTE In the United Kingdom, an emergency stop system complying with the requirements of IEC 60204-1 and ISO 13850 is applicable where there is a risk of personal injury.

Alternatively, the safety function of the emergency stop system shall have a Safety Integrity Level (SIL) per IEC 62061, or a Performance Level (PL) per ISO 13849-1 that is consistent with the results of a risk assessment of the **work cell**.

Restarting of the mechanical system shall only be possible by initiating a start control procedure after the emergency stop control has been manually reset.

For equipment where a person can completely enter the **work cell**, the emergency stop system shall include a minimum of two emergency stop controls, one outside the **work cell** and one within the **work cell**. The system start up procedure shall include a non-hazardous method to ensure no person is present in the **work cell**. If it can be shown, after application of the single fault tests specified in 8.5.4.2.4 to the movement control circuitry or other sensing means, that such tests do not by-pass the non-hazardous start up procedure, the emergency stopping distance test of this subclause is not required.

For equipment where a person can only partially enter a **work cell** or compartment, a minimum of one emergency stop control shall be provided outside of the **work cell**. The emergency stop system shall be operable by the person needing to have access to the **work cell**.

An emergency stop control provided outside the **work cell** shall be readily visible and shall be located on the equipment such that the person operating it can see if the **work cell** is occupied. The installation instructions shall require that space be provided around the control so that an **instructed person** or **skilled person** can easily reach and activate it.

An emergency stop control provided inside the **work cell** shall be readily accessible from anywhere inside the **work cell** and shall be provided with lighting to permit easy identification. It shall consist of a red palm or mushroom head button or be provided with an indirect arrangement, such as an easily identifiable red safety cable, that activates the emergency stop system.

Compliance is checked by inspection and, if necessary, by the following tests.

While the mechanical system is operating at its maximum kinetic energy (carrying maximum load capacity at maximum speed), the emergency stop system shall be activated and the distance to stop measured. The results of the distance measurements shall show that after activation of the emergency stop system, any subsequent motion in any direction would be unlikely to present a risk of injury.

The maximum stopping distance from the point of activation, along the most significant axis, shall be 1 m or less. In addition, if there is an end point along the most significant axis beyond which the MS3 moving part does not operate, there shall be at least 150 mm of empty space available between this end point and the nearest fixed mechanical part, intended to provide sufficient space for a person not to be harmed. The requirements of B.3.8 apply.

8.5.4.2.4 Endurance requirements

Except as referenced in 8.5.4.2.3, this subclause only applies when a **safety interlock** override is provided as specified in 8.5.4.2.2, or if any **instructed person** or **skilled person accessible** cable contains ES3 voltages.

Movable cable assemblies are tested to ensure that no mechanical damage occurs that could result in any of the following:

– a malfunction of the **safety interlock** system;
– compromise any compartment separation barriers or **mechanical enclosures**;
– expose a person to other hazards.

If the voltage in these cables and movement control circuitry are ES3, mechanical endurance tests shall be applied to ensure that no electric shock hazard results.

For cables that carry only voltages meeting the requirements for ES1, if it can be shown that single open-circuit or short-circuit fault testing of these cables and movement control circuitry would not result in a hazard, they are exempt from the mechanical endurance tests.

Compliance is checked by inspection and, when necessary, by the following mechanical endurance tests.

The mechanical system, including the means (for example, limit switches) that limit movement during normal operation, are subjected to 100 000 cycles of operation at rated load and maximum speed through the maximum length or rotation of travel permitted by the design.

After the cycling:

- *a mechanical function check (for example, MS3 moving parts to operate electromechanical switches; end of travel mechanical stop, etc.) and a visual inspection, are conducted. Mechanical stops and electromechanical switches shall perform as intended. There shall be no evidence of loss of mechanical integrity. All safety-related functions (including emergency stop systems, and the like, as applicable) shall operate normally; and*
- *the assembly cables that control the MS3 moving parts, other than those containing only ES1, are examined for damage that exposes conductors carrying greater than ES1. No conductor shall be broken and no individual strands shall have penetrated the insulation. If damage cannot be determined by inspection, the cable assembly shall pass an electric strength test of 1 000 V, in accordance with 5.4, applied between the conductors carrying greater than ES1 and foil wrapped around the body of the cable.*

8.5.4.3 Equipment having an electromechanical device for destruction of media

8.5.4.3.1 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.

EXAMPLES Equipment that includes household use and home-office use document shredding and similar media destruction **devices**, as determined by the nature of their power source.

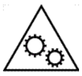
With the exception of industrial equipment or equipment for use in a **restricted access area**, other equipment for use in locations where children are not likely to be present shall have a statement in accordance with Clause F.4.

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 4.4.5, 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.

8.5.4.3.2 Instructional safeguards against moving parts

For equipment installed where children can 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

8.5.4.3.3 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 can 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.

8.5.4.3.4 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.*

8.5.4.3.5 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 4.4.5, 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 34 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, 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, the equipment or lamp assembly is placed on a horizontal surface, and a dark sticky mat (or another adequate method) of adequate size to capture the particles 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 34, 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 35. Where an "x" is given, it means that the test is applicable.

Table 35 – Overview of requirements and tests

Equipment type		Type of test				
		Static stability	**Downward force**	**Relocation**	**Glass slide** [b]	**Horizontal force**
		8.6.2.2	**8.6.2.3**	**8.6.3**	**8.6.4**	**8.6.5**
MS1	All equipment	No stability requirements				
MS2	Floor standing			x		
	Non-floor standing	x				
	Controls or display [a]	x			x	
	Fixed equipment	No stability requirements				
MS3	Floor standing	x	x	x		
	Non-floor standing	x				
	Controls or display [a]	x			x	x
	Fixed equipment	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 can be **accessible** to children.

[b] The glass slide test is not applicable to floor standing equipment, even though the equipment can have controls or a display.

Where thermoplastic materials have an influence on the stability of the equipment, 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 text
- element 3: "The television set may fall, causing serious personal injury or death" or equivalent text
- element 4: the text below or equivalent text

A television set can fall, causing serious personal injury or death. Many injuries, particularly to children, can be avoided by taking simple precautions such as:

– ALWAYS use cabinets or stands or mounting methods recommended by the manufacturer of the television set.
– ALWAYS use furniture that can safely support the television set.
– ALWAYS ensure the television set is not overhanging the edge of the supporting furniture.
– ALWAYS educate children about the dangers of climbing on furniture to reach the television set or its controls.
– ALWAYS route cords and cables connected to your television so they cannot be tripped over, pulled or grabbed.
– NEVER place a television set in an unstable location.
– NEVER place the television set on tall furniture (for example, cupboards or bookcases) without anchoring both the furniture and the television set to a suitable support.
– NEVER place the television set on cloth or other materials that can be located between the television set and supporting furniture.
– NEVER place items that might tempt children to climb, such as toys and remote controls, on the top of the television or furniture on which the television is placed.

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 that are **accessible** to 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 35.

8.6.2.2 Static stability test

The equipment shall be subjected to one of the following tests:

– *the equipment is tilted in all directions such that the base of the equipment is at an angle up to and including 10°; or*
– *the equipment is placed on a plane at an angle of 10° from the horizontal and rotated slowly through an angle of 360° about its normal vertical axis; or*
– *the equipment is placed on a horizontal non-skid surface and subjected to a force equal to:*

- *50 % of the weight of the unit vertical downwards, but not more than 100 N. If, during the test, the supporting surface prevents the equipment from overturning, the test shall be repeated such that the supporting surface is not used to pass the test; and*
- *13 % of the weight in all horizontal directions but not more than 250 N,*

  that is applied to the worst case positions on the equipment by means of a suitable test apparatus having a flat surface of approximately 125 mm by 200 mm, 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.

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.

EXAMPLE 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

8.6.3.1 Requirements

Equipment shall be stable when it is being relocated. Equipment shall:

– be equipped with wheels having a minimum diameter of 100 mm; or

– comply with the test of 8.6.3.2.

8.6.3.2 Test method and compliance criteria

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.

The equipment shall not tip over during the test.

8.6.4 Glass slide test

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 shall 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 20 % of the weight of the equipment or 250 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, ceiling or other structure

8.7.1 Requirements

Classification of equipment for the purposes of assessing mounting means for attachment to a wall, ceiling or other fixed structure (for example, a pole or tower) is done according to Table 34, line 6.

For MS2 or MS3 equipment:

– If the manufacturer defines specific mounting means, the combination of the mounting means 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 define specific mounting means, but the equipment is provided with any part (for example, a hook or threaded hole) which facilitates attaching such mounting means 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, ceiling or other structure.

8.7.2 Test methods

If the construction involves thermoplastic materials that have an influence on the strength of the mounting system, 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.

Afterwards, for equipment mounted to a wall or another structure, a horizontal force of 50 N is applied laterally for 1 min.

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 individual representative point in the mounting system, one at a time, shall be subjected to the following six test forces:

– *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°.*
– *an inward directed push force parallel to its centre axis for 1 min.*
– *an outward directed pull force parallel to its centre axis for 1 min.*

Test 3

If the mounting system design relies upon threaded parts, each threaded part, one at a time, shall be subjected to the following test.

The screw is tightened with a torque according to Table 36 and then loosened, for a total of 5 times. The torque shall be applied gradually.

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 is recommended in the user instructions, any screw with the same diameter shall be used for the test.

Table 36 – 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. Threaded parts shall remain mechanically intact.

8.8 Handle strength

8.8.1 General

A part of the equipment used for lifting or carrying the equipment, regardless of its shape or location or whether the part is intended for lifting or carrying by hand or via mechanical means, is considered to be a handle and shall have adequate strength.

The equipment is classified according to Table 34, 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 can be carried.

Compliance is checked by inspection or by available data, or, where necessary, by the test of 8.8.2. 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.*

8.8.2 Test method

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; and*
– *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.

8.9 Wheels or casters attachment requirements

8.9.1 General

The equipment is classified according to Table 34, line 5. When equipment is intended to be used with carts, stands and similar carriers provided with wheels or casters, the classification is applied using the combined mass.

The likelihood of MS3 equipment, including carts, stands and similar carriers that support the equipment, from tipping over during movement shall be reduced.

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 shall 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 34, 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 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 shall 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 shall 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 shall 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 impact shall be applied to any part of the cart or stand and the test method shall be as described in Clause T.6. However, a cart, stand or carrier made of glass shall instead be tested according to 4.4.3.6.

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 slide-rail mounted equipment (SRME)

8.11.1 General

This subclause specifies requirements for horizontally mounted slide-rails to reduce the likelihood of injury by retaining the SRME in a stable position and not allowing the slide-rails to buckle, the 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 any of the following:

- equipment **subassemblies**;
- other equipment fixed in place in the rack;
- 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 shall be done according to Table 34, 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 with a single extended position shall comply with the downward force test of 8.11.3.1 in the extended position.

Slide rails having a service position and an installation position shall comply with the downward force test of 8.11.3.1 in the service position.

All slide rails shall comply with the tests of 8.11.3.2 and 8.11.3.3 in both the service position and the installation position.

Following each test, the slide-rails and the SRME may be replaced before conducting the next test.

A multi position slide rail shall not extend automatically to any of the extended positions. The SRME shall only be able to go to the service position when pulled out. A latch or other means shall be provided to stop the SRME in the service position. Any service position and installation position shall be explained. An **instructional safeguard** shall be provided for the installer. The elements of the **instructional safeguard** shall be as follows:

– element 1a: not available
– element 2: Stability hazard
– element 3: "The rack may tip over causing serious personal injury"
– element 4: the text below or equivalent text

Before extending the rack to the installation position, read the installation instructions. Do not put any load on the slide-rail mounted equipment in the installation position. Do not leave the slide-rail mounted equipment in the installation position.

8.11.3 Mechanical strength test

8.11.3.1 Downward force test

With the SRME in its extended position, a force in addition to the weight of the SRME shall be applied downwards through the centre of gravity for 1 min.

The additional force applied to the SRME shall be equal to the greater of the following two values, with a maximum of 800 N:

– *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 may be added to the shelf.

8.11.3.2 Lateral push force test

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 does not necessarily have to 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.

8.11.3.3 Integrity of slide rail end stops

To test the integrity of the end stops, a 250 N static pull force is applied at the front of the fully extended rail on the SRME for a period of 1 min, in an attempt to cause the SRME to come off the slide-rail. The SRME is then returned to the (installed) use position and then placed back in the fully extended position. The test is performed 10 times.

8.11.4 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 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 that is likely to be available in locations where children can be present, shall be provided with a means to reduce the risk of injury due to a sharp point or edge at the end of the antenna.

The following is considered to comply:

– *the end piece has no sharp edges or points; or*

– *a minimum 6,0 mm diameter button or ball is provided 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, **accessible** parts shall be classified and when necessary provided with the **safeguards** specified in Clause 9.

NOTE Electric burns due to radio frequency (RF) energy sources are a special case in this document. 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 TS1

TS1 is a class 1 thermal energy source where temperature level:

– does not exceed the TS1 limits under **normal operating conditions**; and
– does not exceed the TS2 limits under:
  - **abnormal operating conditions**; and
  - **single fault conditions**.

9.2.2 TS2

TS2 is a class 2 thermal energy source where the temperature level:

– exceeds the TS1 limits; and
– does not exceed the TS2 limits under**:**
  - **normal operating conditions**,
  - **abnormal operating conditions** and
  - **single fault conditions**.

Except for devices worn on the body in direct contact with the skin, where the malfunction of the equipment is evident, no limits apply.

9.2.3 TS3

TS3 is a class 3 thermal energy source where the temperature exceeds the TS2 limits in Table 37 under **normal operating conditions**, under **abnormal operating conditions**, or under **single fault conditions**.

9.3 Touch temperature limits

9.3.1 Requirements

Except as noted below, touch temperatures of **accessible** parts shall comply with Table 37.

An **accessible** part that, while in contact with the body, is likely to drop in temperature upon touch may be evaluated under the limits of Annex A in IEC Guide 117:2010. An appropriate and reproducible test methodology is determined by the manufacturer with due regard to the test method in IEC Guide 117.

9.3.2 Test method and compliance criteria

The temperature tests are run with the room ambient conditions as defined in B.1.5, except that the room ambient temperature shall be 25 °C ± 5 °C.

If the test is performed at a temperature between 20 °C and 25 °C, the results are adjusted to reflect a value of 25 °C.

NOTE 1 For an explanation of why the test is done at 25 °C without adjusting results for higher ambient temperatures, see IEC TR 62368-2.

The equipment shall be operated in a manner the manufacturer determines likely to result in elevated thermal conditions of ***accessible*** *surfaces and parts.*

NOTE 2 It is possible that this is not 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.*

Table 37 – Touch temperature limits for accessible parts

	Accessible parts [b]	Maximum temperature (T_{max}) °C			
		Metal [d]	**Glass, porcelain and vitreous material**	**Plastic and rubber**	**Wood**
TS1	**Devices** worn on the body (in direct contact with the skin) in normal use (> 8 h) [e]	43 to 48	43 to 48	43 to 48	43 to 48
	Handles, knobs, grips, etc., and surfaces either held or touched in normal use (> 1 min and < 8 h) [a]	48	48	48	48
	Handles, knobs, grips, etc., and surfaces held for short periods of time or touched occasionally (> 10 s and < 1 min)	51	56	60	60
	Handle, knobs, grips etc., and surfaces touched occasionally for very short periods (> 1 s and < 10 s) [f]	60	71	77	107
	Surfaces that do not have to be touched to operate the equipment (< 1 s)	70	85	94	140
TS2	**Devices** worn on the body (in direct contact with the skin) in normal use (> 8 h) [e]	43 to 48	43 to 48	43 to 48	43 to 48
	Handles, knobs, grips, etc., and surfaces held in normal use (> 1 min) [a]	58	58	58	58
	Handles, knobs, grips, etc., and surfaces held for short periods of time or touched occasionally (> 10 s and < 1 min)	61	66	70	70
	Handle, knobs, grips etc., and surfaces touched occasionally for very short periods (> 1 s and < 10 s) [f]	70	81	87	117
	Surfaces that does not have to be touched to operate the equipment (< 1 s)	80 (100) [c]	95 (100) [c]	104	150
TS3	Higher than the TS2 limits				

[a] Examples of these surfaces include a telephone handset, a mobile phone or another handheld **device**, and the palm rest surface of a notebook computer. Limits for > 1 s and < 10 s may be used for local hotspots where touching can be easily avoided by changing the way the **device** is held.

[b] Where necessary, time of contact shall be determined by the manufacturer and shall be consistent with the intended use in accordance with the equipment instructions.

[c] The values in parentheses may be used for the following areas and surfaces:

– an area on the surface of the equipment that has no dimension exceeding 50 mm, and that is 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 surfaces of the equipment, an **equipment basic safeguard** is required.

[d] For metal parts that are covered with plastic or rubber material of at least 0,3 mm thick, the covering is considered suitable for use as a **safeguard** and the temperature limit of plastic and rubber is allowed.

[e] Examples include portable lightweight **devices** such as watches, headsets, personal music players and sports monitoring equipment. For larger **devices** or **devices** in direct contact with vital areas of the face (e.g. the airways), lower limits may apply. For contact durations less than 8 hours based on its intended normal use, apply limits between 48 °C/1 min and 43 °C/8 h. Calculations shall be rounded down to the nearest whole number. An example is a headset with a limited **battery** charge of 2 h.

[f] Examples include surfaces that do not have to be touched for disconnection.

9.4 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 9.5.2 may be used as the **basic safeguard**.

Accessible parts (internal and external) classified as TS3 that require heat for the intended function (for example, a document laminator, thermal print head, fuser heater, etc.) shall comply with all of the following:

– the part does not need to be touched to operate the equipment (for example, a part also serving a handle, knob, or grip function);
– it is unlikely that an **ordinary person** will touch the part intentionally under **normal operating conditions**;
– unintentional contact with the part is unlikely by an **ordinary person** during maintenance not involving the part;
– the part is provided with an **instructional safeguard** on or near the part in accordance with 9.5.2; and
– it is unlikely that the part will be touched by children.

For protection of a **skilled person**, parts and surfaces classed TS3 shall be provided with an **equipment safeguard** or provided with an **instructional safeguard** so that unintentional contact with such parts and surfaces during service operations is unlikely to cause the **skilled person** to recoil into other class 3 energy sources (see Figure 19).

9.5 Requirements for safeguards

9.5.1 Equipment safeguard

An **equipment safeguard** shall limit the transfer of thermal energy (source temperature) under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** or limit accessibility to a thermal energy source to a touch temperature as classified in Table 37.

Temperature limits are applied only for those **abnormal operating conditions** or **single fault conditions** where the equipment continues to operate as intended and, hence, the **abnormal operating condition** or **single fault condition** is not obvious. If a malfunction is evident, then the limits are not applicable.

9.5.2 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 text
– element 3: optional
– element 4: "Do not touch" or equivalent text

9.6 Requirements for wireless power transmitters

9.6.1 General

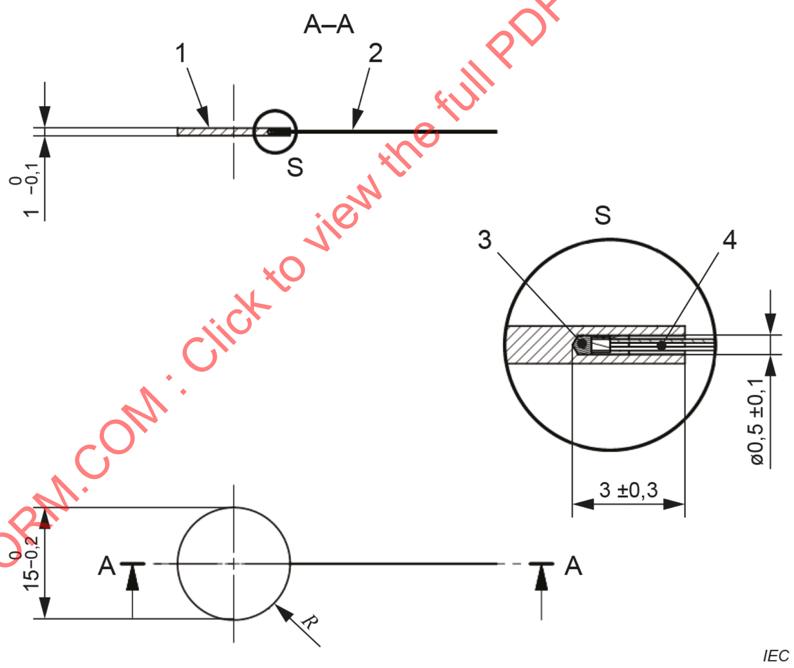
Wireless power transmitters for near field wireless power transfer can warm up foreign metallic objects that can be placed close to or on such a transmitter. To avoid a burn due to high temperatures of the foreign metallic objects, the transmitter is tested as specified in 9.6.3. This requirement applies to wireless power transmitting **devices** that have a substantially flat surface allowing for sufficient contact with both the foreign object and the receiver for engaging near field magnetic induction from its primary coil to a secondary coil that is part of the power receiving **device**.

9.6.2 Specification of the foreign objects

The following foreign objects are used:

– a steel disc, see Figure 49;
– an aluminium ring, see Figure 50; and
– an aluminium foil, see Figure 51.

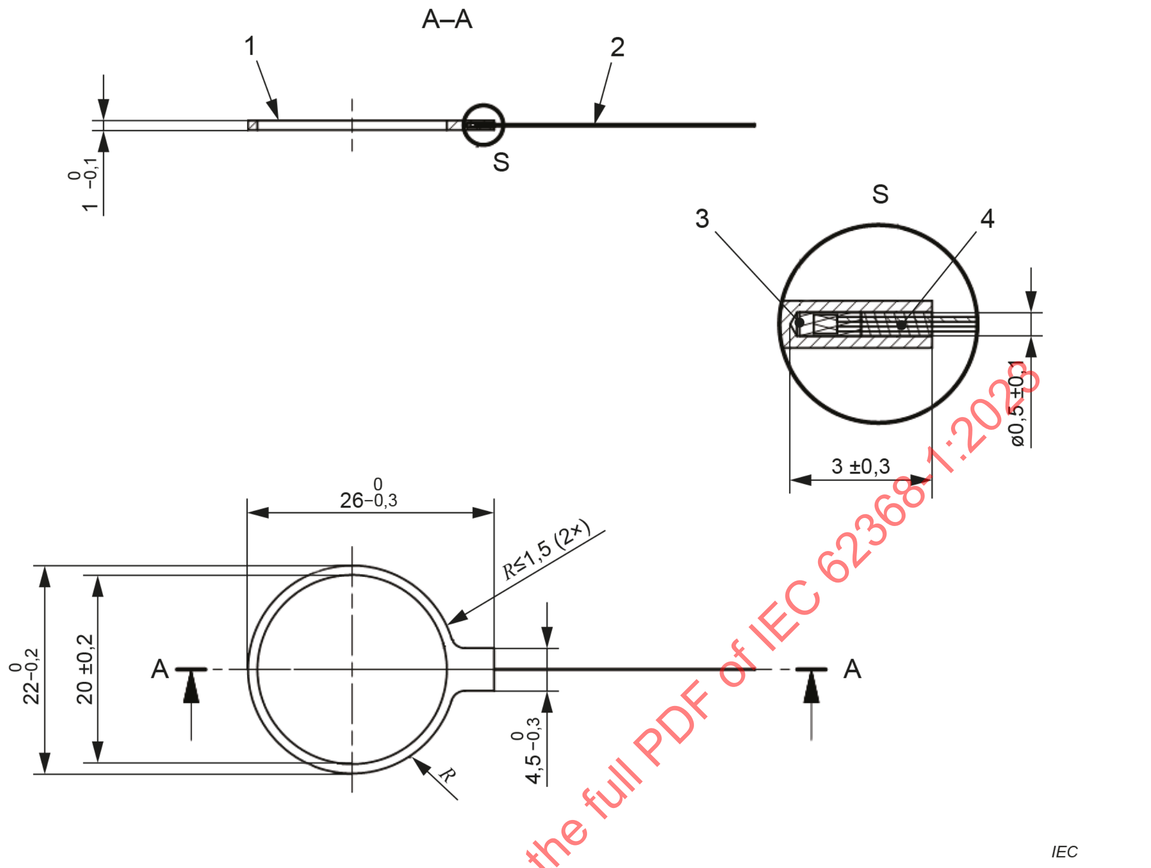
Dimensions in millimetres



No	Name	Remarks
1	Disc	Steel 1,1011/ RFe 160
2	Thermocouple	Any suitable type
3	Heatsink compound	Heat transport
4	Silicone tubing	Strain relief

Figure 49 – Steel disc

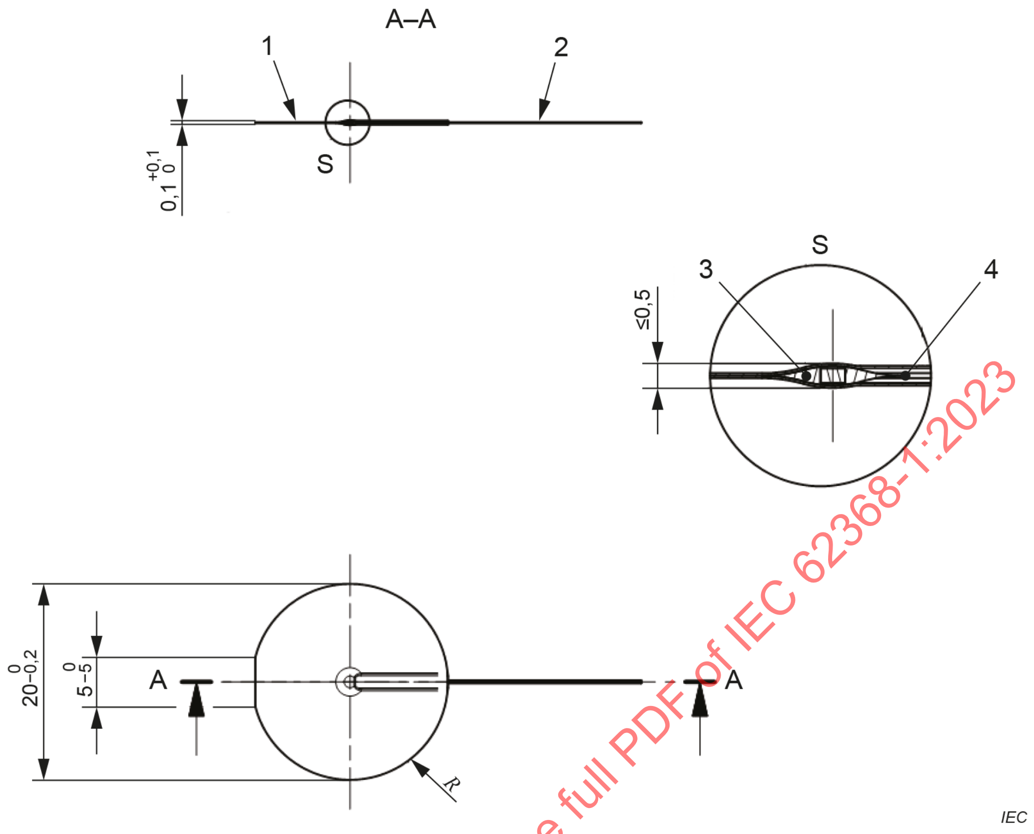
Dimensions in millimetres



No	Name	Remarks
1	Ring	Aluminium (for example AlSiIMg1Mn 100 Hv)
2	Thermocouple	Any suitable type
3	Heatsink compound	Heat transport
4	Silicone tubing	Strain relief

Figure 50 – Aluminium ring

Dimensions in millimetres



No	Name	Remarks
1	Foil	Al 99,5 %
2	Thermocouple	Any suitable type
3	Heatsink compound	Heat transport
4	Silicone tubing	Strain relief (or use of glue layer on the foil)

Figure 51 – Aluminium foil

9.6.3 Test method and compliance criteria

The ***wireless power transmitter*** *is placed in a room under the temperature conditions as specified in 9.3.2.*

The test consists of two parts (part A and part B). During each part, the center of the receiver coil shall be aligned with the center of the transmitter coil. The tests that are performed at a distance normally require the use of 2,0 ± 0,5 mm and 5,0 ± 0,5 mm thick spacers. The frame (if used) and spacer may be integrated.

The transmitter is operated to transmit its maximum power. In order to facilitate securement of the foreign objects, transmitter and receiver, a reliable method shall be used. Reliable methods may be:

– *a frame having:*
  - *a heat resistant material, for example polyether ether ketone (PEEK);*
  - *outer dimensions that secure the transmitter and receiver; and*
  - *a cut-out to receive a foreign object and the attached thermocouple; or*
– *a tape that is capable of maintaining adhesion throughout the test; or*

– *another way to secure the alignment throughout the test; or*

– *a combination of the above.*

During each cycle, the foreign object shall be moved on the transmitter to determine the highest temperature.

Part A: The test is performed by powering up the transmitter and then placing each of the foreign objects specified in 9.6.2 in direct contact with the transmitter. This part has four cycles:

– *one without a receiver present and with the foreign object in direct contact with the transmitter; and*

– *one with a receiver placed in direct contact with the foreign object; and*

– *one with a receiver placed at a vertical distance of 2 mm from the foreign object; and*

– *one with a receiver placed at a vertical distance of 5 mm from the foreign object.*

Part B: The test is repeated by first placing each of the foreign objects specified in 9.6.2 in direct contact with the transmitter and then powering up transmitter. The four cycles of Part A are then repeated.

During the tests of both part A and part B:

– *the temperature of the foreign object shall not exceed 85 °C for the steel disk, 120 °C for the aluminium ring and 155 °C for aluminium foil; and*

– *the temperature of the transmitter shall not exceed the TS2 limits specified in Table 37.*

10 Radiation

10.1 General

To reduce the likelihood of painful effects and injury due to optical energy(visible, IR, UV), 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 38.

Table 38 – Radiation energy source classifications

Source		RS1	RS2	RS3
Lasers	optical fibre communication systems (OFCS)	According to IEC 60825-2		
	free space optical communication systems for transmission of information	According to IEC 60825-12		
	Other lasers, except those used in image projectors	According to IEC 60825-1:2014 [a]		
Lamps and lamp systems (including LEDs), except those used in image projectors		According to IEC 62471:2006 [b]		
Image projectors (beamers)	Image projectors with lasers	According to IEC 60825-1:2014 [a] or IEC 62471-5:2015 if applicable		
	Image projectors with lamps or LEDs	According to IEC 62471-5:2015		
X-Ray		≤ 36 pA/kg at 50 mm [c]	≤ 185 pA/kg at 100 mm [d]	> RS2
PMP acoustic maximum sound pressure [e]	sound output	≤ 85 dB(A)	≤ 100 dB(A)	> RS2
	analogue output	≤ 27 mV	≤ 150 mV	> RS2
	digital output	≤ –25 **dBFS**	≤ –10 **dBFS**	> RS2
PMP acoustic maximum dose exposure [e]	sound output	100 % CSD = ≤ 80 dB(A) / 40 h	≤ 100 dB(A)	> RS2
	analogue output	≤ 15 mV	≤ 150 mV	> RS2
	digital output	≤ –30 **dBFS**	≤ –10 **dBFS**	> RS2

[a] Additional considerations for laser products designed to function as conventional lamps (such as laser image projector), see Note 2 of 10.3.

NOTE 1 For example, in IEC 60825-1:2014, Class 1, Class 1C, Class 1M, Class 2, Class 2M, Class 3R, Class 3B and Class 4 are defined. These are not classifications of radiation energy source itself.

[b] To classify the risk group, **abnormal operating conditions** and **single fault conditions** shall be taken into account.

In general, the radiation of the following low power application of a lamp is classified as Exempt Group. Also, classification according to IEC 62471 (all parts) is not required for:

– 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;

– UV radiation from general purpose incandescent and fluorescent lamps, with ordinary glass envelopes; and

– other similar low power **devices**.

NOTE 2 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 according to the maintenance instructions (CRT exposed) at the maximum test voltage applicable and under the conditions as specified below.

NOTE 3 In the member countries of CENELEC, the amount of ionizing radiation is regulated by European Directive 2013/59/Euratom.

NOTE 4 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; or

– 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 shall be simulated.

NOTE 5 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; or

– 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.

[e] Measurements during **single fault conditions** are not required for listening **devices** and personal music players.

10.2.2 RS1

For X-radiation sources, 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 acoustic radiation sources, RS1 is a class 1 radiation energy source that does not exceed RS1 limits under:

– **normal operating conditions**; and
– **abnormal operating conditions**.

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

Equipment containing laser(s) shall comply with the requirements as indicated in Table 38.

When applying the IEC 60825 series, the requirements of this document shall be considered, in particular those for:

– the robustness of a **safeguard** (see 4.4.3);
– operating conditions (see Annex B); and
– **safety interlocks** (see Annex K).

Laser equipment intended for use by an **ordinary person** or an **instructed person** shall not be Class 3B or Class 4.

NOTE 1 National and regional legislation regarding occupational safety and health (OSH) and regarding the general public, for example for consumer products, can contain additional or different requirements.

NOTE 2 For laser products designed to function as conventional lamps (such as laser image projector), see 4.4 of IEC 60825-1:2014. For additional consideration for such equipment, see 10.4.

Compliance is checked by evaluation of available data sheets, by inspection and, if necessary, by measurement.

NOTE 3 For guidance on measuring techniques, see the IEC 60825 series.

10.4 Safeguards against optical radiation from lamps and lamp systems (including LED types)

10.4.1 General requirements

Equipment emitting optical radiation shall comply with the requirements as indicated in Table 38.

The requirements of 10.4 do not apply to electronic light effect equipment. However, proper installation instructions shall be provided.

For lamps used in other equipment, the following applies:

Radiation not needed to be **accessible** for the correct functioning of the equipment shall not exceed the level specified in Table 39. When the **accessible** radiation level for the correct functioning of the equipment needs to exceed the levels in Table 39, the equipment shall be provided with an **instructional safeguard** in accordance with 10.4.3.

NOTE National legislation regarding occupational safety and health (OSH) can contain additional or different requirements.

Table 39 – Allowable radiation level according to IEC 62471 for each hazard type

Hazard type	Wavelength	Allowed radiation level
Ultraviolet hazard	200 nm to 400 nm	Exempt Group
Retinal blue light hazard	300 nm to 700 nm	Exempt Group or Risk Group 1
Retinal thermal hazard	380 nm to 1 400 nm	Exempt Group or Risk Group 1
Cornea/lens infrared hazard	780 nm to 3 000 nm	Exempt Group
Retinal thermal hazard, weak visual stimulus	780 nm to 1 400 nm	Exempt Group

Lamps and lamp systems intended for use by an **ordinary person** or an **instructed person** shall not emit Risk Group 3 energy.

The Risk Group, based on the classification according to IEC 62471 series, shall be marked on the equipment. If the size or design of the product makes marking impractical, the marking shall be included in the packaging and included in the user instructions. If the **accessible** radiation level does not exceed the level specified in Table 39, marking is not required.

If a **safety interlock** is used for reducing the radiation level, it shall reduce the radiation to the allowable radiation levels specified in Table 39.

When equipment emits optical radiation in more than one hazard type, see also 10.4.3.

The following information should be provided in the user manual for safe operation and installation. This information shall also be provided for safe operation by a **skilled person** who can be exposed to Risk Group 3 energy levels.

– Adequate instructions for proper assembly, installation, maintenance and safe use, including clear warnings concerning precautions to avoid possible exposure to hazardous optical radiation; and
– Advice on safe operating procedures and warnings concerning **reasonably foreseeable misuse**, malfunctions and hazardous failure modes. Where servicing and maintenance procedures are detailed, they should, wherever possible, include explicit instructions on safe procedures to be followed; and
– The marking on the equipment should be reproduced in the user manual. A yellow background is not required in the user manual.

10.4.2 Requirements for equipment safeguards

The **enclosure** protecting against optical radiation not needed to be **accessible** for the correct functioning of the equipment and that exceeds the level specified in Table 39 shall comply with 4.4.3 and is considered to be a **reinforced safeguard**.

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 are considered to be resistant to degradation.

10.4.3 Instructional safeguard

For image projectors, the **instructional safeguard** shall comply with the requirements of 6.5.4 and 6.5.5 of IEC 62471-5:2015 for Risk Group 2 and Risk Group 3, respectively.

For image projectors with lamps, the cautionary statement defined in IEC 62471-5:2015 shall be used as an **instructional safeguard**.

For all other equipment with lamps, an **instructional safeguard** in accordance with Clause F.5 shall be used. The elements of the **instructional safeguard** shall be as follows:

– element 1a: the UV radiation symbol , IEC 60417-6040:2010-08 for ultraviolet hazard; or

the visible radiation symbol , IEC 60417-6041:2010-08 for retinal blue light hazard and retinal thermal hazard; or

the IR radiation symbol , IEC 60417-6151:2012-02 for cornea/lens infrared hazard and retinal thermal hazard, weak visual stimulus

– element 2: According to Table 40 or equivalent text

– element 3 and 4: According to Table 41 or equivalent text

The elements 1a and 2 shall be black on a yellow background.

Table 40 – Hazard-related risk group marking of equipment

Hazard	Exempt group	Risk group 1	Risk group 2	Risk group 3
Ultraviolet hazard 200 nm to 400 nm	Not required	NOTICE Ultraviolet emitted from this product	CAUTION Ultraviolet emitted from this product.	WARNING Ultraviolet emitted from this product.
Retinal blue light hazard 300 nm to 700 nm	Not required	Not required	CAUTION Possibly hazardous optical radiation emitted from this product	WARNING Possibly hazardous optical radiation emitted from this product
Retinal thermal hazard 380 nm to 1 400 nm	Not required	Not required	CAUTION Possibly hazardous optical radiation emitted from this product	WARNING Possibly hazardous optical radiation emitted from this product
Cornea/lens infrared hazard 780 nm to 3 000 nm	Not required	NOTICE Infrared emitted from this product	CAUTION Infrared emitted from this product	WARNING Infrared emitted from this product.
Retinal thermal hazard, weak visual stimulus 780 nm to 1 400 nm	Not required	WARNING Infrared emitted from this product	WARNING Infrared emitted from this product.	WARNING Iinfrared emitted from this product.

Table 41 – Explanation of marking information and guidance on control measures

Hazard	Exempt group	Risk group 1	Risk group 2	Risk group 3
Ultraviolet hazard 200 nm to 400 nm	Not required	Minimize exposure to eyes or skin. Use appropriate shielding.	Eye or skin irritation can result from exposure. Use appropriate shielding.	Avoid eye and skin exposure to unshielded product.
Retinal blue light hazard 300 nm to 700 nm	Not required	Not required	Do not stare at operating lamp. Can be harmful to the eyes.	Do not look at operating lamp. Eye injury can result.
Retinal thermal hazard 380 nm to 1 400 nm	Not required	Not required	Do not stare at operating lamp. Can be harmful to the eyes.	Do not look at operating lamp. Eye injury can result.
Cornea/lens infrared hazard 780 nm to 3 000 nm	Not required	Use appropriate shielding or eye protection.	Avoid eye exposure.Use appropriate shielding or eye protection.	Avoid eye exposure. Use appropriate shielding or eye protection.
Retinal thermal hazard, weak visual stimulus 780 nm to 1 400 nm	Not required	Do not stare at operating lamp.	Do not stare at operating lamp.	Do not look at operating lamp.

When equipment emits optical radiation in more than one hazard spectral region, the equipment shall be classified for the most restrictive case. If the optical radiation in any spectral region requires a marking per Table 40 or Table 41, all relevant warnings shall be included. For example, for a lamp assigned to Risk Group 3 on the basis of a retinal IR hazard and emitting UV to the level of Risk Group 2, the legend of the marking shall indicate Risk Group 3, with the appropriate 'Warning' text; and show the 'Caution' text for Risk Group 2 for the UV, but shall not mention Risk Group 2 explicitly, as illustrated in Figure 52.

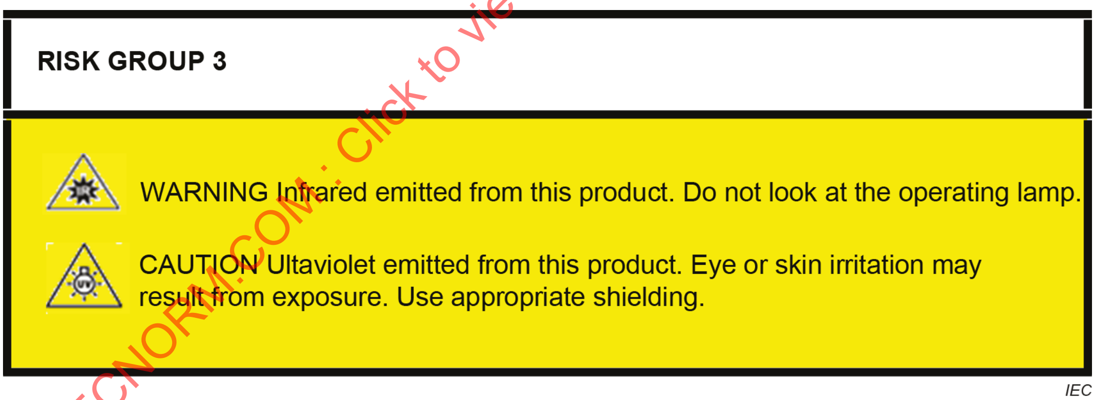


Figure 52 – Example of a warning label for a lamp with multiple hazard spectral regions

10.4.4 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 the relevant part of the IEC 62471 series.

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 shall 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; and*
- *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 (PMP) 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.).

EXAMPLES Portable CD players, MP3 audio players, mobile phones with MP3 type features, PDAs or similar equipment.

Personal music players shall comply with the requirements of either 10.6.2 or 10.6.3.

NOTE 1 Protection against acoustic energy sources from telecom applications is referenced to ITU-T P.360.

NOTE 2 It is the intention of the Committee to allow the alternative methods for now, but to only use the dose measurement method as given in 10.6.3 in the future. Therefore, manufacturers are encouraged to implement 10.6.3 as soon as possible.

Listening **devices** sold separately shall comply with the requirements of 10.6.6.

These requirements are valid for music or video mode only.

For equipment that is clearly designed or intended primarily for use by children, additional limits of the relevant toy standards can 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.

The requirements do not apply to any of the following:

– **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**), and with a proprietary connector between the player and its listening **device**, or where the combination of player and listening **device** is known by other means such as setting or automatic detection, the $L_{\mathrm{Aeq},T}$ acoustic output shall be lower or equal to the relevant RS1 sound output value of Table 38 when playing the fixed "programme simulation noise" described in EN 50332-1.
– for equipment provided with a standardized connector (for example, a 3,5 mm phone jack) that allows connection to a listening **device** for general use, the unweighted RMS output voltage shall be lower or equal to the relevant RS1 analogue output value of Table 38 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a digital output, the output signal shall be lower or equal to the relevant RS1 digital output value of Table 38 when playing the fixed "programme simulation noise" described in EN 50332-1.

NOTE 1 Unless otherwise specified in this document, wherever the term acoustic output is used in 10.6.2, $L_{\mathrm{Aeq},T}$ is the A-weighted equivalent sound pressure level over a 30 s period.

If the player is able to analyse a song, and where the average sound pressure (long term $L_{\mathrm{Aeq},T}$) measured over the duration of the song is lower than the average produced by the programme simulation noise, the output is considered RS1 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 $L_{\mathrm{Aeq},T}$) which is much lower than the average programme simulation noise.

For example, if the player is set with the programme simulation noise to 85 dB(A), but the average sound pressure of the song is only 65 dB(A), the output is considered to be RS1 as long as the average sound level of the song is not above the basic limit of 85 dB(A).

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**), and with a proprietary connector between the player and its listening **device**, or where the combination of player and listening **device** is known by other means such as setting or automatic detection, the $L_{\mathrm{Aeq},T}$ acoustic output shall be lower or equal to the relevant RS2 sound output value of Table 38 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a standardized connector (for example, a 3,5 mm phone jack) that allows connection to a listening **device** for general use, the unweighted RMS output voltage shall be lower or equal to the relevant RS2 analogue output value of Table 38 when playing the fixed "programme simulation noise" described in EN 50332-1.

– for equipment provided with a digital output, the output signal shall be lower or equal to the relevant RS2 digital output value of Table 38 when playing the fixed "programme simulation noise" 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 Requirements for dose-based systems

10.6.3.1 General requirements

Personal music players shall give the warnings as provided below when tested according to EN 50332-3.

The manufacturer may offer optional settings to allow the users to modify when and how they wish to receive the notifications and warnings to promote a better user experience without defeating the **safeguards**. This allows the users to be informed in a method that best meets their physical capabilities and **device** usage needs. If such optional settings are offered, an administrator (for example, parental restrictions, business/educational administrators, etc.) shall be able to lock any optional settings into a specific configuration.

The personal music player shall be supplied with easy to understand explanation of the dose management system and how to use it. The user should be made aware that other sources can significantly contribute to the **sound exposure** (for example work, transportation, concerts, clubs, cinema, car races, etc.).

10.6.3.2 Dose-based warning and automatic decrease

When a dose of 100 % CSD is reached (RS2), and at least at every 100 % further increase of CSD, the **device** shall warn the user and require an acknowledgement. In case the user does not acknowledge, the output level shall automatically decrease to RS1.

NOTE 100 % CSD is based on 80 dB(A) for 40 h.

The warning shall at least clearly indicate that listening above 100 % CSD leads to the risk of hearing damage or loss.

10.6.3.3 Exposure-based warning and requirements

The purpose of the dose-based only requirement is to inform and educate users about safe listening practice.

In addition to dose-based requirements, a system shall therefore either:

– Limit the 30 s integrated exposure level (MEL30) to the relevant RS2 limit of Table 38. The limiter settling time shall be 20 s or faster. The measurement of such limiting functionality is, after allowing the 20 s settling time of the PMP limiter, conducted according to EN 50332-1 or EN 50332-2 as applicable.

– Warn the user in case **momentary exposure level (MEL)** equals or exceeds 100 dB(A). The warning may be given visually or audibly. If the warning is given visually, it shall remain visible for at least 5 s. If the warning is given audibly, it shall interrupt the programme clearly and unmistakeably for at least 1 s.

10.6.4 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.

10.6.5 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.**

An **equipment safeguard** shall prevent exposure of an **ordinary person** to an RS2 source unless all of the following are met:

– an **instructional safeguard** is provided as given below; and

– the **instructional safeguard** is acknowledged by the user. The output level shall not be higher than RS1 until the acknowledgment is made. The acknowledgement shall be repeated at least once every 20 h of cumulative listening time.

  NOTE 2 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.

The output level shall automatically return to an output level not exceeding RS1 when the power is switched off.

A **skilled person** shall not unintentionally be exposed to RS3.

When required, an **instructional safeguard** in accordance with Clause F.5 shall be used, except that the **instructional safeguard** shall be placed on the equipment, 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 text
- element 3: "Hearing damage risk" or equivalent text
- element 4: "Do not listen at high volume levels for long periods." or equivalent text

10.6.6 Requirements for listening devices (headphones, earphones, etc.)

10.6.6.1 Corded listening devices with analogue input

With 94 dB(A) L_{Aeq} acoustic pressure output of the listening **device**, and with the volume and sound settings in the listening **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 level, the input voltage of the listening **device** when playing the fixed "programme simulation noise" as described in EN 50332-1 shall be ≥ 75 mV.

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.

10.6.6.2 Corded listening devices with digital input

With any playing **device** playing the fixed "programme simulation noise" described in EN 50332-1, and with the volume and sound settings in the listening **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 level, the $L_{\mathrm{Aeq},T}$ acoustic output of the listening **device** shall be ≤ 100 dB(A) with an input signal of –10 **dBFS**.

10.6.6.3 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 level for the above mentioned programme simulation noise,
- the $L_{\mathrm{Aeq},T}$ acoustic output of the listening **device** shall be ≤ 100 dB(A) with an input signal of –10 **dBFS**.

10.6.6.4 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 document

Some examples of equipment within the scope of this document 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 document, 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, network surveillance cameras, 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, tablets, smartphones, wearable devices, plotters, printers (including 3D 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, electronic kiosks, 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 Test applicability

This Annex B specifies various tests and test conditions applicable to the equipment.

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 document 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 can require the use of a **safeguard** to reduce the likelihood of injury or fire.

B.1.2 Type of test

Except where otherwise stated, tests specified are **type tests**.

B.1.3 Test samples

Unless otherwise specified in this document, 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 **subassemblies** 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 this document. 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.1.4 Compliance by inspection of relevant data

Where in this document 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.1.5 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.

Unless otherwise specified in this document, 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 shall 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.

For **normal operating conditions**, measurements are made with the EUT operating at the most unfavourable supply voltage, see B.2.3.

B.1.6 Specific output conditions

Where equipment is designed such that one or more of its power sources require a specific load, protocol or software to turn on the supply output, to keep the supply output active or to obtain the intended output voltage, current or power available under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**, a method of achieving that output shall be employed.

If the power source is of a type that requires handshaking or negotiating between a load or intelligently detects loads and as a result does not allow output of normally occurring voltages or currents into resistive loads, the source shall be connected to a terminating **device** or impedance that turns on the source voltage or current and generates the power delivery under the conditions specified.

If the source is a type that does not provide normal voltages or currents into a resistive load, the source shall be connected to a terminating **device** or impedance that turns on the source and creates the worst case condition.

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; and
- 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 AC **mains** and +20 % and −15 % for DC **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.

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; and
– normal operating voltages generated external to the equipment for all IDs of Table 13. Any ringing signals received from **external circuits** as indicated in Table 13, ID 1a, 1b, 1c and 2 shall also be included.

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); and
– 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.3;*
– *for equipment where the primary function is to display 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 Annex E of this document.*

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 RMS ammeter or power meter, during a representative period.

*For equipment supplied by the **mains**, 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 %, short term conditions not being taken into account. For equipment not supplied by the **mains**, the measured input current or input power shall be less or equal to the ratings of the equipment.*

Compliance is checked by measuring the input current or input power of the equipment under the following conditions:

– *where equipment has more than one **rated voltage**, the input current or input power is measured at each **rated voltage**; and*
– *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**; and*
  - *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.2.6.4 Equipment intended for building-in or rack-mounting

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.

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; and

– for equipment that uses an **insulating liquid** described in 5.4.12.1: loss of liquid.

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 card (thick, stiff paper or thin cardboard) with a minimum density of 200 g/m^2, 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 shall be covered simultaneously. External surfaces shall not exceed the TS2 limits in Table 37.
– 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 text
  - element 3: optional
  - element 4: "This equipment is not intended to be used on soft support (like beddings, blankets etc.)." or equivalent text

B.3.3 DC mains polarity test

If the connection to the DC **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 DC.

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 and appliance outlets directly connected to the **mains**, are connected to the most unfavourable load impedance, including short-circuit.

The source shall be connected to a terminating **device** or impedance that turns on the source voltage or current to create the worst case **abnormal operating condition**.

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.3.2.

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; and
– 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.1.5.

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

– for circuits used in **pollution degree** 1 and **pollution degree** 2 environments, the **clearance** for **basic insulation** for printed wiring boards as specified in IEC 60664-1:2020, Table F.2; or

– the electric strength test of 5.4.9.1 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

– for circuits used in **pollution degree** 1 and **pollution degree** 2 environments, the **creepage distance** for **basic insulation** for printed wiring boards as specified in IEC 60664-1:2020, Table F.5; 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.

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 any of the following:

– PTC thermistors complying with IEC 60730-1:2013, Clauses 17, 19, J.17 and J.19;

– 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 document;

– isolating components (for example, optocouplers and transformers) complying with the relevant component requirements in Annex G for **reinforced insulation**;

– 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 DC 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, 9.4, 10.3, 10.4.1, 10.5.1 and 10.6.5 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**.*

*After a **single fault condition** that might impact an insulation used as a **safeguard**, the insulation shall withstand the electric strength test of 5.4.9.1 for the relevant insulation.*

*During and after a **single fault condition**, the opening of a conductor on a printed board shall not be used as a **safeguard**, except for the following situations, in which case the fault condition shall be repeated 3 times:*

- *Conductors of a printed board of **V-1 class material** or **VTM-1 class material** are allowed to 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**.*

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 C defines the test requirements and test procedures for materials that have **safeguard** properties and that are subject to UV radiation exposure.

C.1.2 Requirements

The following requirements apply to equipment, or parts of equipment, that are exposed to lamps that produce significant UV radiation in the spectrum 180 nm to 400 nm and to outdoor equipment exposed to sunlight.

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 may serve as part of the **enclosure**.

Table C.1 – Minimum property retention limits after UV exposure

Parts to be tested	Property	Standard for the test method	Minimum retention after test
Parts providing mechanical support	Tensile strength [a]	ISO 527 (all parts)	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 document	[d]

[a] Tensile strength and flexural strength tests shall be conducted on specimens no thicker than the actual thicknesses.

[b] The side of the sample exposed to UV radiation shall 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** is allowed to change as long as it does not fall below that specified in Clause 6 of this document.

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 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 for a minimum of 720 h. The test apparatus shall operate with a black-panel temperature of 63 °C ± 3 °C in a relative humidity of (50 ± 5) %; or*

– *a xenon-arc (see C.2.4) with continuous exposure for a minimum of 1 000 h. The test apparatus shall operate with a 6 500 W, water-cooled xenon-arc lamp, a spectral irradiance of 0,35 W/m^2 at 340 nm, a black-panel temperature of 63 °C ± 3 °C in a relative humidity of (50 ± 5) %.*

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, shall be used in accordance with the procedures given in ISO 4892-1 and ISO 4892-4 using a type 1 filter, with water spray.

C.2.4 Xenon-arc light-exposure test

The apparatus described in ISO 4892-2:2013, or equivalent, is used in accordance with the procedures given in ISO 4892-1 and ISO 4892-2 using cycle 1 of method A of Table 3, without water spray.

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; and
– 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 transient voltages in **external circuits** as indicated in Table 13, ID 1a and 3a unearthed.

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 transient voltages in **external circuits** as indicated in Table 13, ID 1b and 3a earthed and 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 (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.*

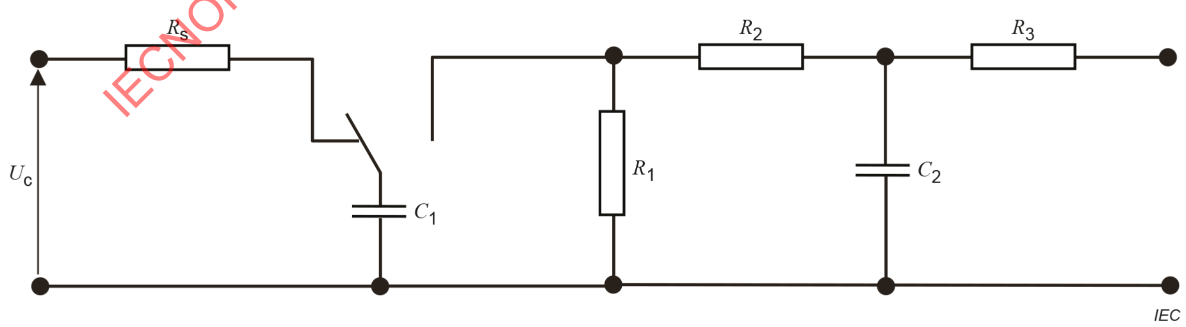


Figure D.1 – 1,2/50 μs and 10/700 μs voltage impulse generator

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.

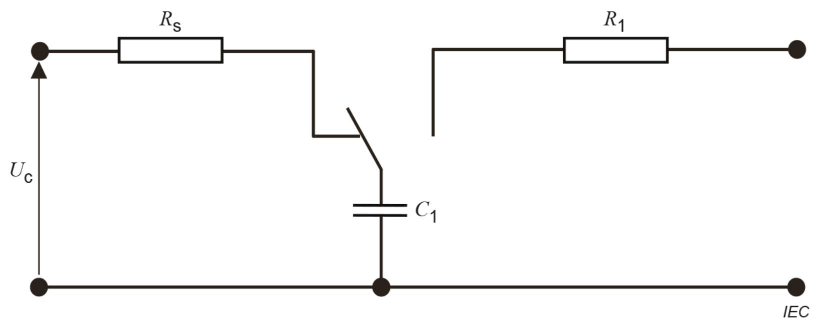
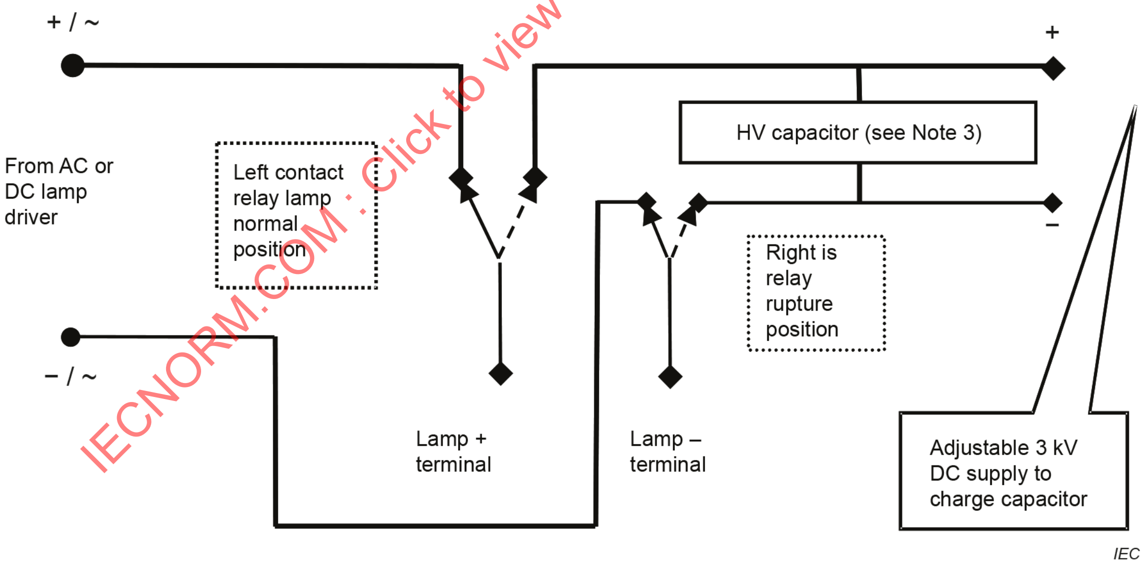


Figure D.2 – Antenna interface test generator circuit

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 is typically 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 intended to amplify audio signals

E.1 Electrical energy source classification for audio signals

When classifying audio signals as an electrical energy source according to 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.

Table E.1 – Audio signal electrical energy source classes and safeguards

Class	Audio signal voltage V RMS	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 can result in an unpleasant sensation.

E.2 Audio signals used during test

E.2.1 Pink noise test signal

A band-limited **pink noise** test signal shall be used for operation after **non-clipped output power** has been established using a sine wave. The **pink noise** test signal shall be limited by a band-pass filter with characteristics as shown in Figure E.1.

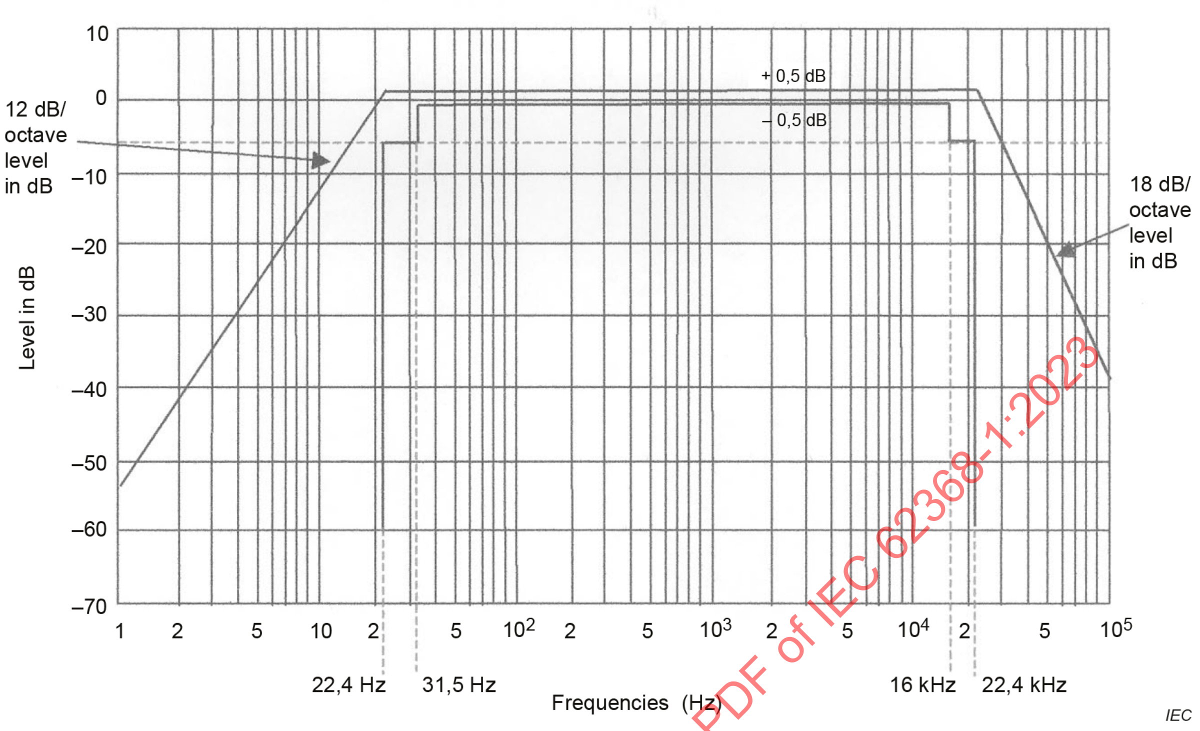
NOTE 1 The **pink noise** filter may be integral to the generator or added externally.

The equipment used for measuring the output signal shall indicate true RMS values for crest factors up to at least 3. The frequency response shall at least conform to that shown in Figure E.1.

In order to achieve a **pink noise** test signal, a wide-band signal may be used as specified in 6.1 of IEC 60268-1:1985, with at band-pass filter having a frequency response within the limits shown in Figure E.1.

A band-pass filter, which has a substantially constant transmission factor between 22,4 Hz and 22,4 kHz, and which decreases outside this frequency band at the rates specified for octave-band filters having mid-band frequencies of 31,5 Hz and 16 000 Hz as specified in IEC 61260-1:2014, has a response within the limits of this requirement.

For wide-band measurement, see 6.1 of IEC 60268-1:1985.



When there are strong signals just above or below the band limits, the results will depend, to some degree, on the individual frequency response of the filter actually used.

Figure E.1 – Band-pass filter for wide-band noise measurement

E.2.2 Sine-wave signal

Where the amplifier function is not adversely affected, a sine wave of 1 kHz or any frequency corresponding to the geometric mean of the upper and lower – 3 dB response points of the relevant part of the equipment may be used to supply each channel.

If the result of a measurement performed with a sine wave does not comply with this document, the measurement with **pink noise** test signal is decisive.

E.3 Operating conditions of equipment containing an audio amplifier

E.3.1 Normal operating conditions

The source shall be connected to a terminating device or impedance that turns on the voltage or current source to create the worst case **normal operating condition**.

NOTE The source is the equipment containing an **audio amplifier** or an **audio amplifier** itself.

Equipment containing an **audio amplifier** shall be operated as follows:

– Establish the **non-clipped output power** using a sine wave as described in E.2.2. If visible clipping cannot be established, the maximum attainable power shall be considered as the **non-clipped output power**. Set the power as to deliver a minimum of 1/8 of the **non-clipped output power** into the **rated load impedance** using a **pink noise** test signal with a band-pass filter as describe in E.2.1. As an alternative to the **pink noise** signal, the equipment may be operated using a sine wave audio signal source as specified in E.2.2. In the case where an amplifier is not intended for operation at 1 000 Hz, the **peak response frequency** shall be used.

– Organs or similar instruments that have a tone-generator unit and that can generate a continuous tone 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.
– For **audio amplifiers** used in an electronic musical instrument which do not generate a continuous tone, the **pink noise** signal described in E.2.1 is applied to the signal input terminal or to the appropriate input stage of the **audio amplifier** to deliver a minimum of 1/8 of the maximum attainable output power.

In addition, all of the following shall be considered:

– if tone controls are available to the user, they shall be set to their mid-position;
– the most unfavourable **rated load impedance** or the actual loudspeaker, when provided, is connected to the amplifier output;
– all amplifier channels are operated simultaneously;
– 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 a minimum of 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;
– where the intended amplifier function depends on phase difference between two channels, there shall be a phase difference of 90° between the signals applied to the two channels.

E.3.2 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**.

E.3.3 Audio equipment temperature measurement conditions

The temperature measurements shall be carried out with the equipment positioned in accordance with the instructions 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 of the equipment and 5 cm depth behind the equipment.

Annex F
(normative)

Equipment markings, instructions, and instructional safeguards

F.1 General

This Annex F specifies equipment markings, equipment instructions, and **instructional safeguards** necessary for equipment installation, operation, maintenance, and servicing in accordance with the requirements of this document.

Unless symbols are used, safety related equipment marking, instructions and **instructional safeguards** shall be in a language accepted in the respective countries.

This Annex F does not apply to markings on components. Markings on components are specified in the relevant component standard.

This Annex F may apply to **subassemblies** such as power supply units. Assemblies of components and parts that need other elements to form a complete equipment within the meaning of this document are considered to be a **subassembly** and are not considered to be components. Such **subassemblies** do not need to comply with the requirements of this Annex.

NOTE 1 Where the term marking is used in this document, 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 document do not contradict the markings and instructions required by this document.

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 for safety purposes, whether required by this document 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 and explain the meaning of the symbol in the instruction manual.

F.2.3 Compliance criteria

Compliance is checked by inspection.

F.3 Equipment markings

F.3.1 Equipment marking locations

Equipment markings shall be located near or adjacent to the part or region that is the subject of the marking, unless otherwise specified in this document.

Equipment markings required 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, unless otherwise specified in this document or one of the following conditions is met:

1) 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.
2) For equipment intended to be mounted on a supporting structure (for example, a rack, panel, wall, ceiling, etc.) and where the external surface of the equipment becomes partially or completely invisible after installation, markings may be on any surface, including the bottom, that becomes visible after removal of the equipment from the supporting structure.

Unless there is no possibility of confusion, the location of the markings required in F.3.3 and F.3.6 shall still be located as near as possible or adjacent to the connection point, even if the marking is permitted in an area easily **accessible** by hand, on the bottom, or other permitted surface.

Markings shall not be put on parts that can be removed without the use of a **tool**, unless they apply only to that 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.

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 does not have 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, DC, AC, or three-phase AC, shall be marked on the equipment and shall be adjacent to the equipment voltage rating. If a symbol is used,

– the symbol ~, IEC 60417-5032 (2002-10) shall be used for AC;
– the symbol ⎓, IEC 60417-5031 (2002-10) shall be used for DC;
– the symbol 3~, IEC 60417-5032-1 (2002-10) shall be used for three-phase AC;
– the symbol 3N~, IEC 60417-5032-2 (2002-10) shall be used for three-phase AC with a neutral conductor; or
– the symbol ≂, IEC 60417-5033 (2002-10) shall be used for combined AC and DC.

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 **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). If the equipment is installed by a **skilled person**, this indication may be in the installation instructions or at any location on the equipment, including inside the equipment.

Multi-phase equipment shall be marked with a graphical symbol in accordance with F.3.3.3 or the alphanumeric notation of designated conductors indicating characteristics of the power supply system with the number of phases in accordance with IEC 61293, the phase-to-neutral voltage, a solidus (/), the phase-to-phase 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.

EXAMPLE 3/N/PE ~ 230/400 V 50 Hz.

NOTE 1 The solidus (/) represents the word "or" and the hyphen (-) represents the word "to".

NOTE 2 In Australia and New Zealand, for equipment that is intended for connection to the AC **mains**, a single **rated voltage** must be indicated as 230 V or 400 V as applicable. If multiple **rated voltages** or **rated voltage range** are indicated, it must include 230 V or 400 V.

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** is the current of one phase and the **rated power** is the total power of the three phases.

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** are not to be stated to more than one significant digit.

NOTE 3 In some countries, for markings on equipment, a period is used 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.

Equipment with a **rated voltage range** may be marked with either the maximum **rated current** or with the current range.

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**.

Where the multiple **mains** supplies are identical, they may have one marking indicating the number of supplies.

EXAMPLE "240 V ∿ / 10 A × N" where N is the number of identical **mains** supply connections.

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**.

It is not required to mark the overall system electrical ratings.

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 readable 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 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 marking of the voltage is optional.

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; and
– a suitable **instructional safeguard** shall be provided on the equipment or in the service instructions to alert a **skilled person** to a possible hazard, where both of the following conditions exist:
  - the fuse is used either in:
    – equipment having a non-polarized plug; or
    – the neutral of equipment provided with a polarized plug; or

  - the neutral of **permanently connected equipment**; and
- after operation of the fuse, parts of the equipment that remain energized at ES3 levels can represent a hazard during servicing.

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

- element 1a: the symbol , IEC 60417-6042 (2010-11) and N, IEC 60417-5016 (2002-10) (modified to add alphanumeric notation N for the neutral conductor)
- element 2: "DOUBLE POLE/NEUTRAL FUSING" or equivalent text
- element 3: Optional
- element 4: Optional.

If a fuse is not intended to be replaceable, the marking of the fuse ratings is optional.

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 M.10.

F.3.5.5 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.3.5.6 Terminal marking location

The terminal markings specified in F.3.5.5, F.3.6.1 and F.3.6.3 shall not be placed on screws, removable washers, or other parts that can be removed when conductors are being connected.

F.3.5.7 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 **subassembly** (for example, a power supply unit), 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 Protective bonding conductor terminals

The identification of terminals for **protective bonding conductors** is optional. However, 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 Equipment class marking

The following **class II equipment** provided with a functional earthing connection shall bear the symbol , IEC 60417-6092 (2013-03):

– **equipment** using a class II **mains** input connector and provided with a separate **functional earthing** connection;

– **equipment** using a class I **mains** input connector with the earthing pin connected to **functional earthing** only;

– **equipment** using a class I **mains** input connector with the earthing pin not connected to **functional earthing** or **protective earthing**, but provided with a separate **functional earthing** connection.

All other **class II equipment** shall bear the symbol , IEC 60417-5172 (2003-02).

The above symbols shall not be used for **class I equipment**.

Equipment providing **protective earthing** to other equipment shall not be classified as **class II equipment**.

F.3.6.3 Functional earthing terminal marking

Wiring terminals to be used only for the connection of **functional earthing** shall be marked with the symbol , IEC 60417-5018 (2011-07). 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 a **subassembly**.

F.3.6.4 Compliance criteria

Compliance is checked by inspection.

F.3.7 Equipment IP rating marking

Where an IP construction is used as a **safeguard:**

– the **safeguard** shall be in accordance with IEC 60529; and

– the IP code shall be declared in the instruction manual or on the equipment.

Compliance is checked by inspection.

F.3.8 External power supply unit output marking

The DC output of an external power supply unit shall be marked with:

– the voltage rating, and

– the current rating, and

– the polarity.

Polarity marking is not required when the pin configuration prevents reversed polarity.

The AC output of an external power supply unit shall be marked with:

– the voltage rating, and
– the current rating, and
– the frequency if it is different from the input frequency of the external power unit.

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 in this document, the use of colours in **instructional safeguards** is optional. If an **instructional safeguard** is in colour to indicate hazard severity, the colour shall be in accordance with the ISO 3864 series. Markings that are engraved or moulded do not have to be in contrasting colours provided that they are legible and readily discernible 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 is not necessary.

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. The CAS (American Chemical Society) number of n-hexane is 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 document, 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.

This equipment is not suitable for use in locations where children are likely to be present.

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

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 supply cord connected to a socket-outlet with **protective 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 5.7.6.

– Graphical symbols placed on the equipment and used as an **instructional safeguard** shall be explained. When the full **instructional safeguard** is placed on the equipment in accordance with F.5, there is no need to additionally explain the symbol in the instructions.

– 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.

– For equipment containing an **insulating liquid**, safety instructions shall be provided where applicable, including the use of PPE if needed, taking into account the information in the safety data sheet of the **insulating liquid** and the manufacturer's data.

– The installation instructions for **outdoor equipment** shall include details of any special features needed for protection from conditions in the **outdoor location**.

Compliance is checked by inspection.

F.5 Instructional safeguards

Unless otherwise specified in this document, 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 document, 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 equivalent text.

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.

A single **instructional safeguard** may be related to several parts, provided those parts are closely located near each other. If these parts are not easily identifiable, or not located adjacent to the instructional safeguard, an accompanying document or the instruction manual or the instructions on the equipment shall show the locations of these parts.

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.		

Figure F.1 illustrates one example of the arrangement of the four elements that comprise a complete **instructional safeguard**. Other arrangements in the positioning of the elements are also acceptable.

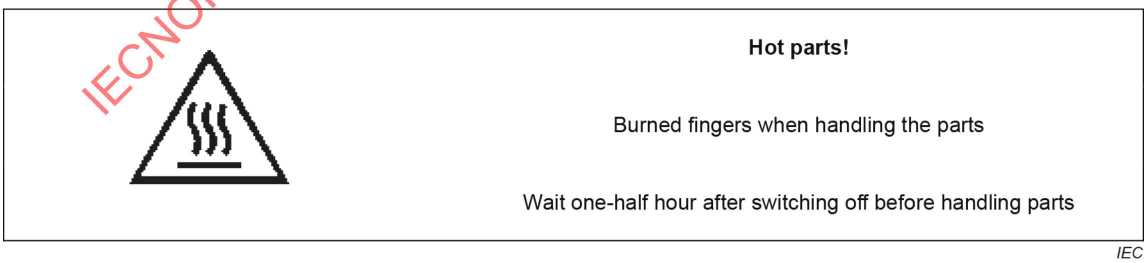
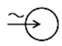
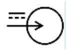
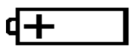
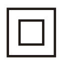


Figure F.1 – Example of an instructional safeguard

See Table F.2 for examples of markings, instructions, and **instructional safeguards**.

Table F.2 – Examples of markings, instructions, and instructional safeguards

Rating	Example
Rated **DC voltage**	48 V DC 48 V ⎓
Rated AC voltage	230 V ~ 230 V ~ ±10 % 100/120/220/240 V AC 100–250 V AC
Rated 3-phase voltage	3/N/PE ~ 230/400 V 400 V/230 V 3Ø 208 V/120 V 3-phase 208 V/120 V 3 ~
Rated frequency	50 Hz to 60 Hz 50/60 Hz
Rated current	1 A
AC **rated power** input, IEC 60417-6045 (2011-01)	
DC **rated power** input, IEC 60417-6046 (2011-01)	
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** power supply cord.

A switch shall comply with all of the following:

– comply with the requirements of IEC 61058-1:2016, whereby the following applies:
  - 10 000 operating cycles (see 7.4.4 of IEC 61058-1:2016);
  - the switch shall be suitable for use in the **pollution degree** environment in which it is used, typically a **pollution degree** 2 environment (see 7.9.2 of IEC 61058-1:2016);
  - the switch have a glow wire temperature of 850 °C (see 7.11.3 of IEC 61058-1:2016);
  - 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 61058-1:2016);
    – the classification of the switch according to:
      - nature of supply (see 7.1 of IEC 61058-1:2016);
      - type of load to be controlled by the switch (see 7.2 of IEC 61058-1:2016);
      - ambient air temperature (see 7.3 of IEC 61058-1:2016).

  Compliance is checked according to IEC 61058-1:2016.

– 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 16.4 i), p) and q) of IEC 61058-1:2016, 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 Clause 17 of IEC 61058-1:2016, with an additional load according to Figure 8 and Figure 9 of IEC 61058-1:2016. 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 61058-1:2016 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 and compliance criteria

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 61810-1:2015.

A relay shall comply with the requirements of IEC 61810-1:2015, taking into account the following:

– materials shall comply with 6.4.5.2, or pass a glow wire test at 750 °C according to IEC 60695-2-11, or pass a needle flame test according to IEC 60695-11-5;

– 10 000 operating cycles for endurance (see 5.6 of IEC 61810-1:2015) and during the electric endurance test (see Clause 11 of IEC 61810-1:2015), no temporary malfunction shall occur;

  NOTE A temporary malfunction is an event that is eliminated during the test at latest after one additional energization cycle without any external influence (see Clause 11 of IEC 61810-1:2015).

– the relay shall be suitable for use in the applicable pollution situation (see Clause 13 of IEC 61810-1:2015);

– 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 5.2 of IEC 61810-1:2015);

  • rated contact load and the type of load (see 5.8 of IEC 61810-1:2015);

  • release voltage (see 5.4 of IEC 61810-1:2015);

  • the ambient air temperature and upper and lower limit of the temperature (see 5.9 of IEC 61810-1:2015);

  • only relay technology category RT IV and RT V shall be considered to meet **pollution degree** 1 environment, for example, the relay meets 5.4.1.5.2 of this document (see 5.10 of IEC 61810-1:2015);

– electric strength (see 10.2 of IEC 61810-1:2015), except the test voltage shall be the required test voltage specified in 5.4.9.1 of this document;

– if the **required withstand voltage** (referred to as impulse withstand voltage in IEC 61810-1) exceeds 12 kV, **clearances** shall comply with Table 14 of this document;

– if the **RMS working voltage** (referred to as voltage RMS in IEC 61810-1) exceeds 500 V, **creepage distances** shall comply with Table 17 of this document;

– **solid insulation** in accordance with 13.3 of IEC 61810-1:2015 or with 5.4.4 of this document.

Compliance is checked according to IEC 61810-1 and the requirements of this document.

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 61810-1:2015, 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 document shall be applied with the modifications shown in G.2.1 of this document.*

*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 60730-1:2013);
   – the **thermal cut-off** shall have at least micro-disconnection, Type 2B (see 6.4.3.2 and 6.9.2 of IEC 60730-1:2013);
   – 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 60730-1:2013);
   – 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 60730-1:2013),

  - 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 60730-1:2013),
  - 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 60730-1:2013);
- 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 60730-1:2013);
- 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 60730-1:2013);
- 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 60730-1:2013.

b) The characteristics of the **thermal cut-off** with regard to
- the ratings of the **thermal cut-off** (see Clause 5 of IEC 60730-1:2013);
- the classification of the **thermal cut-off** according to the:
  - nature of supply (see 6.1 of IEC 60730-1:2013),
  - type of load to be controlled (see 6.2 of IEC 60730-1:2013),
  - degree of protection provided by **enclosures** against ingress of solid objects and dust (see 6.5.1 of IEC 60730-1:2013),
  - degree of protection provided by **enclosures** against harmful ingress of water (see 6.5.2 of IEC 60730-1:2013),
  - pollution situation for which the **thermal cut-off** is suitable (see 6.5.3 of IEC 60730-1:2013),
  - maximum ambient temperature limit (see 6.7 of IEC 60730-1:2013),

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 60730-1:2013; 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 60691:2015);

   – the electrical conditions (see 6.1 of IEC 60691:2015);

   – the thermal conditions (see 6.2 of IEC 60691:2015);

   – the ratings of the thermal link (see Clause 8 b) of IEC 60691:2015); and

   – the suitability for sealing in, or use with impregnating fluids or cleaning solvents (see Clause 8 c) of IEC 60691:2015),

   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 document except across the disconnection (contact parts) and except between terminations and connecting leads of the contacts, for which 10.1 of IEC 60691:2015 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 60730-1:2013.

For PTC thermistors that,

– have a 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 3.39 of IEC 60738-1:2022, exceeds 15 W; and

– have a size of more than 1 750 mm^3; and
– are 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 in accordance with 4.1.2. Such a protective **device** shall have adequate breaking (rupturing) capacity to interrupt the maximum fault current (including short-circuit current) that can flow.

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, fuse resistors, fuse-links not standardized in IEC 60127 series, IEC 60269 series or miniature circuit breakers) shall have adequate ratings, including breaking capacity.

For non-resettable protective **devices**, such as fuse-links, a marking shall be provided in accordance with F.3.5.3.

Fuse resistors used as a **safeguard** in the **mains** shall comply with IEC 60127-8.

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 and comply with IEC 60884-1, 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 when used within their ratings for the purpose of connecting or interconnecting **mains** power.

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 60130-9, 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°, one of the following applies:

– protection against mechanical stress shall be provided. For example, this protection may 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 5.4.9.2.

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.15.2.4.*

– *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 the IEC 61558-2 series with the following additions and limitations:
  - the limit values for ES1 of this document apply (see 5.2.2.2);
  - for **working voltages** above 1 000 V RMS, see 18.3 of IEC 61558-1:2017 using the test voltage specified in 5.4.9.1;
  - the overload test according to G.5.3.3; and
  - IEC 61558-2-16 for transformers used in a switch mode power supply; or
– meet the requirements given in G.5.3.4 for a transformer that uses **FIW**.

EXAMPLES The relevant parts of IEC 61558-2 are:

– IEC 61558-2-1: Separating transformers;
– IEC 61558-2-4: Isolating transformers; and
– 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; and
– 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.1.5, and determined as specified below:

- *with an external overcurrent protective **device**: at the moment of operation, for determination of the time until the overcurrent protective **device** 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; or*
- *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.1.5, 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. After the test, the transformer shall withstand the electric strength test in 5.4.9.1 as applicable.

Table G.3 – Temperature limits for transformer windings and for motor windings (except for the motor running overload test)

	Maximum temperature °C							
Method of protection	**Class 105** (A)	**Class 120** (E)	**Class 130** (B)	**Class 155** (F)	**Class 180** (H)	**Class 200** (N)	**Class 220** (R)	**Class 250** -
No protective **device** used or protected by internal or external impedance	150	165	175	200	225	245	265	295
Protected by a protective **device** that operates during the first hour	200	215	225	250	275	295	315	345
Protected by any protective **device**:								
– maximum after first hour	175	190	200	225	250	270	290	320
– arithmetic average temperature (t_A) during the 2nd hour and during the 72nd hour and during the 400th 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.

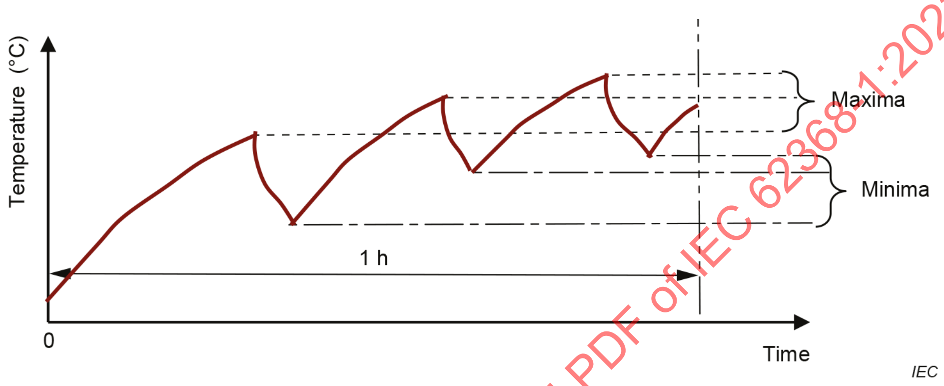


Figure G.1 – Determination of arithmetic average temperature

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; or*

– *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*** *or* ***wrapping tissue*** *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.5.3.4 Transformers using fully insulated winding wire (FIW)

G.5.3.4.1 General

The requirements of G.5.3.4 may only be applied to equipment intended for use in overvoltage categories I and II.

Where **FIW** is used within a transformer, the **FIW** shall comply with IEC 60851-5:2008, IEC 60317-0-7 and IEC 60317-56.

FIW windings at ES2 or ES3 levels shall not be **accessible** to an **ordinary person** or an **instructed person**.

If the wire has a nominal diameter other than defined in Table G.5 (FIW3-9), the minimum electric strength value may be calculated according to the formula below Table G.5.

A transformer that uses **FIW** shall comply with IEC 60085 and may only be used up to and including insulation Class 155 (F).

Where mechanical separation is required below, the mechanical separation shall comply with the electric strength test for **basic insulation** in accordance with 5.4.9.1 except that Table G.4 shall be applied instead of Table 26.

Table G.4 – Test voltages for electric strength tests based on the peak of the working voltages

Voltage up to and including	Test voltage for basic insulation or supplementary insulation	Test voltage for reinforced insulation
V peak	kV peak or DC (Vrms)	
< 70,5	0,35 (0,25)	0,7 (0,5)
212	2 (1,41)	4 (2,82)
423	3 (2,12)	6 (4,24)
846	3,5 (2,47)	7 (4,95)
1 410	3,9 (2,76)	7,8 (5,52)
Linear interpolation may be used between the nearest two points.		
This table is based on Table 14 of IEC 61558-1:2017.		

G.5.3.4.2 Transformers with basic insulation only

FIW serving as **basic insulation** shall be a construction having a minimum test voltage per Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26.

Mechanical separation is required between the **FIW** and enamelled wire.

Clearances and **creepage distances** between the **FIW** and enamelled wire are not required.

NOTE 1 An example of this construction is a transformer with **FIW** as one winding and enamelled wire as the other.

NOTE 2 The specified values in Table G.5 are RMS.

G.5.3.4.3 Transformers with double insulation or reinforced insulation

Transformers with **double insulation** or **reinforced insulation** comprised of:

– two or more **FIW** windings insulated with **basic insulation** and **supplementary insulation**, shall comply with all of the following:

  - **FIW** serving as **basic insulation** and the **FIW** serving as **supplementary insulation** shall each have a minimum test voltage per Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26;
  - mechanical separation that fulfils the electric strength test for **basic insulation** is required between both **FIW** windings; and
  - **clearances** and **creepage distances** between the **FIW** are not required.

– one **FIW** winding provided with **reinforced insulation** shall comply with all of the following:
  - **FIW** serving as **reinforced insulation** shall have a minimum test voltage per Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26;
  - mechanical separation that fulfils the electric strength test for **basic insulation** is required between the **FIW** and enamelled wire windings; and
  - **clearances** and **creepage distances** between the **FIW** and enamelled wire are not required.

– one **FIW** winding provided with **basic insulation** in combination with solid or thin layer insulation serving as **supplementary insulation**, shall comply with all of the following:
  - **FIW** serving as **basic insulation** shall have a minimum test voltage in accordance with Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26;
  - solid or thin layer insulation serving as **supplementary insulation** shall comply with Clause 5, including **solid insulation**; and
  - **clearances** and **creepage distances** between the **FIW** and enamelled wire are required.

G.5.3.4.4 Transformers with FIW wound on metal or ferrite core

FIW shall be designated **basic insulation** based on the peak of the **working voltage**.

FIW serving as **basic insulation** shall be a construction having a minimum test voltage in accordance with Table G.5 that exceeds the test voltages for electric strength tests based on 5.4.9.1 except that Table G.4 shall be applied instead of Table 26.

Mechanical separation is required between the **FIW** and the metal or ferrite core.

G.5.3.4.5 Thermal cycling test and compliance

*For **transformers** with **FIW** the following test is required:*

Three samples of the transformer shall be used. The samples shall be subjected 10 times to the following sequence of temperature cycles:

– *68 h at the highest winding temperature ± 2 °C measured in normal use plus 10 K with a minimum of 85 °C;*

– *1 h at 25 °C ± 2 °C;*

– *2 h at 0 °C ± 2 °C;*

– *1 h at 25 °C ± 2 °C.*

*During each thermal cycling test, a voltage of twice the value of the **working voltage** at 50 Hz or 60 Hz shall be applied to the samples between the windings.*

After conditioning of the three samples above,

– *two of the three samples are then subjected to the humidity treatment of 5.4.8 (48 h treatment) and the relevant electric strength test of 5.4.9.1, except that Table G.4 is applied instead of Table 26; and*

– *the remaining sample shall be subjected to the relevant electric strength test of 5.4.9.1 except that Table G.4 is applied instead of Table 26 immediately at the end of the last period at highest temperature during the thermal cycling test.*

There shall be no insulation breakdown during the test.

G.5.3.4.6 Partial discharge test

*If **FIW** is used and if the recurring peak voltage U_t across the insulation is greater than 750 V, a partial discharge test according to 6.4.6 of IEC 60664-1:2020 (additional test description details below) shall be performed. The partial discharge test shall be done after the thermal cycling test of G.5.3.4.5 at normal room temperature for the two samples that were subjected to the humidity treatment.*

The relevant recurring peak voltage is the maximum measured voltage between the input and the transformer and associated circuitry if the secondary side is earthed.

*The measuring shall be done at the maximum of the **rated voltage** of the equipment.*

A partial discharge test shall be done at the transformer with the measured recurring peak voltage U_t where:

– *U_t is the maximum peak of the **working voltage**;*
– *t_1 is 5 s;*
– *t_2 is 15 s.*

Partial discharge shall be less than or equal to 10 pC at time t_2. The test shall be done according to Figure G.2. For other applications higher values can be required (for example, IEC 61800-5-1).

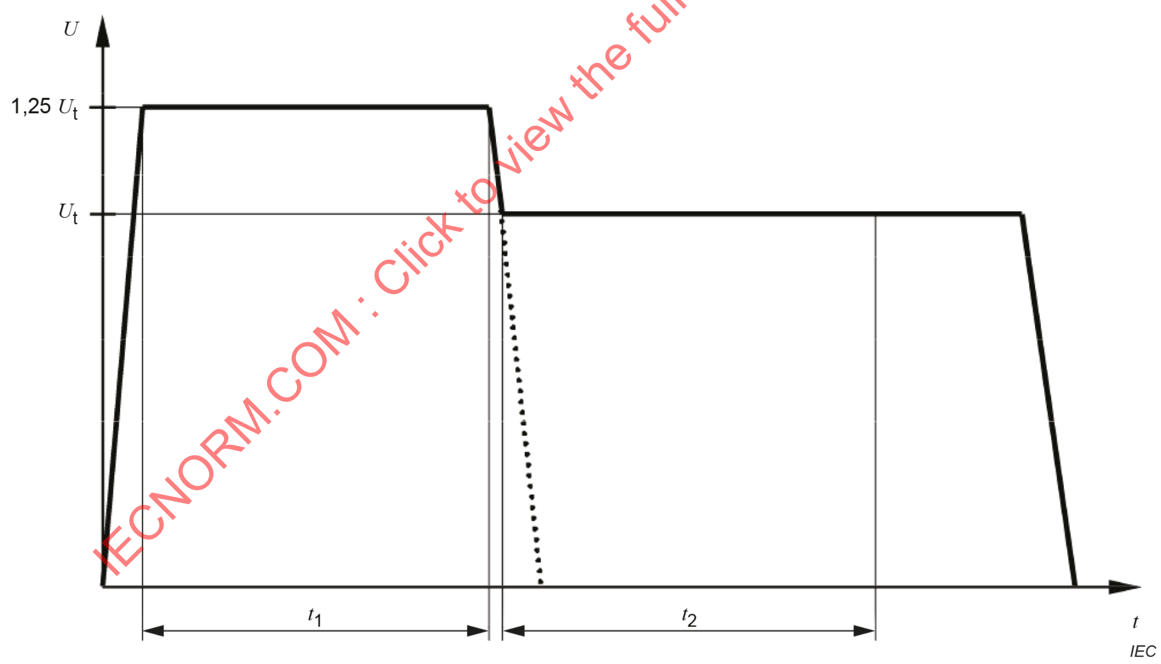


Figure G.2 – Test voltages

G.5.3.4.7 Routine test

*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.*

Table G.5 – Values of FIW wires with minimum overall diameter and minimum test voltages according to the total enamel increase

Nominal conductor diameter d_{Cu} [mm]	Minimum specific breakdown voltage [a] U_b [V/µm]	Minimum overall FIW diameter d_o [mm]							Minimum dielectric strength test voltage values per wire at overall diameter, U_s [V] (duration of 60 s)						
		Grade of FIW 3	Grade of FIW 4	Grade of FIW 5	Grade of FIW 6	Grade of FIW 7	Grade of FIW 8	Grade of FIW 9	Grade of FIW 3	Grade of FIW 4	Grade of FIW 5	Grade of FIW 6	Grade of FIW 7	Grade of FIW 8	Grade of FIW 9
0,04	56	0,055	0,059	0,070	0,080	0,090	0,100		714	904	1 428	1 904	2 380	2 856	
0,045	56	0,062	0,067	0,079	0,090	0,101	0,112		809	1 047	1 618	2 142	2 666	3 189	
0,05	56	0,067	0,073	0,084	0,095	0,106	0,117		809	1 095	1 618	2 142	2 666	3 189	
0,056	56	0,075	0,082	0,093	0,105	0,117	0,129		904	1 238	1 761	2 332	2 904	3 475	
0,063	56	0,084	0,090	0,103	0,116	0,129	0,142		1 000	1 285	1 904	2 523	3 142	3 760	
0,071	56	0,092	0,098	0,111	0,124	0,137	0,150	0,163	1 000	1 285	1 904	2 523	3 142	3 760	4 379
0,08	56	0,102	0,109	0,123	0,137	0,151	0,165	0,179	1 047	1 380	2 047	2 713	3 380	4 046	4 712
0,09	56	0,114	0,121	0,135	0,149	0,163	0,177	0,191	1 142	1 476	2 142	2 808	3 475	4 141	4 808
0,1	56	0,126	0,133	0,149	0,165	0,181	0,197	0,213	1 238	1 571	2 332	3 094	3 856	4 617	5 379
0,112	53	0,140	0,148	0,165	0,182	0,199	0,216	0,233	1 261	1 622	2 388	3 154	3 919	4 685	5 451
0,125	53	0,155	0,164	0,182	0,200	0,218	0,236	0,254	1 352	1 757	2 568	3 379	4 190	5 001	5 811
0,14	53	0,172	0,182	0,202	0,222	0,242	0,262	0,282	1 442	1 892	2 793	3 694	4 595	5 496	6 397
0,16	53	0,195	0,206	0,228	0,250	0,272	0,294	0,316	1 577	2 072	3 063	4 055	5 046	6 037	7 028
0,18	53	0,218	0,230	0,254	0,278	0,302	0,326	0,350	1 712	2 253	3 334	4 415	5 496	6 577	7 659
0,2	53	0,240	0,253	0,278	0,303	0,328	0,353	0,378	1 802	2 388	3 514	4 640	5 766	6 893	8 019
0,224	53	0,267	0,281	0,308	0,335	0,362	0,389	0,416	1 937	2 568	3 784	5 001	6 217	7 433	8 650
0,25	53	0,298	0,313	0,343	0,373	0,403	0,433	0,463	2 162	2 838	4 190	5 541	6 893	8 244	9 596
0,28	53	0,330	0,346	0,377	0,408	0,439	0,470	0,501	2 253	2 973	4 370	5 766	7 163	8 560	9 956
0,315	53	0,368	0,385	0,416	0,447	0,478	0,509	0,540	2 388	3 154	4 550	5 947	7 343	8 740	10 136
0,355	53	0,412	0,429	0,460	0,491	0,522	0,553	0,584	2 568	3 334	4 730	6 127	7 523	8 920	10 316
0,4	49	0,460	0,479	0,510	0,541	0,572	0,603		2 499	3 290	4 582	5 873	7 164	8 455	
0,45	49	0,514	0,534	0,565	0,596	0,627	0,658		2 666	3 499	4 790	6 081	7 372		
0,5	49	0,567	0,588	0,629	0,670	0,711			2 791	3 665	5 373	7 081	8 788		
0,56	37	0,631	0,654	0,695	0,736	0,777			2 233	2 956	4 246	5 535	6 825		
0,63	37	0,705	0,729	0,770	0,811	0,852			2 359	3 114	4 403	5 692	6 982		
0,71	37	0,790	0,815	0,856	0,897	0,938			2 516	3 302	4 592	5 881	7 171		
0,8	37	0,885	0,912	0,963	1,014				2 673	3 522	5 126	6 730			
0,9	37	0,990	1,019	1,070	1,121				2 831	3 743	5 347	6 950			
1	37	1,095	1,125	1,176	1,227				2 988	3 931	5 535	7 139			
1,12	33	1,218	1,249	1,310					2 749	3 618	5 330				
1,25	33	1,350	1,382	1,443					2 805	3 703	5 414				
1,4	33	1,503	1,536	1,597					2 889	3 815	5 526				
1,6	33	1,707	1,741	1,802					3 001	3 955	5 666				

[a] Value according to Table 6 of IEC 60317-0-7:2017.

*The values of allowed voltage strength for **FIW** dimensions other than specified in Table G.5 are calculated according to the following formula:*

$$V = (d_o - d_{Cu}) \times U \times 0{,}85 \times 10^3$$

where:

d_o *is the minimum overall diameter in mm;*

d_{Cu} *is the nominal copper diameter in mm;*

U *is the voltage value according to Table 6 of IEC 60317-0-7:2017 (see column 2) in V/µm;*

V *is the allowed voltage strength for **FIW** wire in V.*

Higher voltage values, based on the "enamel increase" of the note of Table 6 of IEC 60317-0-7:2017, are under consideration.

G.5.4 Motors

G.5.4.1 General requirements

DC motors supplied from PS2 or PS3 circuits isolated from the AC **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 DC 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 in this document, 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 can serve as a heat sink to the motor frame.*

*Temperatures of windings are measured as specified in B.1.5. 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.6.

Table G.6 – 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 9 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 G.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; or*
- *deterioration of the insulation.*

Discoloration of the insulation can 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 DC motors

G.5.4.5.1 Requirements

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 is not required 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 may 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.6.

*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; or*
– *the load cannot be increased any further without reaching a locked rotor condition.*

*During the test, the motor shall not emit flames or molten metal. The **cheesecloth** or **wrapping tissue** 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 DC motors

G.5.4.6.1 Requirements

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 may 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** or **wrapping tissue** 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 can 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 criteria 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

Except for enamelled winding insulation, 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 of the **working voltage** does not exceed ES2, there is no dimensional or constructional requirement.

If the peak of the **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:
   - have a thickness of at least 0,4 mm provided by a single layer; or
   - comply with 5.4.4.6 if the wire is not a winding wire; or
   - comply with Annex J if the wire is a winding wire.

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.

d) **FIW** used as a **safeguard** in transformers shall comply with G.5.3.4.

For insulation between two adjacent winding wires, one layer on each conductor is considered to provide **supplementary insulation**.

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 Enamelled winding wire insulation

Enamelled winding wire is not considered to provide **supplementary insulation** or **reinforced insulation**, unless it complies with the requirements for **FIW** as specified in G.5.3.4.

Other enamelled winding wires used as **basic insulation** shall comply with all the following conditions:

– 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 25 and Table 26;

– 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; and

– 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.

G.7 Mains power supply cords and interconnection cables

G.7.1 General

A **mains** power 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 **movable equipment**, the flexing test of 3.1 of IEC 60227-2:1997 or alternatively the flexing test of 6.6 of IEC 63294:2021;

  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.

  NOTE 3 Annex A of IEC 63294:2021 gives a table of cross-references for tests between IEC 60227-2:1997, IEC 60227-2:1997/AMD1:2003 and IEC 63294:2021.

– if halogen-free sheathed:

  • for **hand-held equipment**, **transportable equipment** and **moveable equipment**, compliance shall be in accordance with either:

    – IEC 63010-1 and IEC 63010-2[6]; or

    – IEC 62821-1, IEC 62821-2[7] and IEC 62821-3;

[6] This publication with withdrawn and replaced with IEC 63294:2021.

[7] This publication was withdrawn and replaced with IEC 63294:2021.

- for all other types of equipment, compliance shall be in accordance with IEC 62821-1, IEC 62821-2 and IEC 62821-3.

For **pluggable equipment type A** or **pluggable equipment type B** that has **protective earthing**, a **protective earthing conductor** shall be included in the **mains** power supply cord. For all other equipment, if a **mains** power supply 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** power supply 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 power supply cords shall have conductors with cross-sectional areas not less than those specified in Table G.7 (see also 5.6.3).

Table G.7 – Sizes of conductors

Rated current of the equipment up to and including [a]	**Minimum conductor sizes**	
	Cross-sectional area	**AWG or kcmil**
A	mm^2	[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. If the **rated current** of the equipment is not declared by the manufacturer, it is the calculated value of the **rated power** divided by **rated voltage**.

[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

G.7.3.1 General

The requirements in G.7.3 apply to **non-detachable power supply cords** and interconnecting cables. **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.8. The force is applied in the most unfavourable direction for 1 s and repeated 25 times.

Table G.8 – 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.8.*

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 supply 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 can 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 × D^2) 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.*

NOTE The factor 10 in the formula (10 × D^2) is expressed in g/mm².

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.9.

Table G.9 – Range of conductor sizes to be accepted by terminals

Rated current of equipment A	Nominal cross-sectional area mm²	
	Flexible cords	Other cables
Up to and including 3	0,5 to 0,75	1 to 2,5
Over 3 up to and including 6	0,75 to 1	1 to 2,5
Over 6 up to and including 10	1 to 1,5	1 to 2,5
Over 10 up to and including 13	1,25 to 1,5	1,5 to 4
Over 13 up to and including 16	1,5 to 2,5	1,5 to 4
Over 16 up to and including 25	2,5 to 4	2,5 to 6
Over 25 up to and including 32	4 to 6	4 to 10
Over 32 up to and including 40	6 to 10	6 to 16
Over 40 up to and including 63	10 to 16	10 to 25

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 IEC 61051-2 or IEC 61643-331:2020, whether a **fire enclosure** is provided or not, taking into account all of the following:

– Preferred climatic categories (see 4.1 of IEC 61051-2:1991):
  - lower category temperature: −10 °C
  - upper category temperature: +85 °C
  - duration of damp heat, steady state test: 21 days,

  or

  Preferred climatic categories (see 4.1 of IEC 61643-331:2020):
  - lower category temperature: −40 °C
  - upper category temperature: +85 °C
  - relative humidity: 25 % to 75 %.

– 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 1 The maximum continuous voltages are not limited to values specified in 4.2 of IEC 61051-2:2021 or the values in Table 1 and Table 2 of IEC 61643-331:2020, other voltages may be used.

– Combination pulse (Table 4 group 1 of IEC 61051-2:2021 or 8.1 of IEC 61643-331:2020, Figure 4).

  For the test, a combination pulse is selected from 3.31 in IEC 61051-1:2018 or from 8.2.1 of IEC 61643-331:2020, Figure 4. The test consists of 10 positive pulses or 10 negative pulses, each having a shape of 1,2/50 μs for voltage and 8/20 μs for current.

  For the selection, AC **mains** voltage and overvoltage category, see Table 12.

  Mains under 300 V is considered to be 300 V.

  For Overvoltage Category IV of Table 12, a combination pulse 6 kV/3 kA 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 3.31, Table 4 group 1 and Annex B of IEC 61051-2:2021 or the combination pulse test of 8.2.1 Figure 4 of IEC 61643-331:2020, including consideration of the nominal **mains** voltage and overvoltage category, is acceptable.

  After the test, the varistor voltage at the manufacturer's specified current 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 conditions:

– 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.

NOTE 2 A varistor is sometimes referred to as an MOV or a VDR.

NOTE 3 Nominal varistor voltage is a voltage, at a specified DC current, used as a reference point in the component characteristic (see IEC 61051-1).

G.8.2 Safeguards against fire

G.8.2.1 General

This subclause applies to varistors used as a **safeguard** against fire:

– when the method "reduce the likelihood of ignition" of 6.4.1 is chosen; or

– when the method "control fire spread" of 6.4.1 is chosen and the **enclosure** is made of **combustible material** and located less than 13 mm from the varistor.

The **safeguards** in this subclause are not applicable to a varistor used in a suppression circuit whose nominal varistor voltage, as specified in IEC 61051-1, is above AC **mains transient voltage**.

A varistor shall be regarded as a **PIS**.

The varistor overload test of G.8.2.2 and the **temporary overvoltage** test of G.8.2.3 shall be performed depending on the maximum continuous AC voltage of the varistor according to Table G.10.

Table G.10 – Varistor overload and temporary overvoltage test

Maximum continuous AC 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.8.2.2	G.8.2.2 and G.8.2.3	G.8.2.2 and G.8.2.3
Over 2 × V_r to 1 200 + 1,1 × V_r	No test	G.8.2.3	G.8.2.3
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.8.2.2 Varistor overload test

The following test is simulated as required by Table G.10 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 AC source of 2 × V_r.*

– *Current is the current resulted from a test resistor R_x connected in series with the AC source.*

– *V_r is the* ***rated voltage*** *or the upper voltage of the* ***rated voltage range*** *of the equipment.*

The test shall be performed with an initial test resistor $R1 = \frac{16xVr}{1A}$.

If the circuit does not open immediately during the initial application of test current, the test shall be continued until temperature stability (see B.1.5).

Subsequently, the test shall be repeated with new values of R_x (R_2, R_3, R_4, etc.) until the circuit opens (with the respective resistance value halving with each repetition), where:

– $R_2 = R_1 / 2$

– $R_3 = R_2 / 2$

– $R_4 = R_3 / 2$

– $R_x = R_{(x-1)} / 2$

Components in parallel with the varistor that can 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.*

During the test, the circuit is allowed to:

– *open due to the operation of a protective* ***device*** *such as a fuse, a thermal fuse; or*

– *close due to the operation of a GDT.*

G.8.2.3 Temporary overvoltage test

The ***temporary overvoltage*** *test is simulated by the following test methods where applicable:*

*A surge suppression circuit containing varistors connected between the **mains** conductors and the earth is tested according to 8.3.8.1 and 8.3.8.2 of IEC 61643-11:2011. The compliance criteria of B.4.8 may be used as an alternative to the compliance criteria of IEC 61643-11.*

If a surge suppression circuit is used, the combination pulse specified in G.8.1 is applied before this test.

During the test, the circuit is allowed to:

– *open due to the operation of a protective **device** such as a thermal fuse; or*
– *close due to the operation of a GDT.*

NOTE For different power distribution systems, the **temporary overvoltages** are defined in Annex B of IEC 61643-11:2011.

Components in parallel with the varistor that can 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 so that the available output power becomes PS1 or PS2 are not shorted from input to output if they comply with all of the following:

– 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 output current is limited to 5 A or less (specified maximum load);
– 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 the conditioning test; and
– the test program as specified in G.9.2.

G.9.2 Test program

The test program consists of the performance tests outlined in Table G.11.

The following specifications are to be supplied by the manufacturer for application of tests:

– *power source limitation/specification (if less than 250 VA);*
– *maximum input voltage (volts); and*
– *maximum output load (amperes).*

Six samples are used for testing as follows:

Sample 1: Line 1
Sample 2: Lines 2 and 3
Sample 3: Lines 4 and 5
Sample 4: Line 6
Sample 5: Line 7
Sample 6: Line 8.

The power source for the tests should be capable of delivering 250 VA minimum, unless the IC current limiter has a lower specification or is tested in the end product.

Table G.11 – Performance test program for integrated circuit (IC) current limiters

Line	Test category	Test condition	Cycles	Device condition temperature °C [a b c]	Device enable voltage	Device input voltage	Device output load (amperes) to RTN [d,e]
1	Start up	Enable pin – cycle	10 000	25	Off to On	Maximum (rated)	Maximum (rated)
2	"	Enable pin – cycle	50	70	Off to On	Maximum (rated)	0 Ω || 470 µF
3	"	Enable pin – cycle	50	-30	Off to On	Maximum (rated)	0 Ω || 470 µF
4	"	Input power pin – cycle	50	70	On	Maximum (rated)	0 Ω || 470 µF
5	"	Input power pin – cycle	50	-30	On	Maximum (rated)	0 Ω || 470 µF
6	Short Circuit	Output power pin – short circuit	50	70	On	Maximum (rated)	Open to 0 Ω (open to short)
7	Overload	Enable pin – cycle	50	25	Off to On	Maximum (rated)	150 % maximum
8	"	Input power pin – cycle	50	25	On	Maximum (rated)	150 % maximum

RTN = Return

|| = in parallel

[a] T_{ma} not applied

[b] ± 2 °C

[c] sample conditioned 3 h before test

[d] ± 20 %

[e] Load should be implemented through a suitably rated capacitor and a parallel conductive wire providing similar characteristics to a shorted, zero ohm (0 Ω) resistive load. The capacitor voltage rating should be not less than the maximum voltage rating of the component under test.

G.9.3 Compliance criteria

After the test program, 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

For each of the tests in this clause, ten samples of resistors are tested. A sample is a single resistor if used alone or a group of resistors as used in the application. Prior to each test, the resistance of the samples is measured, followed by the conditioning of G.10.2.

G.10.2 Conditioning

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.*

G.10.3 Resistor test

*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.

G.10.4 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.

After the tests, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.10.5 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 13).

After the tests, the resistance of each sample shall not have changed by more than 20 %. No failure is allowed.

G.10.6 Overload test

*The samples are each subjected to a voltage of such a value that the current through it is 1,5 times the value measured through a resistor, having a resistance equal to the specified rated value, which is fitted to the equipment, when operated under **single fault conditions**. During the test the voltage is kept constant. The test is performed until thermal steady state is reached.*

After the tests, 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 60384-14:2013/AMD1:2016, 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.12, according to the rules of application in the table.

NOTE IEC 60384-14 usually bases the evaluation of **clearance** and **creepage distances** on **pollution degree** 2.

Table G.12 is based on requirements for **pollution degree** 2. For **pollution degree** 3, different values may apply.

Table G.12 – Capacitor ratings according to IEC 60384-14

Capacitor subclass according to IEC 60384-14	Rated voltage of the capacitor V RMS	Type test impulse test voltage of the capacitor kV peak	Type test RMS test voltage of the capacitor kV RMS
Y1	Up to and including 500	8	4
Y2	Over 150 up to and including 300	5 [a]	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 **RMS 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 For a single capacitor serving as **basic safeguard** or **supplementary safeguard**
- – the type test impulse test voltage of the single capacitor shall be not less than the required test voltage of Table 25 for **basic insulation**;
- – the type test RMS test voltage of the single capacitor multiplied by 1,414 shall be not less than the required test voltage of Table 26 and Table 27 for **basic insulation**.

4 For a single capacitor serving as **reinforced safeguard**
- – the type test impulse test voltage of the single capacitor shall be not less than the required test voltage of Table 25 for **reinforced insulation**;
- – the type test RMS test voltage of the single capacitor multiplied by 1,414 shall be not less than the required test voltage of Table 26 and Table 27 for **reinforced insulation**.

5 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.

6 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.

7 If two or more capacitors are used in series they shall:
- – be tested with the test voltages of this table multiplied by the number of capacitors used;
- – be the same subclass and shall be the same capacitance rating and voltage rating;
- – 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.12 Optocouplers

Optocouplers shall comply with the requirements of IEC 60747-5-5:2020. In the application of IEC 60747-5-5:2020,

– the **type testing** as specified in 5.5.4 of IEC 60747-5-5:2020 shall be performed with a voltage $V_{\text{ini,a}}$ that is at least equal to the appropriate test voltage in 5.4.9.1 of this document; and

– the **routine testing** as specified in 5.5.2 of IEC 60747-5-5:2020 shall be performed with a voltage $V_{\text{ini,b}}$ that is at least equal to the appropriate test voltage in 5.4.9.2 of this document.

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 when required (see Table G.13).

Table G.13 – Minimum separation distances for coated printed boards

Peak of the 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.14), 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.3 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.3, interpolation may be used between the nearest two temperature index lines.

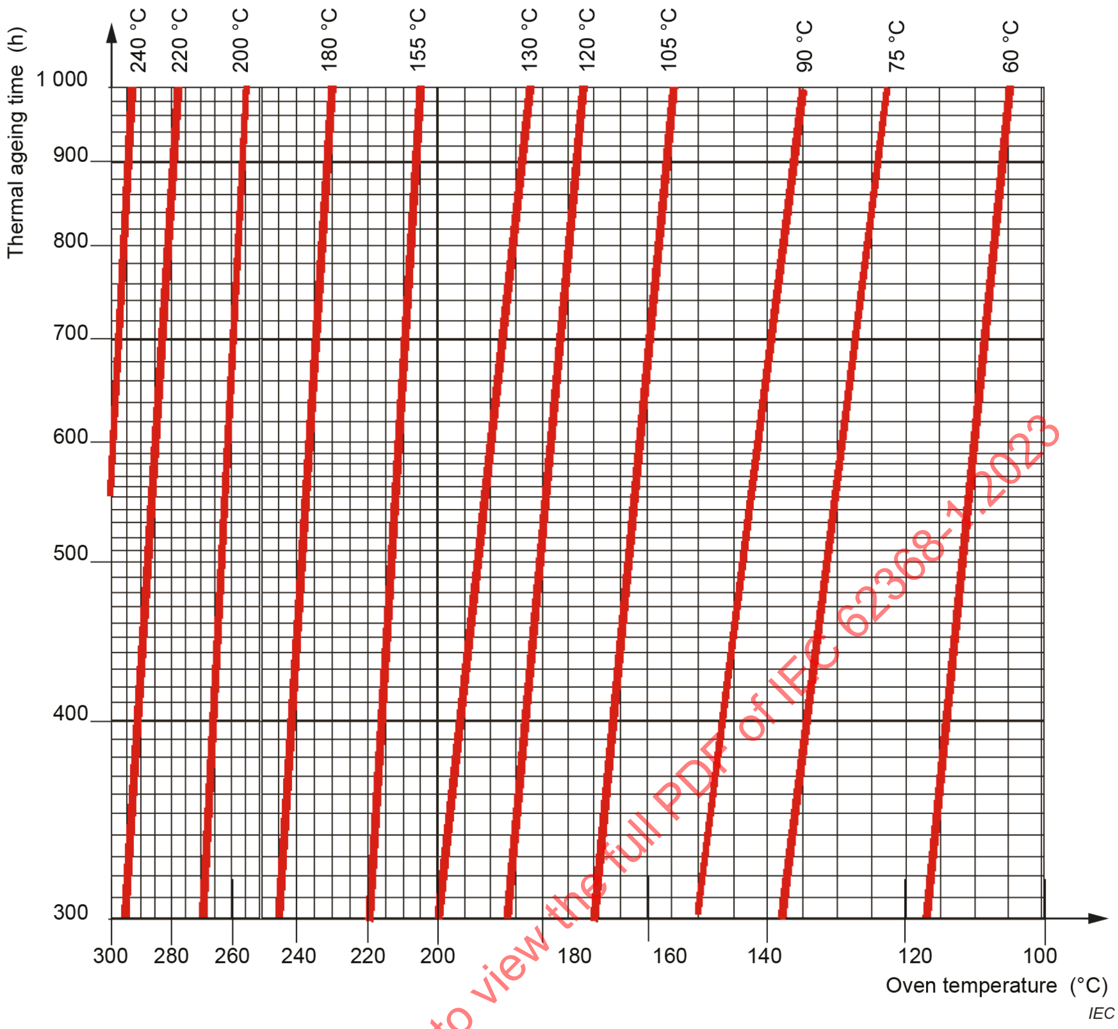


Figure G.3 – Thermal ageing time

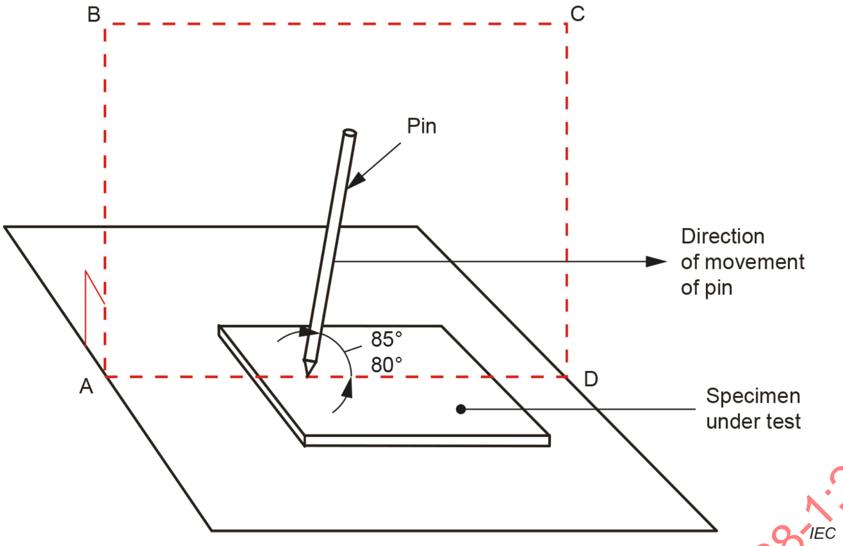
Samples 1 and 2 are then subjected to the humidity conditioning of 5.4.8 and shall withstand the electric strength test of 5.4.9.1 between conductors.

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.4. 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.4 – 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.

If mechanical stress or bending is applied to the board, additional tests to identify cracking can 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 or LFC assemblies

G.15.1 Requirements

An **LFC** or **LFC assembly** located internal to the equipment shall comply with all of the following:

– flammable or conductive **coolant** liquid shall be enclosed by the **LFC** and/or **LFC assembly**;
– the **coolant** shall be provided with protection in accordance with Clause 7;
– the **LFC** or **LFC assembl**y shall be mounted within the equipment in such a way that the non-metalic parts (for example, flexible tubing) shall not come into contact with sharp edges or any other surface that could damage the **LFC**;
– a **self-contained LFC** shall comply with the tests described in G.15.2;
– a **modular LFC** shall comply with the tests described in G.15.3. An **LFC** or **LFC assembly** that complies with IEC 61010-1, for which testing criteria is comparable and acceptable, are also considered to comply without additional test or evaluation.

The tests may be performed on separate samples and the order of tests is not specified, except that:

– after the test of G.15.2.2, the test of G.15.2.1 is conducted for a **self-contained LFC**;
– after the test of G.15.3.3, the test of G.15.3.2 is conducted for a **modular LFC**.

G.15.2 Test methods and compliance criteria for self-contained LFC

G.15.2.1 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 1 min at room temperature and at a pressure that is the highest of the following:*

– *three times the maximum working pressure specified by the manufacturer at the maximum temperature measured during **normal operating conditions**; and*
– *two times the maximum measured working pressure at the maximum temperature measured during application of the **abnormal operating conditions** and **single fault conditions**.*

G.15.2.2 Creep resistance test

*Two samples of the **LFC**, of which one or more parts are made of non-metallic materials, shall be conditioned for 14 days at a temperature of 87 °C and placed in a full draft air-circulating oven. Following the conditioning, the system shall comply with the test of G.15.2.1 and non-metallic parts shall show no sign of deterioration such as cracking and embrittlement.*

G.15.2.3 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 condition as received and the remaining five specimens after a conditioning test for 40 days 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.*

*Alternatively, the five samples of the finished **LFC assembly** shall be tested as far as the part under test is suitable for the tensile strength test. The samples of finished assembly filled with the intended liquid at the internal pressure maintained at atmospheric pressure is conditioned for 40 days at 38 °C in a full draft air-circulating oven.*

G.15.2.4 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.15.2.5 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*** and ***single fault conditions**, followed by room temperature for 1 h.*

NOTE The LFC is not energized during the above test.

G.15.2.6 Force test

*One sample of the **LFC** is subjected to:*

- *the tests of T.2 applied in the most unfavourable direction to fittings **accessible** to a **skilled person**; and*
- *the test of T.3 applied in the most unfavourable direction to fittings **accessible** to an **instructed person** or to an **ordinary person**.*

G.15.2.7 Compliance criteria

Compliance is checked by inspection and evaluation of the available data or by the tests of G.15.2. During and after these tests, there shall be no rupture, no leaks and no loosening of any connection or part.

G.15.3 Test methods and compliance criteria for a modular LFC

G.15.3.1 General

Tests listed in G.15.3 may be performed on individual components or after final system integration.

G.15.3.2 Hydrostatic pressure test

The maximum pressure of the **liquid cooling system** in **normal operating conditions**, **abnormal operating conditions**, or **single fault conditions** shall not exceed the rated maximum working pressure for a **modular LFC**.

NOTE In cases where the **liquid cooling system** pressure under **abnormal operation conditions** or **single-fault conditions** could exceed the rated pressure of a **modular LFC**, an external **safeguard** to the **modular LFC** (for example, pressure relief valve) may be used.

*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-pressurized (for example, an ink cartridge) is not subjected to this test.*

*One sample of the **LFC** or **LFC assembly** is subjected to a hydrostatic pressure test for 1 min at room temperature at a pressure that is 1,5 times the rated maximum working pressure of the **LFC** or **LFC assembly** specified by the manufacturer, or 345 kPa (50 psi), whichever is greater. If the **LFC** or **LFC assembly** incorporates a pressure relief valve that is rated above the testing criteria, the test continues up to activation of the pressure relief valve.*

G.15.3.3 Creep resistance test

*Two samples of the **LFC** or **LFC assembly** of which one or more parts are made of non-metallic materials, shall be conditioned for 14 days at a temperature of 87 °C in a full draft air-circulating oven. Following the conditioning, the system shall comply with the test of G.15.3.2 and non-metallic parts shall show no sign of deterioration such as cracking and embrittlement.*

G.15.3.4 Tubing and fittings compatibility test

*Ten samples 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 applicable standard of the ISO 527 series. Five specimens shall be tested in the condition as received and the remaining five specimens after a conditioning test for 40 days in a 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.*

*Alternatively, the five samples of the finished **LFC assembly** shall be tested as far as the part under test is suitable for the tensile strength test. The samples of finished assembly are filled with the intended liquid and conditioned for 40 days at 38 °C in a full draft air-circulated oven. The internal pressure of the assembly is maintained at atmospheric pressure.*

G.15.3.5 Thermal cycle test

*One sample of the **LFC** or **LFC assembly** 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** and **single fault conditions**, followed by conditioning at room temperature for 1 h.*

NOTE The **LFC** or **LFC assembly** is not energized during the above test.

G.15.3.6 Force test

*One sample of the **LFC** or **LFC assembly** is subjected to:*

– *the tests of T.2 applied in the most unfavourable direction to fittings **accessible** to a **skilled person**; and*

– *the test of T.3 applied in the most unfavourable direction to fittings **accessible** to an **instructed person** or to an **ordinary person**.*

G.15.3.7 Compliance criteria

Compliance is checked by inspection and evaluation of the available data or by the test 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 that includes a capacitor discharge function (ICX)

G.16.1 Requirements

An ICX and any associated components critical to the discharge function of a capacitor (such as the **mains** capacitor) to an **accessible** part are fault tested unless 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; 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
- 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, with the following test cycle:

– *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 smallest capacitance and a resistor with the smallest resistance specified by the manufacturer of the ICX. 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 as determined in 5.4.2.3.2.2.*

The impulses are to be superimposed on the ***mains*** *voltage. The* ***mains*** *voltage is taken as the maximum of:*

- *the equipment* ***rated voltage range*** *when tested in the equipment, or*
- *the maximum* ***mains*** *voltage as specified by the ICX manufacturer when tested separately.*

Where a coupling/decoupling network (CDN) is used to perform the superimposition, subclause 7.2 and 7.3 of IEC 61000-4-5:2014/AMD1:2017 or Annex A of ITU-T Recommendation K.44:2019 provide detailed guidance for the test setup.

– *Application of an AC* ***mains*** *voltage that is 120 % of the* ***rated voltage*** *for 2,5 min.*

– *10 000 cycles of the connection and disconnection of the* ***mains****. If the ICX is tested by itself, a capacitor with the largest capacitance and a resistor with the smallest resistance as specified by the manufacturer shall be used. The connection and disconnection cycle time shall not be less than 2 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 includes information of failure of any associated circuitry components that 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 H 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 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

$$I_{TS1} = \frac{I_p}{\sqrt{2}} \qquad \text{for } (t_1 \le 600 \text{ ms})$$

$$I_{TS1} = \frac{t_1 - 600}{600} \times \frac{I_{pp}}{2\sqrt{2}} + \frac{1\,200 - t_1}{600} \times \frac{I_p}{\sqrt{2}} \qquad \text{for } (600 \text{ ms} < t_1 < 1200 \text{ ms})$$

$$I_{TS1} = \frac{I_{pp}}{2\sqrt{2}} \qquad \text{for } (t_1 \ge 1\,200 \text{ ms})$$

where:

I_p *is the peak current, in mA, of the relevant waveform given in Figure 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 RMS.*

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 DC current in mA flowing through the 5 000 Ω resistor during the non-active period of the cadence cycle;*

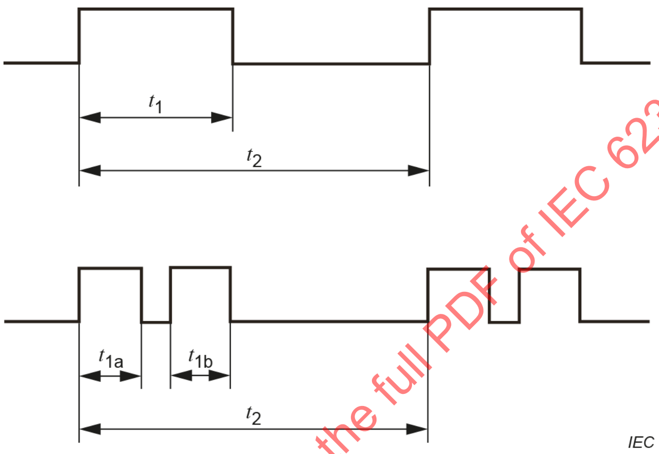
t_1 *and* t_2 *are expressed in ms.*

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

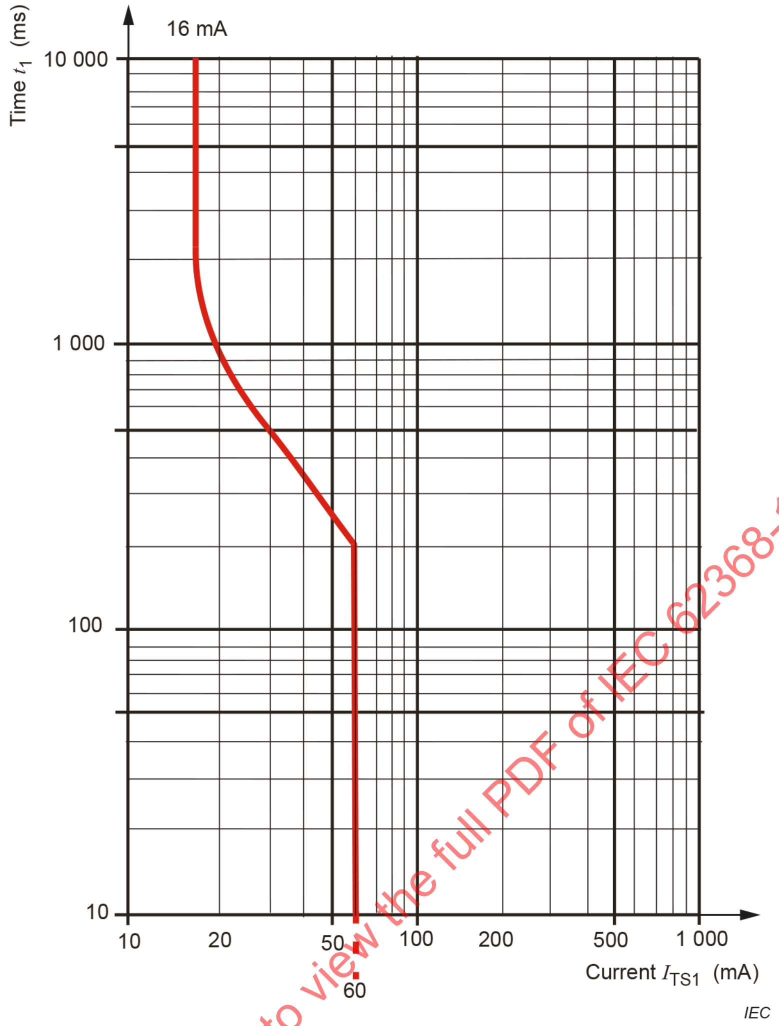


Figure H.2 – I_{TS1} limit curve for cadenced ringing signal

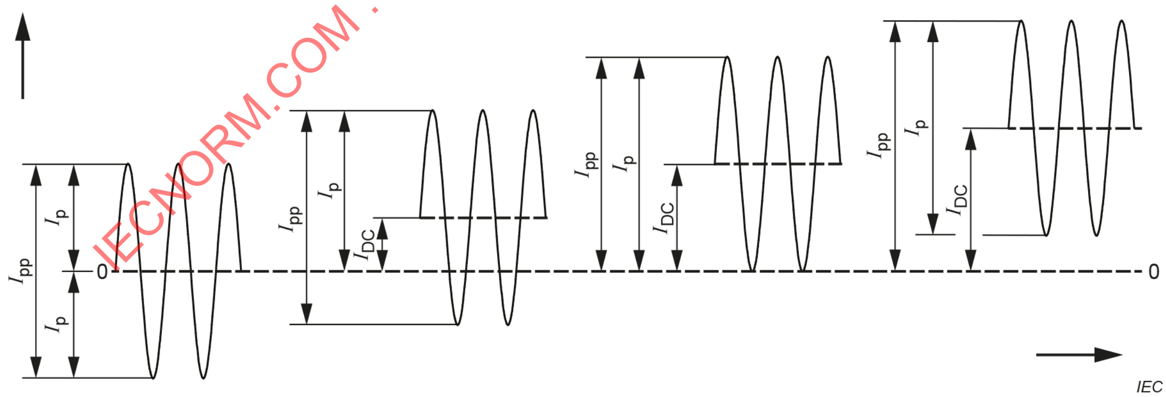


Figure H.3 – Peak and peak-to-peak currents

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 DC.

H.3.1.4 Single fault condition current

Where cadenced ringing becomes continuous as a consequence of a **single fault condition**, 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 any 500 Ω or greater resistor does not exceed 100 mA peak-to-peak, neither a tripping **device** nor a monitoring voltage is required;

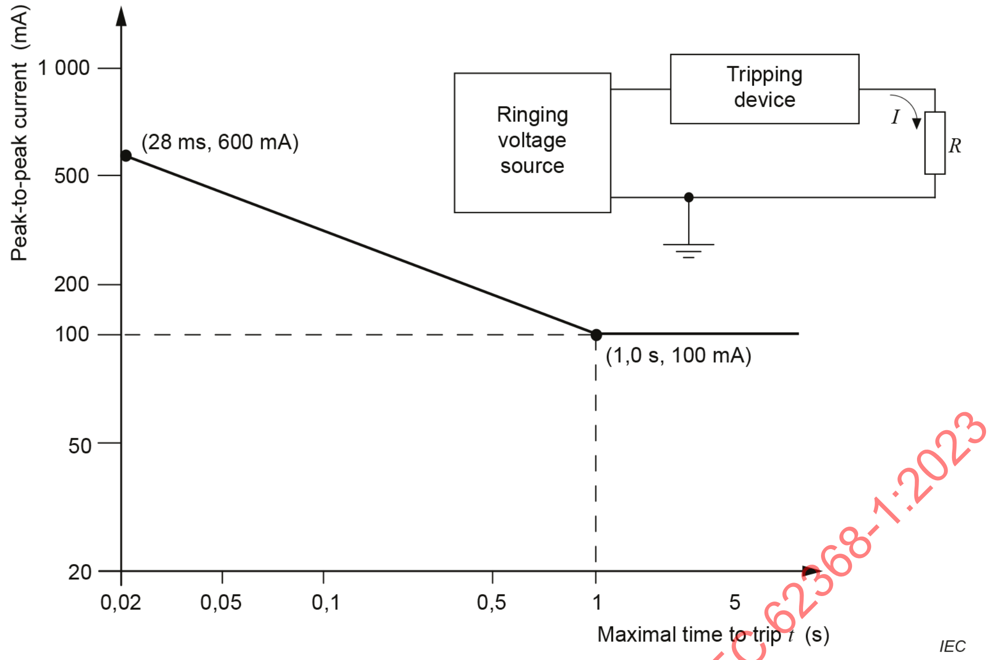
– if the current through any 1 500 Ω or greater resistor exceeds 100 mA peak-to-peak, a tripping **device** shall be included. If the tripping **device** meets the trip criteria specified in Figure H.4 with $R \geq 500$ Ω, no monitoring voltage is required. If, however, the tripping **device** only meets the trip criteria with $R \geq 1\,500$ Ω, a monitoring voltage shall also be provided;

– if the current through any 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 $R \geq 500$ Ω, 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 DC, 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 **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 document, minimum **clearances** for insulation in circuits connected to the **mains** are based on the **mains transient voltage**.

According to 4.3.2 of IEC 60664-1:2020, the value of the **mains transient voltage** is determined from the **mains** voltage and the overvoltage category, I to IV (see Table 12 and 5.4.2.3.2.3 of this document).

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, IEC 60364-4-44:2007/AMD1:2015 and IEC 60364-4-44:2007/AMD2:2018, clause 443.

NOTE 2 The term overvoltage category in this document is synonymous with rated impulse voltage category used in IEC 60364-4-44:2007, IEC 60364-4-44:2007/AMD1:2015 and IEC 60364-4-44:2007/AMD2:2018, clause 443.

For the overvoltage category of DC power distribution systems, see 5.4.2.3.2.3 and Table 12 using the **DC mains voltage** value as the value for the AC **mains** voltage in Table 12.

NOTE 3 See also Annex F of IEC 60664-1:2020 where "rated impulse withstand voltage" is replaced by "**mains** transient voltage" in this document.

Table I.1 – Overvoltage categories

Overvoltage category	Equipment and its point of connection to the AC mains	Examples of equipment
IV	Equipment that will be connected to the point where the **mains** supply enters the building	**1** Electricity meters **2** Communications ITE for remote electricity metering
III	Equipment that will be an integral part of the building wiring	**3** Socket-outlets, fuse panels and switch panels **4** Power monitoring equipment
II	Pluggable or **permanently connected equipment** that will be supplied from the building wiring	**5** Household appliances, portable tools, home electronics **6** 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	**7** 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 can be used to provide **basic insulation**, **supplementary insulation**, **double insulation** or **reinforced insulation** in wound components without interleaved insulation are specified below.

This Annex J 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 0,03 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

*Unless otherwise specified in this document, 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 %.*

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 RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS 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 60851-5:2008. 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 RMS or 8,4 kV peak for **reinforced insulation**; or*

– *3 kV RMS 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 RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS 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 RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS or 2,1 kV peak for **basic insulation** or **supplementary insulation**.*

J.2.3 Flexibility and adherence

Clause 5.1.1 (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 document, with minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS 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 %), but with a maximum force for winding on the mandrel of 100 N.

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 5.1.1 (in Test 8) of IEC 60851-3:2009, followed by the electric strength test of 5.4.9.1 in this document, with a minimum test voltage of:

– *3 kV RMS or 4,2 kV peak for **reinforced insulation**; or*

– *1,5 kV RMS 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 specified in J.2.3. 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.

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 60851-5:1996, 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 RMS or 4,2 kV peak for* ***reinforced insulation****; or*

– *1,5 kV RMS 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 manufacturer shall subject the wire to a spark test during manufacture according to IEC 62230 as specified in J.3.2 and J.3.3.

J.3.2 Spark test

The test voltage for the spark test shall be in accordance with the electric strength test of 5.4.9.1, with a minimum of:

– *3 kV RMS or 4,2 kV peak for* ***reinforced insulation****; or*

– *1,5 kV RMS 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 60417-5041 (2002-10) for hot parts; or

, IEC 60417-6056 (2011-05) for moving fan blades; or

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

any other symbol that represents the hazard being present

– 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 straight unjointed version of the test probe 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 Annex G or K.7.1 where applicable.

Compliance is checked in accordance with Annex G or K.7.1 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.*

The components and parts of the ***safety interlock*** *used as a* ***safeguard*** *mechanism are not subjected to* ***single fault conditions*** *if they comply with K.2 or K.6 as applicable.*

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 or K.7.1.

K.7 Interlock circuit isolation

K.7.1 Separation distances for contact gaps and interlock circuit elements

Separation distances for contact gaps and interlock circuit elements shall comply with the following requirements as applicable.

a) 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).

b) 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, such as the fixed separation distances in a **safety interlock** circuit, shall comply with the requirements of 5.4.2 for basic insulation. The **temporary overvoltage** is not taken into account to determine the voltage to be used in Table 10 and Table 11 unless the circuit is subject to a **temporary overvoltage**.

c) 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, such as the fixed separation distances in a **safety interlock** circuit, shall comply with the requirement of 5.4.2 for **basic insulation**, except that if a life-threatening hazard is involved in the interlocked space, the fixed separation distances shall comply with the requirement for **reinforced insulation**. The **temporary overvoltage** is not taken into account to determine the voltage to be used in Table 10 and Table 11 unless the circuit is subject to a **temporary overvoltage**.

As an alternative to a), b) and c), the separation distances for the contact gap between contacts in the off position shall withstand the electric strength test of 5.4.9.1 required for **basic insulation** or **reinforced insulation**, as applicable. The contact gap shall comply with the above requirements before and after the test of K.7.2.

The altitude multiplication factor of Table 16 does not need to be taken into account.

The separation distances for the contact gap of the switch or relay shall comply with K.7.3 and K.7.4 in addition to the above requirements, unless the switch or relay complies with G.1 and G.2 respectively. The endurance test condition shall represent the maximum **normal operating condition** within the equipment with respect to voltage and current that the contacts interrupt.

Two independent interlock systems, in series, using **basic insulation** may be used as an alternative to the provision of **reinforced insulation**.

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 the **direct plug-in equipment**; 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 AC **mains** that is overvoltage category **I**, overvoltage category **II** or overvoltage category **III**, or from a DC **mains** that is ES3, a **disconnect device** shall have a contact separation of at least 3 mm. For an AC **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 DC **mains** that is not at ES3 levels,

– a **disconnect device** shall have a contact separation at least equal to the minimum **clearance** for **basic insulation**; and
– 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** may 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 distribution 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 distribution 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 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

Except for equipment supplied from ES1 and in which ES2/ES3 is not generated, 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 near each **disconnect device** giving adequate instructions for the removal of all power from the unit.

One **instructional safeguard** may be used for more than one **disconnect device**, as long as it is clearly visible from the disconnect points.

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 text, and "Electrical shock hazard" or equivalent text

– element 3: optional

– element 4: "Disconnect all power sources" or equivalent text

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 M provides additional requirements for equipment that contains **batteries**. Use of **batteries** in the equipment can require **safeguards** that have not been addressed in other parts of this document. This Annex M 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**.

This annex also applies where a **battery** can be removed from the equipment for charging with an external **battery** charger intended to charge **batteries** for equipment within the scope of this document.

Where a **battery** safety standard contains equivalent requirements to the requirements in this Annex M, a **battery** in compliance with that **battery** standard is considered to fulfil the corresponding requirements of this Annex M, and tests that are part of the **battery** safety standard need not be repeated under this Annex M.

For the following types of non-rechargeable consumer grade primary **batteries**, M.3 and M.10 apply:

– carbon zinc;

– alkaline.

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 (all parts), IEC TS 61430, IEC 61434, IEC 61959, IEC 62133-1, IEC 62133-2, IEC 62281, IEC 62485-2 and IEC 62619.

For **batteries** used for sub-system powering applications in **stationary equipment**, IEC 62133-2 may be used as an alternative to IEC 62619.

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 or construction 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; and

– for **batteries** that are replaceable by an **ordinary person**, reverse polarity installation shall be prevented if this could create a class 2 or class 3 energy source (see also B.3.6).

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).*

– *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 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.*

*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 test applies:*

– *Reverse charging of a rechargeable **battery**. Check whether the equipment containing a **battery** has such construction design that the **battery** can 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.*

  *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.*

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**; and*

– *the charging current and charging voltage shall comply with M.4.2.*

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 **secondary lithium batteries**, except for coin-cell **secondary lithium batteries** with an internal resistance greater than 3 Ω, are subject to the requirements in this clause. For measuring the internal resistance of the **cell**, see Annex D of IEC 62133-2:2017.

For **batteries** complying with IEC 62133-2 and used for sub-system powering applications in **stationary equipment** where electric, electronic and software controls and systems are relied upon as a **safeguard**, shall in addition either:

– comply with 8.1 of IEC 62619:2022; or

– be protected by a **supplementary safeguard**. Such a **supplementary safeguard** shall be

  - in accordance with G.3; or
  - in accordance with Annex F of IEC 62133-2:2017; or
  - a **fire enclosure** in accordance with 6.4 in addition to the **enclosure** of the **battery**; or

- some other equivalent **safeguard**.

M.4.2 Charging safeguards

M.4.2.1 Requirements

Under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** the charging voltage, the charging current and the cell temperature shall be within the battery/cell manufacturer´s specification (see 3.3.17.4, Note 1 to entry).

M.4.2.2 Test

M.4.2.2.1 General

*Tests are performed under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions**, measuring all of the following parameters:*

– *cell temperature;*

– *charging voltage;*

– *charging current.*

***Cell** temperatures shall be measured at the points where the highest temperatures are obtained.*

NOTE 1 The measurement points where the highest temperatures are obtained can be different by the application of ***abnormal operating conditions*** *or* ***single fault conditions***.

NOTE 2 For potted assemblies, thermocouples could be attached to the cell surface before potting.

*The charging voltage and charging current shall be measured while the **battery** is charging until the **battery** becomes fully charged. At the start of the test, the equipment shall be in a discharged state using the manufacturer's recommended method.*

*The charging current shall be measured during the entire charging cycle up to the **maximum specified charging voltage**.*

*The charging current of each **cell** shall be measured, except when one of the following conditions are met:*

– *the charging current is inherently limited to a value equal to or less than the maximum charging current specified by the cell manufacturer for a single cell; or*

– *the charging circuit design or protection device (for example, a PTC) limits the charging current to a value equal to or less than the maximum charging current of a single **cell** within the battery as specified by the **cell** manufacturer.*

*In case of doubt, the charging voltage, current, or temperature of each **cell** shall be measured.*

*Where appropriate for the purpose of the measurement, the **battery** may be replaced by a circuit simulating the **battery** load.*

*Additionally, where the **battery** can be removed from the equipment and charged externally, testing with manufacturer's designated external charger or manufacturer's specified charging method (for example, through USB) shall be performed.*

M.4.2.2.2 Abnormal operating conditions

***Abnormal operating conditions** that can affect the charging voltage, charging current, or the **cell** temperature shall be applied in accordance with Clause B.3.*

Ambient temperatures beyond the equipment temperature ratings (above and below), shall be used that are sufficient to validate the operation of the ***battery*** *charging* ***safeguards*** *in accordance with M.4.2.3.*

The testing shall be conducted in a temperature chamber by decreasing/increasing the chamber temperature at a rate that allows stabilisation before the next decrease/ increase in chamber temperature in order to verify ***battery*** *temperature* ***safeguard*** *operation point.*

M.4.2.2.3 Single fault conditions

Single fault conditions *that can affect the charging voltage, the charging current, or the cell temperature shall be applied in accordance with Clause B.4.*

Single fault conditions *involving temperature sensing devices, in accordance with B.2.4, shall be considered if this results in the charging* ***safeguards*** *being defeated. In such cases, the equipment and/or* ***battery*** *charging circuit shall take appropriate action.*

M.4.2.3 Compliance criteria

During and after the tests, the following applies:

Under ***normal operating conditions***, ***abnormal operating conditions*** *within the equipment temperature ratings,* ***and single fault conditions****:*

- *the charging voltage shall not exceed the* ***maximum specified charging voltage****; and*
- *the charging current shall not exceed the* ***maximum specified charging current****; and*
- *the* ***cell*** *temperature of each individual* ***cell*** *shall not exceed the* ***highest maximum specified charging temperature****.*

If the ***cell*** *manufacturer specifies more than one charging temperature operating range with different values for charging voltage and charging current, each charging operating range shall be checked.*

Under ***abnormal operating conditions*** *outside the equipment temperature ratings:*

- *when the temperature of the* ***battery*** *exceeds the* ***highest specified charging temperature****, the* ***battery*** *charging circuit shall stop charging; and*
- *when the* ***battery*** *temperature is lower than the* ***lowest specified charging temperature****, the* ***battery*** *shall stop charging.*

If the ***battery*** *manufacturer specifies more than one charging temperature operating range with different values for charging voltage and charging current, each charging operating range shall be checked.*

NOTE 1 The term operating range is considered to have the same meaning as operating region as detailed in Annex A of IEC 62133-2:2017.

Under ***abnormal operating conditions*** *or* ***single fault conditions****, a charging voltage or charging current is permitted to exceed the* ***maximum specified charging voltage*** *or the* ***maximum specified charging current*** *as long as one of the following conditions occur:*

- *activation of a* ***supplementary safeguard*** *which prevents an unsafe condition of the* ***battery*** *(for example, a thermal fuse); or*
- *activation of a protection device or circuitry (for example, a protection circuit module (PCM) or a PTC* ***device****) which prevents these voltages or currents from reaching the* ***cell****(s) terminals.*

A higher voltage and/or current is permitted elsewhere in the charging circuit. Also short transient voltage/current levels within the time limit of the protection device/circuitry specification are permitted relating to operation of a PCM.

*Under **normal operating conditions**, **abnormal operating conditions** and **single fault conditions** no fire or **explosion** during or after test shall occur.*

NOTE 2 Venting without flame, fire or expulsion of solid materials is a **safeguard** of a **secondary lithium battery**.

M.4.3 Fire enclosure

Secondary lithium batteries shall be provided with a **fire enclosure**. 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 exempt from this requirements if the equipment uses a **cell** or a combination of **cells** that complies with PS1.

Where the **fire enclosure** is part of the end product:

– materials and openings shall comply with 6.4.8; and
– a **cell** or any combination of **cells** exceeding PS1 are considered to be a **resistive PIS**.

Where the **fire enclosure** is part of the **battery** itself:

– the material shall:
  - comply with the requirements of Clause S.1; or
  - be made of **V-1 class material**; or
  - be made of non-**combustible material**.
– the **battery** shall be enclosed on all sides with openings not exceeding 3 mm in any dimension.

*Compliance is checked by inspection of the relevant material or by evaluation of the **secondary lithium battery** data sheet.*

For determining the power level, consideration should be given to the configuration. Power dissipation is based on the internal resistance of the **cell** and the circuit load. The same quantity of **cells** will have a different power dissipation depending on a serial or parallel configuration of the **cells**.

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 tests 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 can 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.*

The compliance criteria of M.3.3 apply.

M.6 Safeguards against short-circuits

M.6.1 Requirements

The electric energy stored in **cells** or **batteries** can 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, care is taken to use insulated **tools**.

Unless internal fault testing has been conducted on the **cell** 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.6.2 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.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 can 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.

In a compartment containing both a **battery** and electrical components, the risk of ignition of local concentrations of hydrogen and oxygen by adjacent operational arcing parts, such as contactors and switches close to **battery** vents or valves, shall be controlled. This shall be achieved, for example, by the use of fully enclosed components, separation of **battery** compartments or adequate ventilation.

The ventilation system shall be so constructed that any potential fault, including distortion of the **battery** cases due to overheating or thermal runaway, does not result in the ventilation system failing to vent **explosive** gasses.

If ventilation tubes are used for conducting **explosive** gas from the **battery** cases to the outside air, they shall not be the only means of eliminating the build-up of gas from the cabinet. An independent means of natural ventilation that adequately ventilates the **enclosure** containing the **batteries** shall be provided.

If mechanical or forced-air ventilation is used, adequate ventilation shall continue to be provided under **single fault conditions**.

Enclosures with mechanical or electromechanical dampers shall continue to provide adequate ventilation when the damper is in the closed position.

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.

If it can be shown that the ventilation capability of the **enclosure** is compliant with the calculated required ventilation air flow (Q) according to M.7.2, the equipment is in compliance with Clause M.7. Unless it can be demonstrated under a **single fault condition** in the charging circuitry that the charge voltage cannot exceed the values for float charging in Table M.1, or if the **battery enclosure** contains no internal charging capability, calculations shall be conducted for boost charge condition for the **battery** types and maximum capacity specified and approved by the manufacturer. If the ventilation cannot be adequately shown, one of the ventilation tests in M.7.3 shall be conducted in order to ensure adequate ventilation.

The hydrogen generation (flow rate for testing) for the maximum supported **battery** capacity and supported **battery** types shall be calculated using data from the **battery** manufacturer, or the values for I_{float} and I_{boost} with supporting data as given in Table M.1 or by the following:

$$q_{\text{Batt}} = 0{,}45 \times 10^{-3} \frac{\text{m}^3}{\text{Ah}} \times I_{\text{gas}} \times C_{\text{rt}} \times n$$

with I_{gas}, C_{rt}, and n as described in M.7.2.

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 gas concentration shall not exceed 1 % by volume if the mixture is in proximity to an ignition source, and not exceed 2 % by volume if the mixture is not in proximity to an ignition source.*

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:*

$$Q = v \times q \times s \times n \times I_{\text{gas}} \times C_{\text{rt}} \times 10^{-3} \quad \left[\text{m}^3/\text{h}\right]$$

where:

Q *is the ventilation air flow in m^3/h;*

v *is the necessary dilution of hydrogen:*

$$\frac{(100-4)\,\%}{4\,\%}=24\,;$$

q $= 0{,}45 \times 10^{-3}\left[\mathrm{m^3/Ah}\right]$ *generated hydrogen at 20 °C;*

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 5 h 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 for current I_{float} and I_{boost}, factors f_g and f_s, and voltages U_{float} and U_{boost}

Parameter	Lead-acid batteries vented cells Sb < 3 % [a]	Lead-acid batteries VRLA cells	NiCd batteries vented cells [b]
Gas emission factor f_g	1	0,2	1
Gas emission safety factor f_s (including 10 % faulty **cells** and ageing)	5	5	5
Float charge voltage U_{float} [c] V/**cell**	2,23	2,27	1,40
Typical float charge current I_{float} mA/Ah	1	1	1
Current (float) I_{gas} mA/Ah (under float charge conditions relevant for air flow calculation)	5	1	5
Boost charge voltage U_{boost} [c] V/**cell**	2,40	2,40	1,55
Typical boost charge current I_{boost} mA/Ah	4	8	10
Current (boost) I_{gas} mA/Ah (under boost charge conditions relevant for air flow calculation)	20	8	50

[a] For an antimony (Sb) content higher than 3 %, the current used for calculations shall be doubled.

[b] For recombination type NiCd **cells** consult the manufacturer.

[c] Float and boost charge voltage can vary with the specific gravity of electrolyte in lead-acid **cells**.

The values of float and boost charge current increase with temperature. The consequences of an increase in temperature, up to a maximum of 40 °C, have been accommodated in the values in Table M.1.

In case of use of gas recombination vent plugs, the gas producing current I_{gas} the values for vented cells may be reduced to 50 % of the values for vented **cells**.

The ventilation air volume requirements, for example, for two 48 V strings of VRLA **cells** in the same **battery** cabinet and each with 120 Ah rated C_{10} capacity amount, under float and under boost charge service conditions are:

– service with float charge condition only: Q = 0,05 × 24 × 1 × 120 × 0,001 = 0,144 m^3/h per string or 288 l/h total;

– service with boost charge condition: Q = 0,05 × 24 × 8 × 120 × 0,001 = 1,15 m^3/h per string or 2 300 l/h total.

*For recombinant NiCd cells, or for lead-acid **battery** types where the gassing rate in volts per cell per hour (per ampere-hour) is published by the manufacturer, it is permitted to determine the minimum air flow rate Q using the measure gas emissions at boost-charge volts per cell charging, unless it can be verified that the output voltage of the charging circuit cannot exceed the float voltage under any conditions required by this document. The equation for Q becomes:*

$$Q = v \times s \times n \times r\ (\times C_{rt}) \times 10^{-3}\ (m^3/h)$$

where

v *= 24, the necessary dilution of hydrogen;*

s *= 5, general safety factor;*

n *is the number of **cells**;*

r *is the outgassing rate at a given voltage per cell per hour (may be per ampere-hour rating);*

C_{rt} *is the capacity C_{10} for lead acid **cells** (Ah) or capacity C_5 for NiCd **cells** (Ah).*

NOTE C_{rt} is not required for determining Q if the gassing rate r is provided in ml/(h-***cell***) or the equivalent.

For the purpose of calculating the area of ventilation openings required for natural ventilation, the air velocity is assumed to be 0,1 m/s.

Alternately, the following equation may be used:

$$A = 28 \times Q$$

where

Q *is the ventilation rate of fresh air (m^3/h);*

A *is the free area of openings in air inlet and outlet (cm^2).*

M.7.3 Ventilation tests

M.7.3.1 General

*The test shall be performed with the EUT stabilized at 25 °C. If forced air ventilation is used, it shall be run under **single fault conditions**. Movable mechanical or electro-mechanical dampers shall be closed or in the unpowered position. The air movement around the cabinet shall be minimized, or the EUT shall be placed in a cabinet to prevent air movement around the EUT during testing.*

M.7.3.2 Ventilation test – alternative 1

*Samples of the atmosphere within the **battery** compartment shall be taken after 7 h of operation. The samples shall be taken at locations where the greatest concentration of hydrogen gas is likely. The hydrogen gas concentration shall not exceed 1 % by volume if the mixture is in proximity to an ignition source, and not exceed 2 % by volume if the mixture is not in proximity to an ignition source. See M.3.2 for evaluating the overcharging of a rechargeable **battery**.*

M.7.3.3 Ventilation test – alternative 2

*The performance of the EUT **battery** ventilation system shall be verified by conducting a test utilizing hydrogen, or helium to represent hydrogen.*

The test will determine if the EUT is capable of ventilating the calculated hydrogen generation rate.

*Step 1 Helium or hydrogen sensors (depending on the chosen gas) shall be placed in all cabinet compartments that are subjected to hydrogen evolution from the **battery** compartment.*

*Step 2 Helium or hydrogen shall be injected into the **battery** compartment until a concentration of 1 % or 2 % as required below is reached. The rate of helium or hydrogen injection required to maintain the concentration under steady state conditions shall be reported. Steady state shall be defined as a maximum variation of ± 0,25 % over a period of 1 h.*

Step 3 Compare the rate of helium or hydrogen obtained in Step 2 with the calculated hydrogen generation rate in M.7.1.

If the calculated hydrogen generation rate for the maximum ***battery*** *capacity as specified by the manufacturer exceeds the amount of helium or hydrogen that was being injected by more than 1 % by volume if the mixture is in proximity to an ignition source, or exceeds 2 % by volume if the mixture is not in proximity to an ignition source, the EUT compartment ventilation system is not in compliance with this requirement.*

If the calculated hydrogen generation rate, for the maximum ***battery*** *capacity as specified by the manufacturer, is less than or equal to the rate of helium or hydrogen that was being injected, the EUT compartment ventilation system is in compliance with this requirement.*

M.7.3.4 Ventilation test – alternative 3

The test shall be performed as described in M.7.3.1 with a hydrogen or helium source used to inject a flow rate described in M.7.1. Samples of the atmosphere within the ***battery*** *compartment or other area where hydrogen can accumulate is continuously monitored for 7 h or until the levels are stable. Steady state shall be defined as a maximum variation of ±0,25 % over a period of 1 h. The gas monitored in this manner shall be returned to the EUT under test. The hydrogen gas concentration shall not exceed 1 % by volume if the mixture is in proximity to an ignition source, and not exceed 2 % by volume if the mixture is not in proximity to an ignition source. The sampling method in the original test may also be used, however, if hydrogen is used, care should be taken to establish that safe levels exist in the EUT prior to injecting for 7 h.*

NOTE This method is particularly suited to evaluating mixed or complex systems or ventilation patterns.

M.7.4 Marking requirement

Unless the **batteries** are provided with the equipment, the compartment shall be marked either with the supported **battery** types and the maximum capacities or "Use only batteries approved by the manufacturer", provided that this information is specified in the installation/service instructions.

M.8 Protection against internal ignition from external spark sources of rechargeable batteries with aqueous electrolyte

M.8.1 General

The requirements specified below apply to rechargeable **batteries** with aqueous electrolyte 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 may 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 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 can 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 may 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 kelvin (293 K = 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).

NOTE LEL is equivalent to the abbreviation LFL in IEC 60079-10-1:2020.

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

$$Q = f \times \left(\frac{dV}{dt}\right)$$

$$Q = 0{,}05 \times (N) \times I_{\text{gas}} \times C_{\text{rt}} \times 10^{-3} \qquad [\text{m}^3/\text{h}]$$

This hourly ventilation air flow Q can be used to define a hypothetical volume. Assuming a hemispherical dispersal of gas, a volume of a hemisphere V_z = 2/3 π 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:

$$d^3 = \frac{3}{2\pi} \times 0{,}05 \times 10^6 \times (N) \times I_{\text{gas}} \times C_{\text{rt}} \qquad \left[\text{mm}^3\right]$$

$$d = 28{,}8 \times \left(\sqrt[3]{N}\right) \times \sqrt[3]{I_{\text{gas}}} \times \sqrt[3]{C_{\text{rt}}} \qquad [\text{mm}]$$

Depending on the source of gas release, the number of **cells** per monobloc **battery** (N) or vent openings per **cell** involved ($1/N$) shall be taken into consideration (for example, by the factor $\sqrt[3]{N}$, respectively $\sqrt[3]{1/N}$).

The distance d as a function of the rated capacity for various charge currents I (mA/Ah) is shown in Figure M.1.

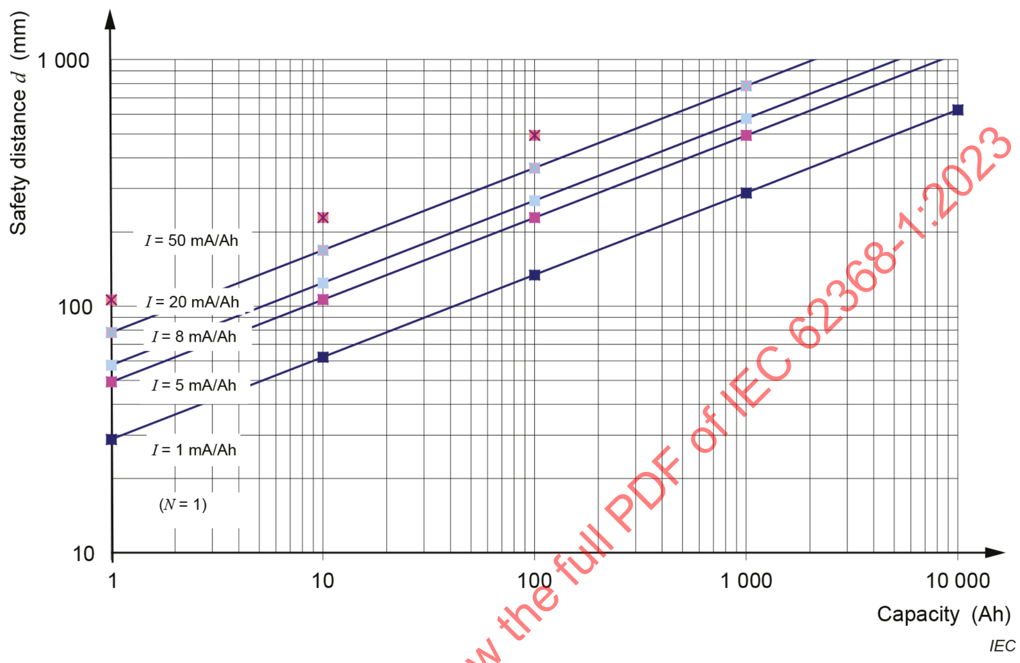


Figure M.1 – Distance d as a function of the rated capacity for various charge currents I (mA/Ah)

M.9 Preventing electrolyte spillage

M.9.1 Protection from electrolyte spillage

Equipment shall be constructed so that spillage of electrolyte from **batteries** that can 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 the 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 provided with **instructional safeguards** to avoid **reasonably foreseeable misuse** and to protect the **battery** from extreme conditions and user's abuse beyond the manufacturer's intended conditions for use, storage and transportation. The **instructional safeguards** shall be in accordance with F.5 except that the complete **instructional safeguard** may be provided in instructions. This requirement does not apply if the equipment or its **battery** complies with the relevant requirements in this document or the applicable **battery** standards with such misuse and extreme conditions taken into account.

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; and
– a **battery** subjected to extremely low air pressure that can result in an **explosion** or the leakage of flammable liquid or gas.

For the replacement of a **battery**, the elements of the **instructional safeguard** shall be as follows:

– elements 1a or 1b: not required
– element 2: "CAUTION" or equivalent text
– element 3: "Risk of fire or explosion if the battery is replaced by an incorrect type" or equivalent text
– element 4: optional

Compliance is checked by inspection or by evaluation of available data provided by the manufacturer.

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
Cr = Chromium Ni = Nickel										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

Magnesium, magnesium alloys	Zinc, zinc alloys	80 tin/20 zinc on steel, zinc on iron or steel I	Aluminium	Cadmium on steel	Aluminium/magnesium alloy	Mild steel	Duralumin	Lead	Chromium on steel, soft solder	Cr on Ni on steel, tin on steel, 12 % Cr stainless 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	0,15	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

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 shall be avoided.

Annex O
(normative)

Measurement of creepage distances and clearances

In the following Figure O.1 to Figure O.16, 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 equal to or more than 3 mm, the value of X is given in Table O.1.

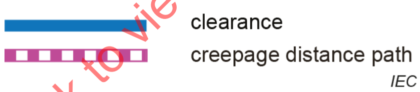
If the required minimum **clearance** is less than 3 mm, the value of X is the smaller of:

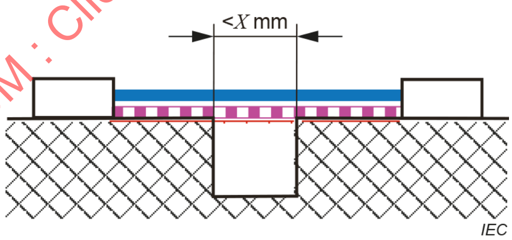
– the relevant value in Table O.1; or
– one third of the required minimum **clearance**.

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 O, the following convention is used:

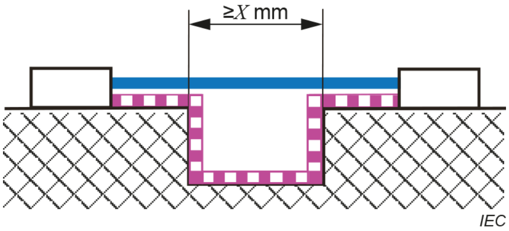




Condition: Path under consideration includes a parallel or converging-sided groove of any depth with width less than X mm.

Rule: **Creepage distance** and **clearance** are measured directly across the groove.

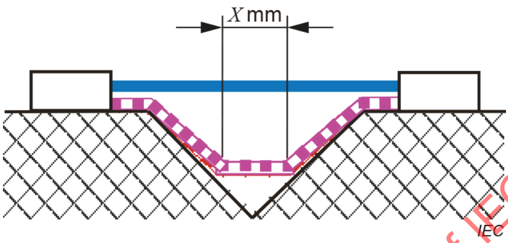
Figure O.1 – Narrow groove



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.

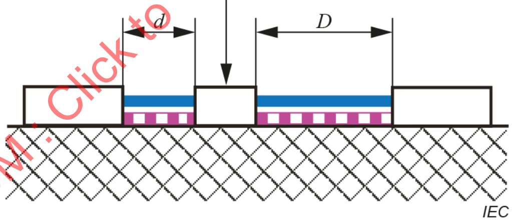
Figure O.2 – Wide groove



Condition: Path under consideration includes a V-shaped groove with 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.

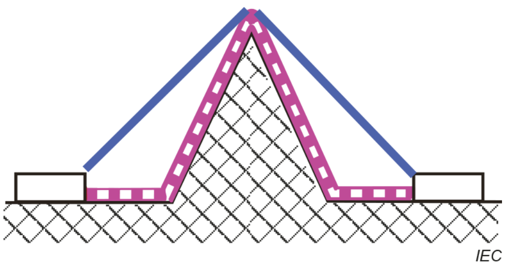
Figure O.3 – V-shaped groove



Condition: Insulation distance with intervening, unconnected conductive part.

Rule: **Clearance** is the distance $d + D$, **creepage distance** is also $d + D$.

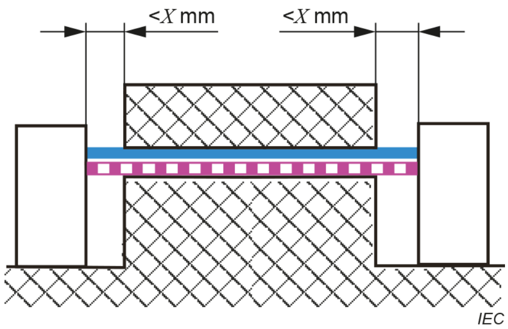
Figure O.4 – Intervening unconnected conductive part



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.

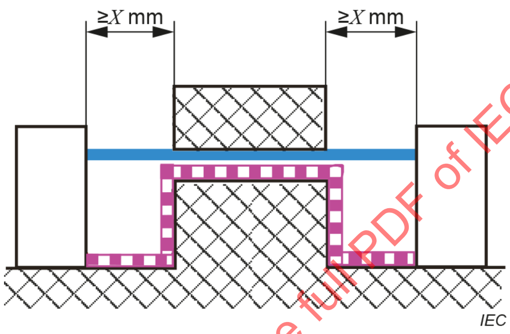
Figure O.5 – Rib



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.

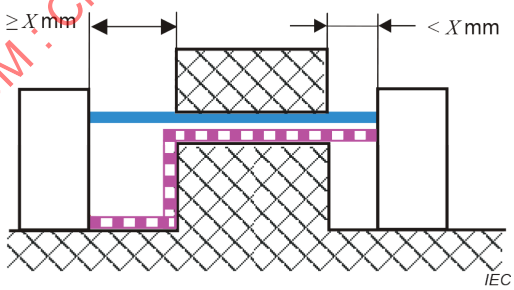
Figure O.6 – Uncemented joint with narrow groove



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.

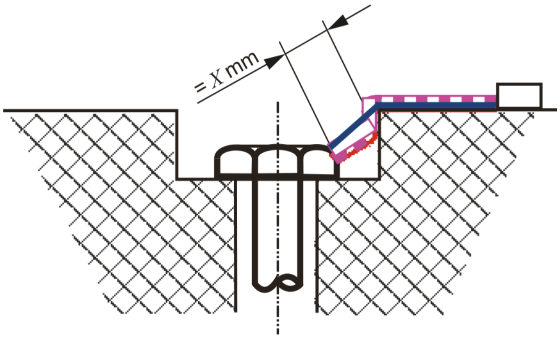
Figure O.7 – Uncemented joint with wide groove

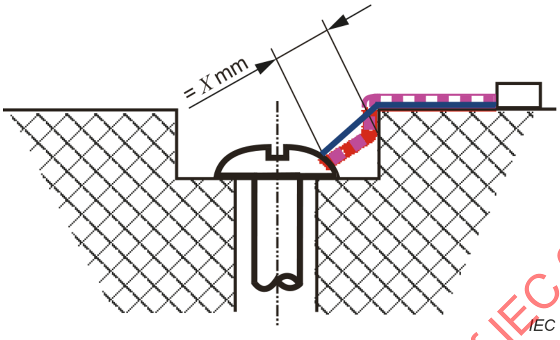


Condition: Path under consideration includes an uncemented joint with grooves on one side less than *X* mm wide, and a groove on the other equal to or more than *X* mm wide.

Rule: **Clearance** and **creepage distance** path are as shown.

Figure O.8 – Uncemented joint with narrow and wide grooves

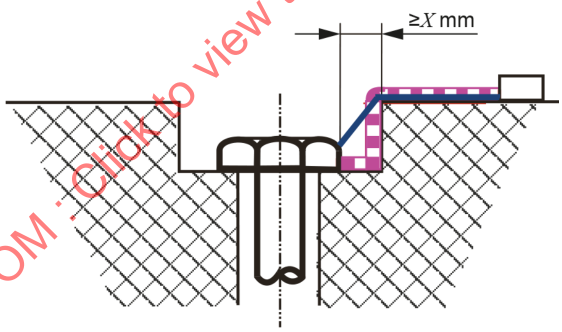


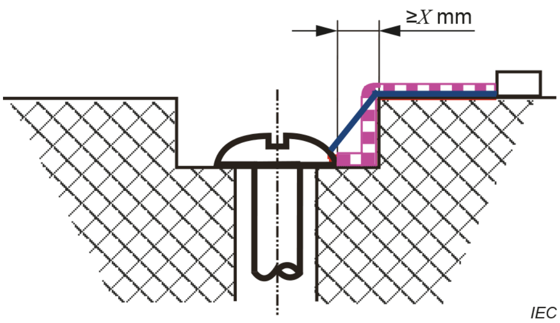


Gap between head of screw and wall of recess too narrow to be taken into account.

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

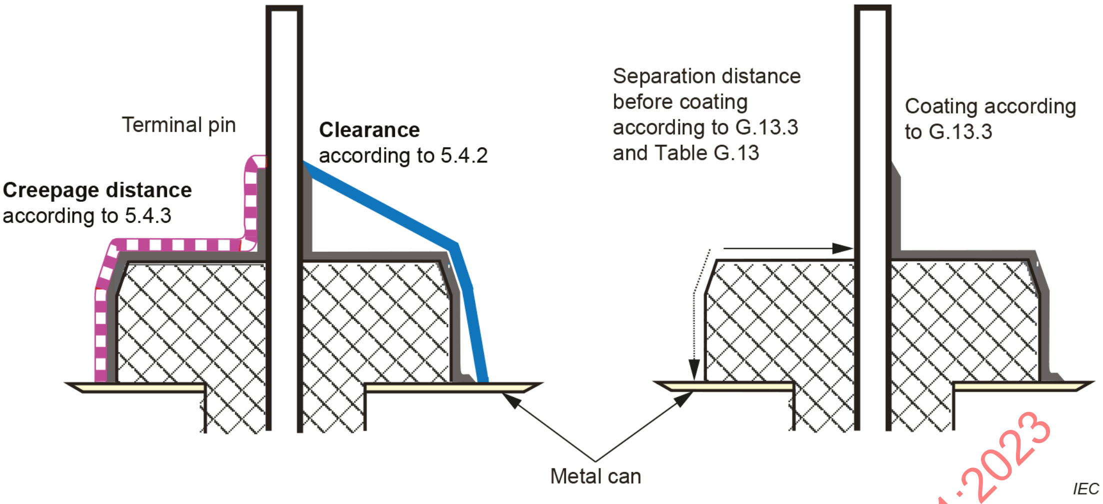


Figure O.11 – Coating around terminals

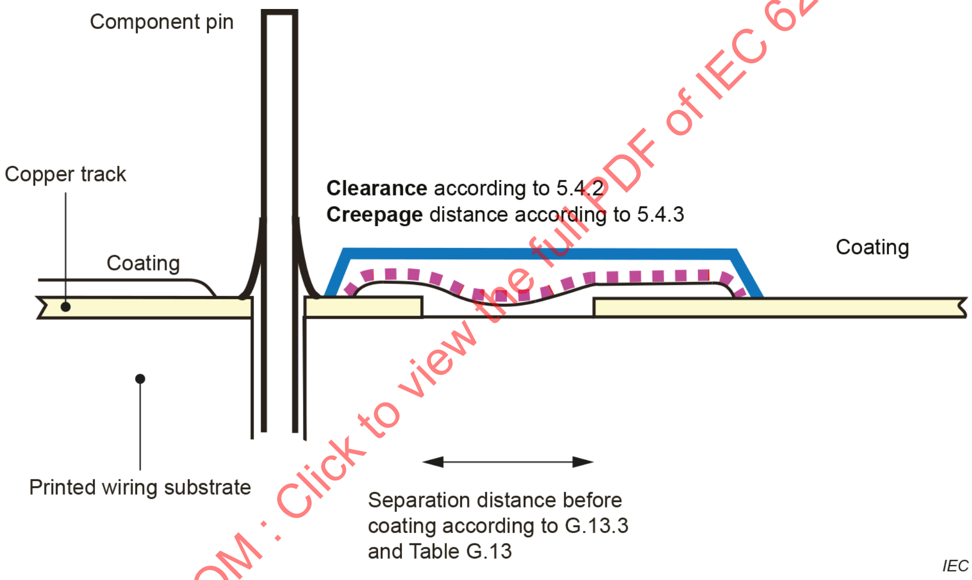


Figure O.12 – Coating over printed wiring

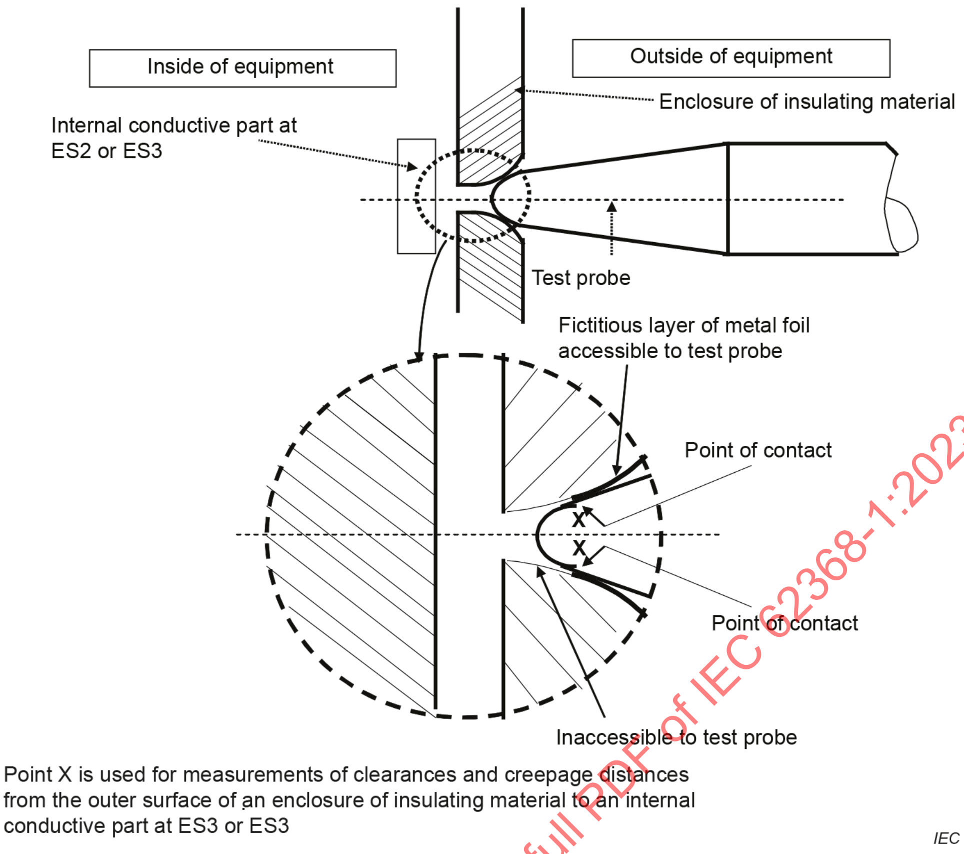


Figure O.13 – Example of measurements in an enclosure of insulating material

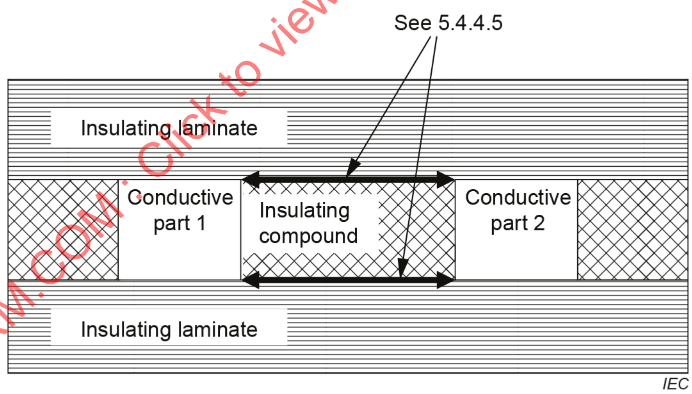


Figure O.14 – Cemented joints in multi-layer printed boards

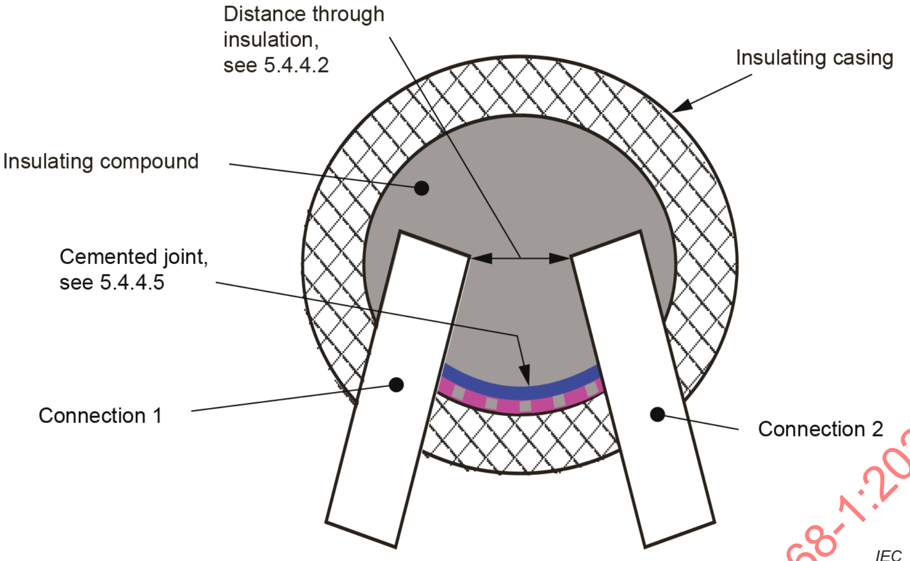


Figure O.15 – Device filled with insulating compound

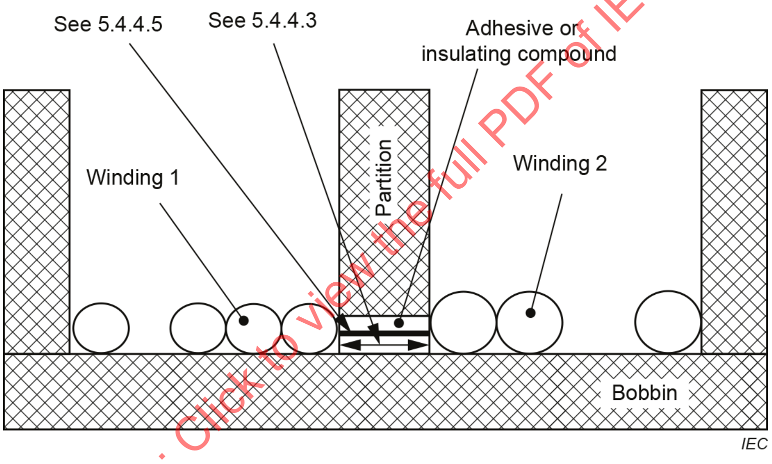


Figure O.16 – Partitioned bobbin

Annex P
(normative)

Safeguards against conductive objects

P.1 General

This Annex P 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 metallized 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 P are **supplementary safeguards**.

This Annex P 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.4 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

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**.

Any one of 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 according to IEC 60529;
- 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;
- side openings that do not exceed 11 times the thickness of the **enclosure**, as described in Figure P.3.

Compliance is checked by inspection or measurement.

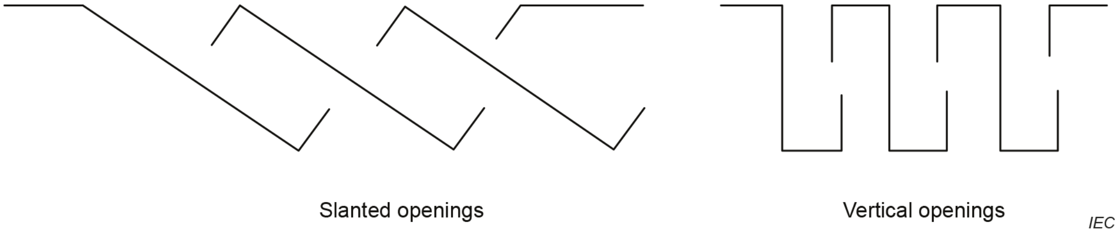


Figure P.1 – Examples of cross-sections of designs of top openings which prevent vertical entry

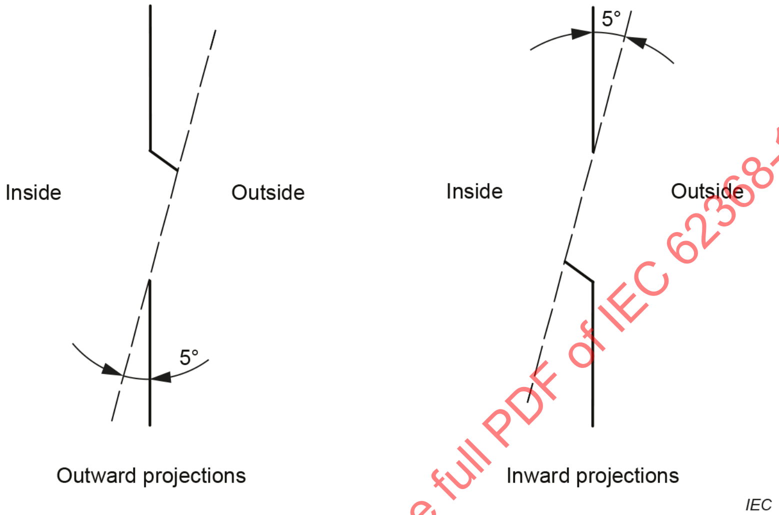


Figure P.2 – Examples of cross-sections of designs of side opening louvres which prevent vertical entry

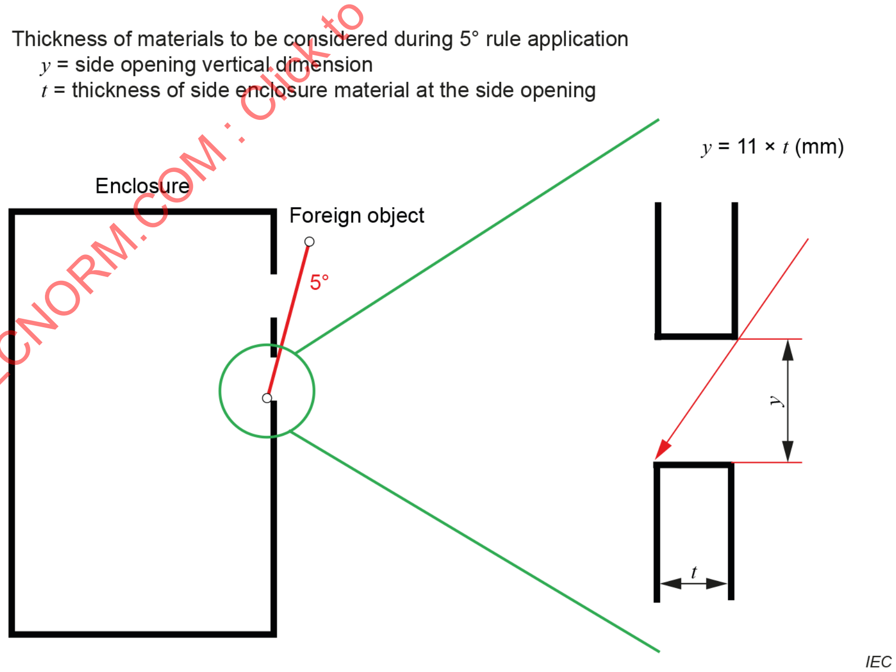


Figure P.3 – Enclosure thickness Safeguards against the consequences of entry of a foreign object

P.2.2 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.4 there are

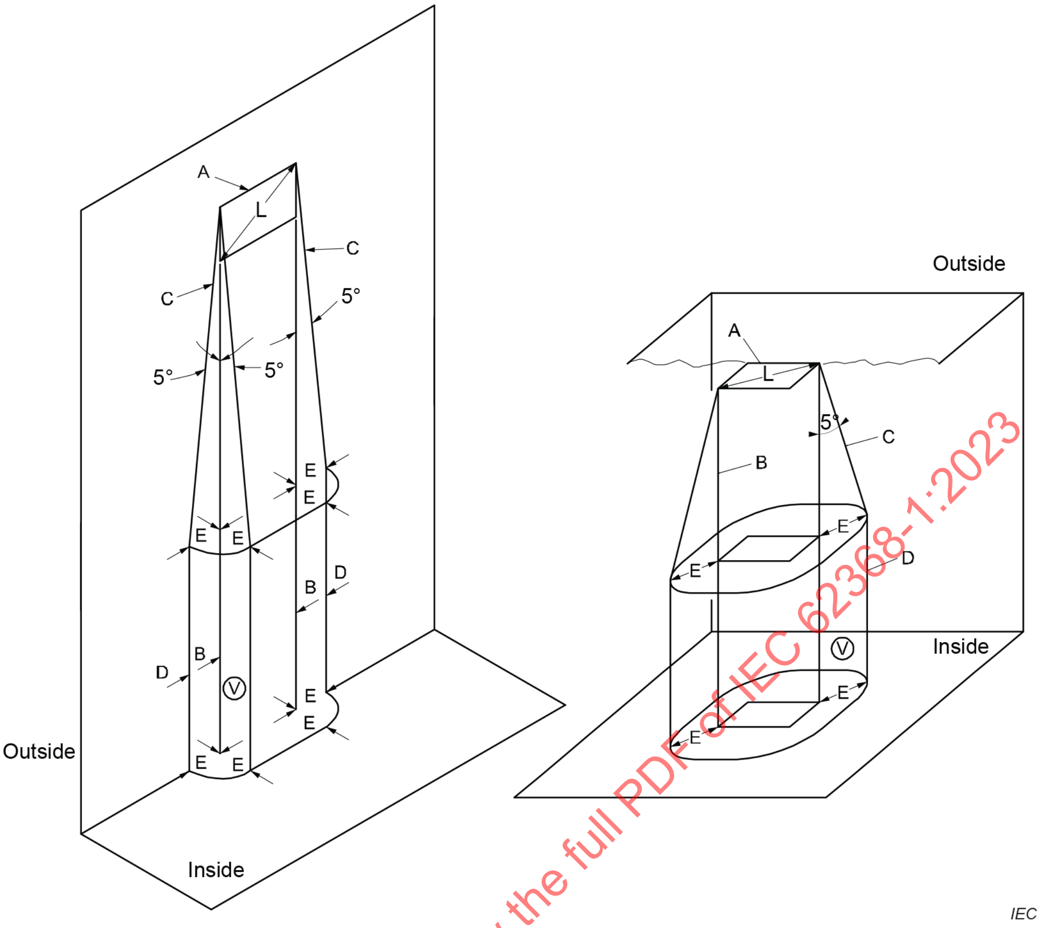
  - no bare conductive parts of a **safeguard**, or
  - no **PIS**, or
  - no bare conductive parts of ES3 or PS3 circuits, or
  - only conductive parts covered with conformal or other similar coatings;

  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.4, bare conductive parts at ES3 or PS3 subjected to the tests of P.2.3;

– side openings of a **fire enclosure** meeting the requirements of 6.4.8.3.5.

Other constructions shall be subject to the test of P.2.3.



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 safeguards** or **reinforced safeguards**

Figure P.4 – 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.4 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.

P.2.3 Consequence of entry test

An attempt shall be made to short all bare conductive parts of ES3 or PS3 within volume V, Figure P.4, 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 can defeat any **equipment safeguard**.

These requirements do not apply to any of the following:

– 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 can 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 an **LFC** or **LFC assembly** bursts or relieves its pressure, the **coolant** shall not defeat a **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 can 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 metallized 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.

*For metallized coatings, **clearances** and **creepage distances** for **pollution degree** 3 shall be maintained instead of the tests of P.4.2.*

P.4.2 Tests

*A sample of the equipment or a **subassembly** of the equipment containing parts having metallized 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 (TC) for a minimum of 4 h; and*
- *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 4.4.3.

With the concurrence of the manufacturer, the above time durations may be extended.

After the above tests:

– *a metallized coating or a part secured by adhesive shall not fall off or partly dislodge;*
– *a metallized 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; and*
– ***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 17, 19, J.17 and J.19 of IEC 60730-1:2022; or

   2) meet the requirements of IEC 60730-1:2013 for a **device** providing Type 2.AL action;

c) 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

d) an overcurrent protective **device** is used and the output is limited in compliance with Table Q.2; or

e) an IC current limiter with a nominal output voltage rating not exceeding 60 V DC that complies with Clause G.9.

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 maximum power transfer in turn. ***Single fault conditions*** *are applied in a regulating network according to Clause Q.1.1, item c) while 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 AC	V DC	A	VA
U_{oc} ≤ 30	U_{oc} ≤ 30	≤ 8,0	≤ 100
–	30 < U_{oc} ≤ 60	≤ 150/U_{oc}	≤ 100

[a] U_{oc}: Output voltage measured with all load circuits disconnected. Voltages are for substantially sinusoidal AC and ripple free DC For non-sinusoidal AC and DC 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 AC	V DC	A	VA	A
≤ 20	≤ 20	≤ 1 000/U_{oc}	≤ 250	≤ 5,0
20 < U_{oc} ≤ 30	20 < U_{oc} ≤ 30			≤ 100/U_{oc}
–	30 < U_{oc} ≤ 60			≤ 100/U_{oc}

[a] U_{oc}: Output voltage measured with all load circuits disconnected. Voltages are for substantially sinusoidal AC and ripple free DC For non-sinusoidal AC and for DC 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 R 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 AC wall socket-outlet, generator, power supply or ***battery****.*

If the overcurrent protective ***device*** *is provided in the equipment, then this is used for the test.*

For AC 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 AC sources, or that specified to be provided externally to the equipment for DC 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*** *power supply cord supplied or specified by the equipment manufacturer. Where there is no* ***mains*** *power supply cord provided or specified, a* ***mains*** *power supply cord with a length of 1 m and a cross-sectional area of minimum 2,5 mm^2 or 12 AWG shall be used. For DC sources, the cable shall be sized for the maximum* ***rated 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 can be more than one point at which this short-circuit can be applied to determine the worst case.

The ***protective bonding conductor*** *is connected to a source capable of supplying an AC or DC 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; and*
- *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 test is performed on three test specimens.

The following additional requirements apply to the specified clauses of IEC 60695-11-5:2016.

Clause 6 of IEC 60695-11-5:2016 – 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 60695-11-5:2016 – Flame application times

The values of duration of application of the test flame are as follows:

– *the test flame is applied for 10 s;*
– *if the duration of the flaming does not exceed 30 s, the test flame is immediately reapplied for 1 min at the same point;*
– *if again the duration of the flaming does not exceed 30 s, the test flame is immediately reapplied for 2 min at the same point.*

Clause 8 of IEC 60695-11-5:2016 – Conditioning and test conditions

Prior to being tested, the specimens 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 shall be applied.

Subclause 9.3 of IEC 60695-11-5:2016 – 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 shall 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 60695-11-5:2016 – 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. The test is performed on three test specimens. When testing the integrity of top openings, the top openings shall be covered with a single layer of* ***cheese cloth****.*

For the purpose of this document, the following additional conditions apply to the stated clauses of IEC 60695-11-5:2016.

Clause 6 of IEC 60695-11-5:2016 – 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 60695-11-5:2016 – Flame application times

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 60695-11-5:2016 – Conditioning and test conditions

Prior to being tested, the specimens 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 shall be applied.

Subclause 9.3 of IEC 60695-11-5:2016 – Application of needle flame

Application for the needle flame test for ***combustible materials****:*

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 or if the test specimen drips molten or flaming material during the application of the flame, the flame is applied at an angle of approximately 45° from the vertical.

Application for the needle flame test for top openings:

The test flame is applied at a distance measured from the closest point of a ***PIS*** *to the closest surface point of the test specimen. The application of the flame is measured from the top of the needle flame burner to the closest surface point, see Figure S.1. If the distance is too small to maintain the flame during the test, the distance is increased to a point where a flame can be maintained.*

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. In case of openings having different dimensions, the test shall be conducted on one opening of each group of openings with the same dimensions.

Dimensions in millimetres

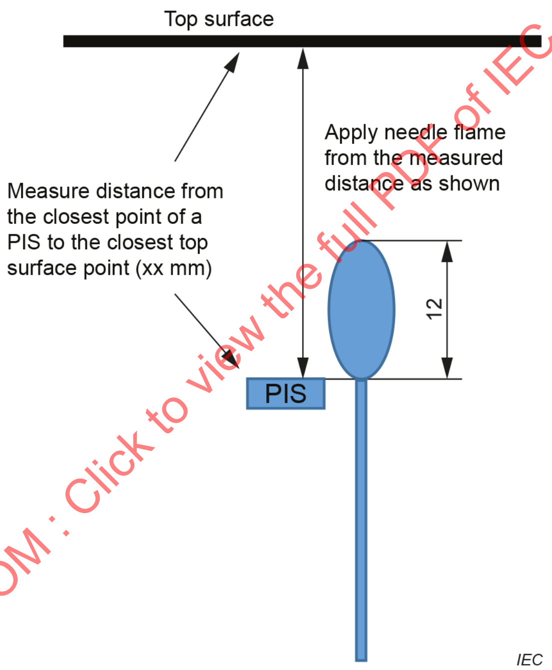


Figure S.1 – Top openings / surface of fire enclosure or fire barrier

Clause 11 of IEC 60695-11-5:2016 – Evaluation of test results

The existing text is replaced by the following.

Application for the needle flame test for ***combustible materials****:*

After application of the test flame, the test specimen shall not show any additional holes.

Application for the needle flame test for top openings:

The ***cheesecloth*** *shall not ignite.*

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 60695-11-20:2015, using the plate procedure of IEC 60695-11-20:2015, 8.3.*

For the purpose of this document, the following additional requirements apply to the specified clauses of IEC 60695-11-20:2015.

Clause 7 of IEC 60695-11-20:2015 – Test specimen

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 60695-11-20:2015 – 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 60695-11-20:2015 – Plate shaped test specimens

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 shall 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 60695-11-20:2015 – 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 shall occur.

S.6 Grille covering material, cloth, and reticulated foam

The part shall be supported so that its thinnest outside surface is in a horizontal position. A fuel tablet shall be placed on the thinnest section of the part. The fuel tablet is then to be ignited with a match applied to the top of the fuel tablet. The fuel tablet is to burn until it is completely consumed or until it burns through the part and falls to the surface below. The test is concluded when the part ceases to flame or glow. When all burning and glowing ceases, the part shall not have burned further than 50 mm from the centre of the fuel tablet.

The fuel tablet is specified as follows:

- *description: White, round, bevelled, compressed tablet;*
- *material: hexamethylene-tetramine (C6H12N4);*
- *burn time: 130 s ± 10 %;*
- *size: 6 mm ± 1 mm in diameter;*
- *weight of 149 mg ± 5 mg.*

Annex T
(normative)

Mechanical strength tests

T.1 General

In general, this Annex T describes a number of tests that are invoked by this document. 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; or

– an axial force is likely to be applied to the handle, lever, knob or cover under **normal operating conditions**.

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); and*

– *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.

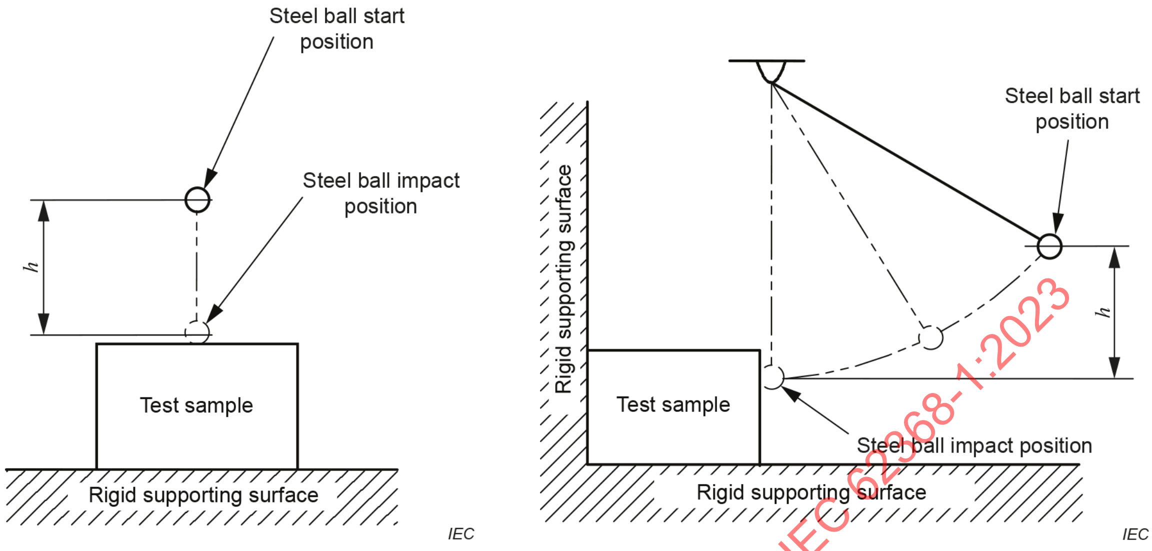


Figure T.1 – Impact test using sphere

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 equipment and* ***movable equipment****;*
- *1 000 mm ± 10 mm for* ***hand-held equipment****,* ***direct plug-in equipment*** *and* ***transportable equipment****;*
- *350 mm ± 10 mm for a part acting as a* ***fire enclosure*** *only of desk-top equipment and* ***movable equipment****;*
- *500 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.*

Relative humidity need not be maintained at a specific value during this test.

T.9 Glass impact test

The test sample is supported over its whole area and shall be subjected to a single impact, specified in Table T.1. 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	Safeguards against	Impact J	Height mm
Unless otherwise specified below, any glass used as a **safeguard** against class 3 energy sources except PS3	Exposure to class 3 energy sources	3,5	714
Glass on floor standing equipment	Skin-lacerations	3,5	714
Glass on all other equipment	Skin-lacerations	2	408
Laminated glass used as a **safeguard** against class 3 energy sources except PS 3	Exposure to class 3 energy sources	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 shall be applied to the end pieces of five additional samples. The torque shall be gradually applied with the rod fixed. When the specific torque is reached, It shall be maintained for no more than 15 s. The holding time for any one sample shall be not less than 5 s and the average holding time of the five samples shall be not less than 8 s.

The value of torque is given in Table T.2.

Table T.2 – Torque values for end-piece test

End-piece diameter mm	**Torque** Nm
< 8,0	0,3
≥ 8,0	0,6

Annex U
(normative)

Mechanical strength of CRTs and protection against the effects of implosion

U.1 General

This Annex U 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 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; and*
– *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 test probes.

Accessible parts of an equipment can 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**.*

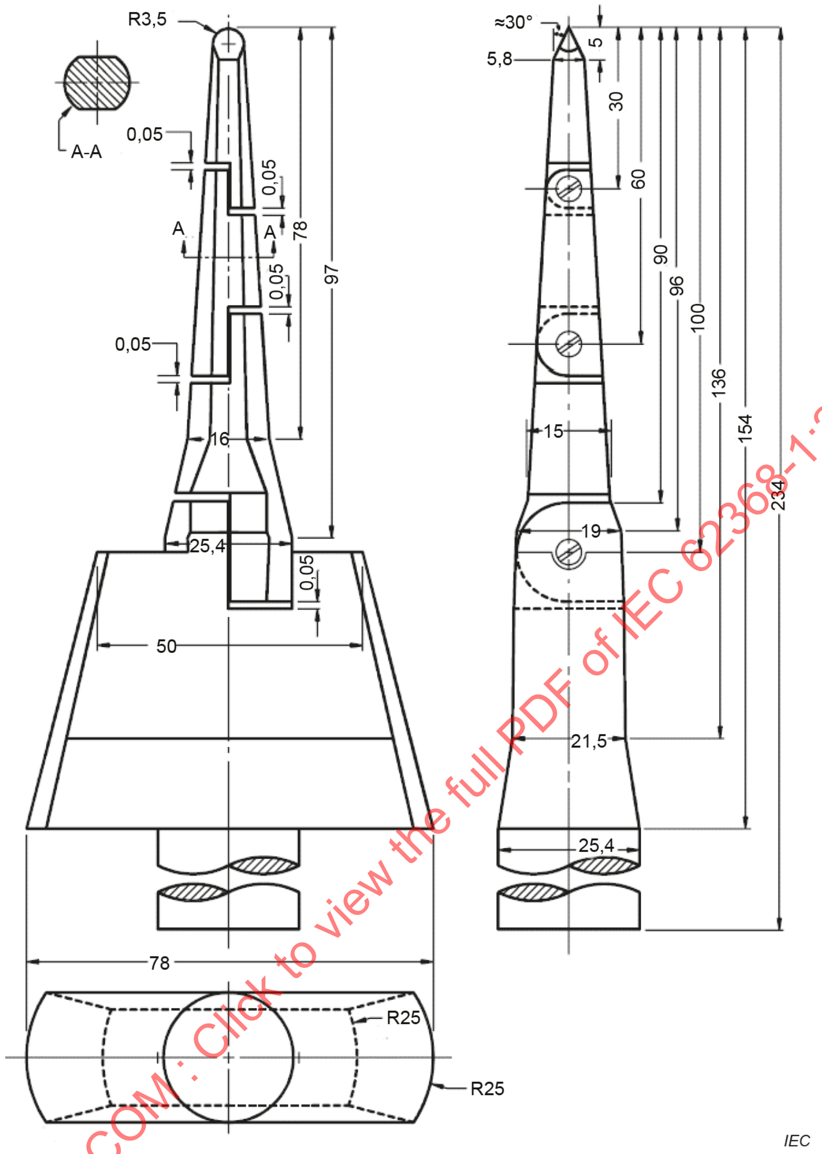
NOTE 2 The equipment may be dismantled to perform this test.

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.

NOTE The test with the unjointed version is to assess if test probe can be forced through the opening. The use of the jointed version can result in the test probe joints bending before the required force is reached.

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

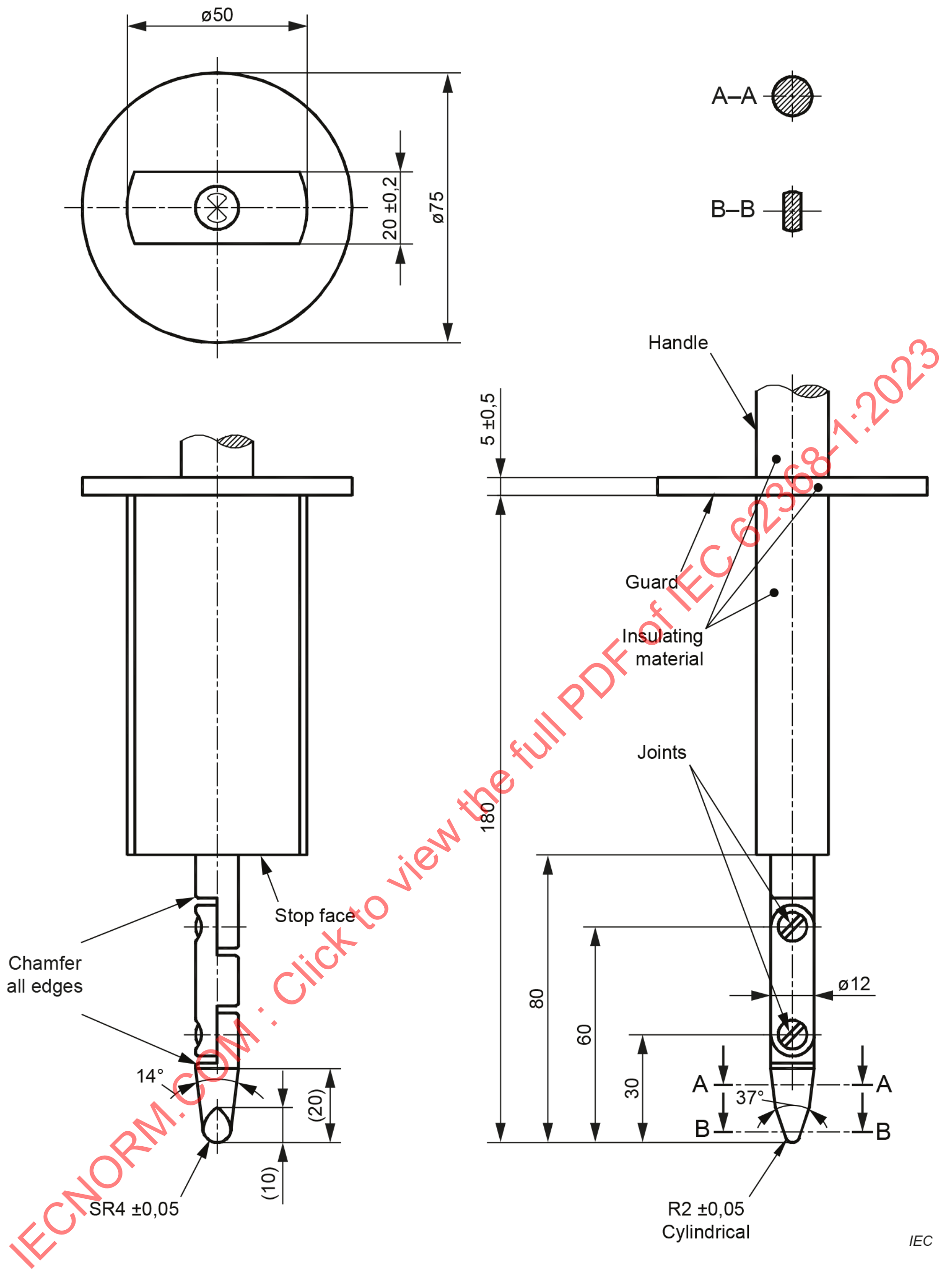
> 15 mm ≤ 25 mm: ± 0,1 mm

> 25 mm: ± 0,3 mm

Material of the test probe: heat-treated steel, for example.

Figure V.1 – Jointed test probe for equipment likely to be accessible to children

Dimensions in millimetres



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

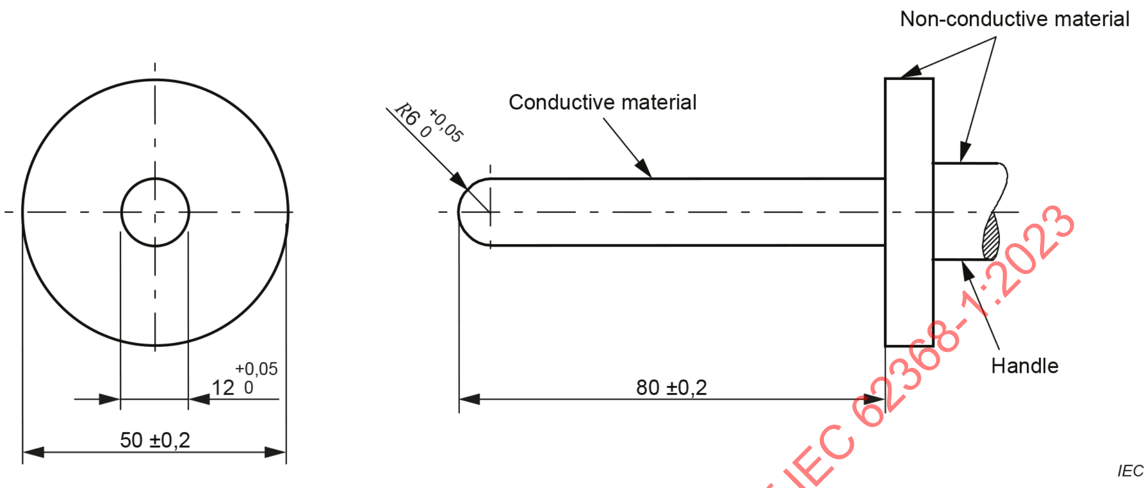
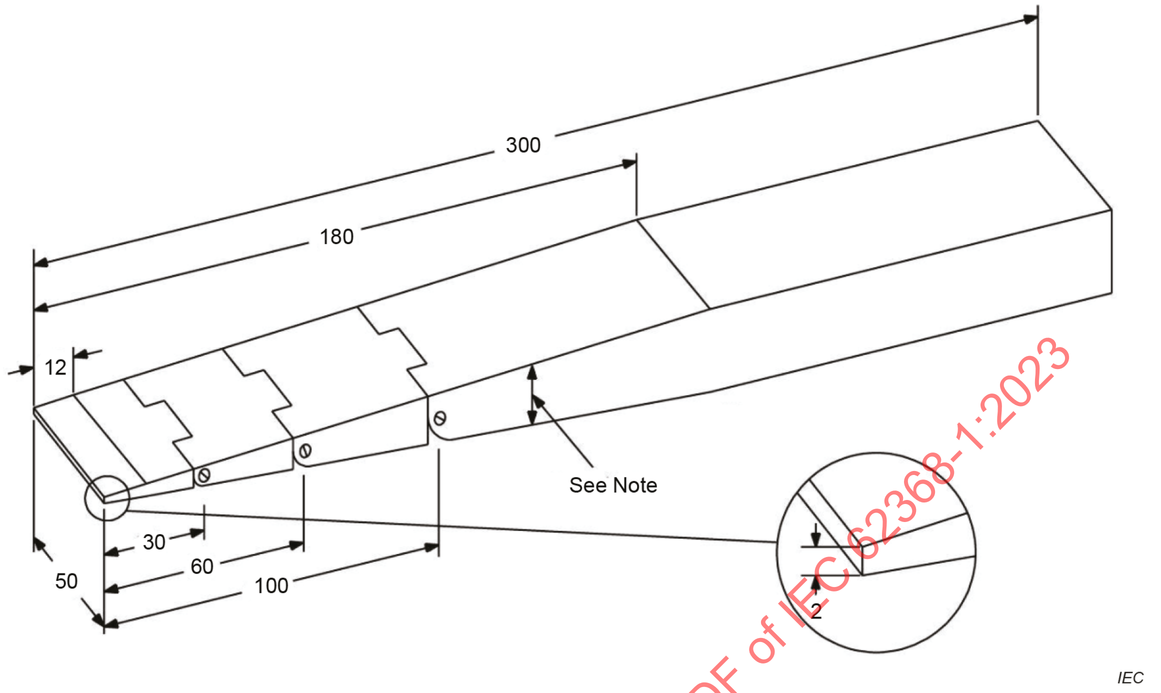


Figure V.3 – Blunt probe

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:

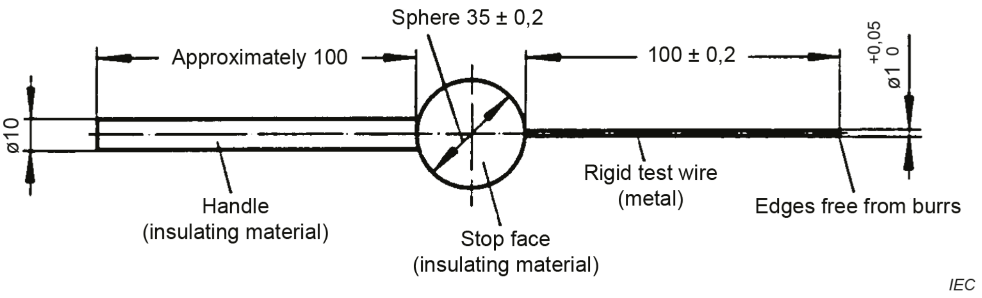
Distance from probe tip mm	**Probe thickness** mm
0	2
12	4
180	24

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 of 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 document

W.1 General

This document introduces new safety terms associated with the new safety concepts.

This Annex W identifies the relevant terms in this document and, where different, compare them to the equivalent IEC/TC 64 [8] 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 Table W.1 to Table W.6 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 60664-1:2020 and IEC 62368-1

IEC 60664-1:2020	IEC 62368-1
3.1.2 **mains supply** AC or DC power distribution system (external to the equipment) that supplies operating power to the equipment Note 1 to entry: **Mains supply** includes public or private utilities and, unless otherwise specified in this document, equivalent sources such as motor-driven generators and uninterruptible power supplies.	**3.3.1.3** **mains** AC or DC power distribution system (external to the equipment) that supplies operating power to the equipment Note 1 to entry: **Mains** include public or private utilities and, unless otherwise specified in this document, equivalent sources such as motor-driven generators and uninterruptible power supplies.
3.1.4 **clearance** shortest distance in air between two conductive parts	**3.3.12.1** **clearance** shortest distance in air between two conductive parts
3.1.5 **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
3.1.6 **solid insulation** solid insulating material or a combination of solid insulating materials, placed between two conductive parts or between a conductive part and a body part	**3.3.5.6** **solid insulation** insulation consisting entirely of solid material

[8] 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 60664-1:2020	IEC 62368-1
3.1.7 **working voltage** highest RMS value of the AC or DC voltage across any particular insulation which can occur when the equipment is supplied at rated voltage	**3.3.14.8** **working voltage** voltage across any particular insulation while the equipment is supplied at **rated voltage** or any voltage in the **rated voltage range** under **normal operating conditions**
3.1.17 **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
3.1.19 **rated impulse voltage** value of the impulse withstand voltage 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 **mains** input to the equipment, arising from external transients
3.1.25 **pollution degree** numeral characterizing the expected pollution of the micro-environment	**3.3.6.15** **pollution degree** numeral characterizing the expected pollution of the micro-environment
3.1.29 **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
3.1.30 **basic insulation** insulation of hazardous-live-parts which provides basic protection	**3.3.5.1** **basic insulation** insulation to provide a **basic safeguard** against electric shock
3.1.31 **supplementary insulation** independent insulation applied in addition to basic insulation for fault protection	**3.3.5.7** **supplementary insulation** independent insulation applied in addition to **basic insulation** to provide **supplementary safeguard** for fault protection against electric shock
3.1.32 **double insulation** insulation comprising both basic insulation and supplementary insulation	**3.3.5.2** **double insulation** insulation comprising both **basic insulation** and **supplementary insulation**
3.1.33 **reinforced insulation** insulation of hazardous-live-parts which provides a degree of protection against electric shock equivalent to double insulation	**3.3.5.5** **reinforced insulation** single insulation system that provides a degree of protection against electric shock equivalent to **double insulation**

IEC 60664-1:2020	IEC 62368-1
3.1.41 **type test** test made on one or more devices representative to a certain design to check the conformity to the specifications	**3.3.6.24** **type test** test on a representative sample with the objective of determining if, as designed and manufactured, it can meet the requirements of this document
3.1.42 **routine test** conformity test made on each individual item during or after manufacture	**3.3.6.17** **routine test** test to which each individual **device** is subjected during or after manufacture to ascertain whether it complies with certain criteria
3.1.43 **sampling test** test on a number of devices taken at random from a batch	**3.3.6.18** **sampling test** test on a number of **devices** taken at random from a batch
3.1.12 **temporary overvoltage** overvoltage at power frequency of relatively long duration	**3.3.14.7** **temporary overvoltage** overvoltage at mains power frequency of relatively long duration

Table W.2 – Comparison of terms and definitions in IEC 61140:2016 and IEC 62368-1

IEC 61140:2016 terms	IEC 62368-1 terms
3.1.1 **basic protection** protection against electric shock under fault-free conditions	*For consistency throughout the document the term "**safeguard**" is used to describe the device or scheme that provides protection against an energy source.* **3.3.11.2** **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	**3.3.11.17** **supplementary safeguard** **safeguard** applied in addition to the **basic safeguard** that is or becomes operational in the event of failure of the **basic safeguard**

IEC 61140:2016 terms	IEC 62368-1 terms
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 to entry: This concept does not necessarily imply a risk of electric shock.	*The term **live part** is not defined.* *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 1 to entry: 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** voltage not exceeding the maximum value of the prospective touch voltage which is permitted to be maintained indefinitely under specified conditions of external influences	*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 60479-1 – under **normal operating conditions**; and – under **single fault conditions** of a component, device or insulation not serving as a **safeguard**; and – not exceeding ES2 limits under **single fault conditions** of a **basic safeguard** or of a **supplementary safeguard**.
3.28 **limited-current-source** device supplying electrical energy in an electric circuit – with protective-separation from hazar-dous-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 60479-1 – under normal conditions; and – under **single fault conditions**.

IEC 61140:2016 terms	IEC 62368-1 terms
5.2.7 **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 1 to entry: For persons, the following values (AC 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, AC 0,5 mA or DC 2 mA are recommended. – Values not exceeding the threshold of pain AC 3,5 mA or DC 10 mA may be specified.	*ES1 current limit is 0,5 mA AC and 2 mA DC* *ES2 current limit is 5 mA AC, 25 mA DC (these values are taken from IEC 60479-1)*
No equivalent term	**3.3.11.14** **safeguard** physical part or system or instruction specifically provided to reduce the likelihood of injury, or, for fire, to reduce the likelihood of ignition or spread of fire
No equivalent term. Based on double insulation	**3.3.11.3** **double safeguard** **safeguard** comprising both a **basic safeguard** and a **supplementary safeguard**
No equivalent term. Based on reinforced insulation	**3.3.11.13** **reinforced safeguard** single **safeguard** that is provides protection under – **normal operating conditions**, – **abnormal operating conditions**, and – **single fault conditions**.
No equivalent term. Roughly equivalent to a warning	**3.3.11.6** **instructional safeguard** an instruction invoking specified behaviour
No equivalent term	**3.3.11.8** **precautionary safeguard** **instructed person** behaviour to avoid contact with or exposure to a class 2 energy source based on supervision or instructions given by a **skilled person**

IEC 61140:2016 terms	IEC 62368-1 terms
No equivalent term	**3.3.11.16** **skill safeguard** **skilled person** behaviour to avoid contact with or exposure to a class 2 or class 3 energy source based on education and experience
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 range 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	**3.3.7.9** **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

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 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 fault conditions** of a **basic safeguard** or of a **supplementary safeguard**.

IEC 60950-1:2005 terms	IEC 62368-1 terms
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 document.	*See detailed TNV classes for comparison.*
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	**5.2.1.1** ES1 on which transients according to Table 13, ID 1a, 1b and 3a 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	**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. NOTE The electrical characteristics are not identical to TNV circuits but will give equivalent level of safety.
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	**5.2.1.2** ES2 on which transients according to Table 13, ID 1a, 1b and 3a are possible 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
1.2.13.6 **USER** any person, other than a service person *The term user in this document 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 to entry: 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 to entry: 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 to entry: 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.	**3.3.1.2** **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.
None	**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

IEC 60950-1:2005 terms	IEC 62368-1 terms
1.2.13.5 **service person** person having appropriate technical training and experience necessary to be aware of hazards to which that person may be exposed in performing a task and of measures to minimize the risks to that person or other persons	**3.3.8.3** **skilled person** person with relevant education or experience to enable him or her to identify hazards and to take appropriate actions to reduce the risks of injury to themselves and others
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 to entry: 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 to entry: Cable distribution systems may be subjected to greater transients than telecommunication networks.	**3.3.1.2** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.

Table W.4 – Comparison of terms and definitions in IEC 60728-11:2016 and IEC 62368-1

IEC 60728-11:2016 terms	IEC 62368-1 terms
3.1.4 **cable networks <for television signals, sound signals and interactive services>** regional and local broadband cable networks, extended satellite and terrestrial television distribution networks or systems and individual satellite and terrestrial television receiving systems Note 1 to entry: These networks and systems can be used in downstream and upstream directions. **3.1.5** **CATV network** **community antenna television network** regional and local broadband cable networks designed to provide sound and television signals as well as signals for interactive services to a regional or local area Note 1 to entry: Originally defined as Community Antenna Television network. **3.1.31** **MATV network** **master antenna television network** extended terrestrial television distribution networks or systems designed to provide sound and television signals received by terrestrial receiving antenna to households in one or more buildings Note 1 to entry: Originally defined as master antenna television network. Note 2 to entry: This kind of network or system can possibly be combined with a satellite antenna for the additional reception of TV and/or radio signals via satellite networks. Note 3 to entry: This kind of network or system can also carry other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.	**3.3.1.2** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.

IEC 60728-11:2016 terms	IEC 62368-1 terms
3.1.44 **SMATV network** **satellite master antenna television network** extended distribution networks or systems designed to provide sound and television signals received by satellite receiving antenna to households in one or more buildings Note 1 to entry: Originally defined as satellite master antenna television network. Note 2 to entry: This kind of network or system can possibly be combined with terrestrial antennas for the additional reception of TV and/or radio signals via terrestrial networks. Note 3 to entry: This kind of network or system can also carry control signals for satellite switched systems or other signals for special transmission systems (e.g. MoCA or WiFi) in the return path direction.	

Table W.5 – Comparison of terms and definitions in IEC 62151:2000 and IEC 62368-1

<table>
<tr><th>IEC 62151:2000 terms</th><th>IEC 62368-1 terms</th></tr>
<tr><td>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 to entry: 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 to entry: 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 to entry: 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.</td><td>3.3.1.2
external circuit
electrical circuit that is external to the equipment and is not mains

Note 1 to entry: The relevant external circuits are identified in Table 13.</td></tr>
<tr><td>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 1 to entry: The limiting values of voltage under normal operating and single fault conditions are specified in 4.1.</td><td>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 fault conditions of a basic safeguard or of a supplementary safeguard.</td></tr>
</table>

IEC 62151:2000 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 document. Note 1 to entry: The voltage relationships between TNV CIRCUITS are shown in Table 1.	**5.2.1.2** **ES2** ES2 is a class 2 electrical energy source where – both the **voltage** and the **current** exceed the limits for ES1; and – under • **normal operating conditions**, and • **abnormal operating conditions**, and • **single fault conditions**, either the **voltage** or the **current** does not exceed the limit for ES2.

Table W.6 – Comparison of terms and definitions in IEC 60065:2014 and IEC 62368-1

IEC 60065:2014 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 1 to entry: The designation should be specified by the manufacturer.	**3.3.3.9** **professional equipment** equipment for use in trades, professions or industries and which is not intended for sale to the general public
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 1 to entry: 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 60065:2014 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 to entry: 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 to entry: 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 to entry: 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.	**3.3.1.2** **external circuit** electrical circuit that is external to the equipment and is not **mains** Note 1 to entry: The relevant **external circuits** are identified in Table 13.
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 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.

IEC 60065:2014 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) AC or DC and the product of the peak value of this voltage and the measured RMS 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 1 to entry: An electronic protection circuit may be used to prevent such a fault from becoming a potential ignition source.	**3.3.9.2** **arcing PIS** **PIS** where an arc can 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 can occur in conductive patterns on printed boards is considered to be within the scope of this definition.

Annex X
(normative)

Alternative method for determining clearances for insulation in circuits connected to an AC mains not exceeding 420 V peak (300 V RMS)

For an AC **mains** not exceeding 420 V peak (300 V RMS):

– if the peak of the **working voltage** does not exceed the peak value of the AC **mains** supply voltage, the alternate minimum **clearance** is determined from Table X.1;

– if the peak of the **working voltage** exceeds the peak value of the AC **mains** supply voltage, the alternate minimum **clearance** is the sum of the following two values:

- the **clearance** from Table X.1, and
- the appropriate additional **clearance** from Table X.2.

NOTE A **clearance** obtained by the use of Table X.1 lies between the values required for homogeneous and inhomogeneous fields. As a result, it is possible to not pass the appropriate electric strength test if the field is substantially inhomogeneous.

Table X.1 – Alternative minimum clearances for insulation in circuits connected to AC mains not exceeding 420 V peak (300 V RMS)

Clearances in mm

Voltage up to and including V	Mains transient voltage							
	1 500 V [a]				2 500 V [a]			
	Pollution degree							
	1 and 2		3		1 and 2		3	
	B/S	R	B/S	R	B/S	R	B/S	R
71	1,0	2,0	1,3	2,6	2,0	4,0	2,0	4,0
210	1,0	2,0	1,3	2,6	2,0	4,0	2,0	4,0
420	B/S 2,0 R 4,0							
If the peak of the **working voltage** exceeds the peak value of the AC **mains** supply voltage, linear interpolation is permitted between the nearest two points, the calculated minimum **clearance** being rounded up to the next higher 0,1 mm increment.								
[a] The relationship between **mains transient voltage** and AC **mains** supply voltage is given in Table 12.								

Table X.2 – Additional clearances for insulation in circuits connected to AC mains not exceeding 420 V peak (300 V RMS)

Clearances in mm

Mains transient voltage						
1 500 V [a]				2 500 V [a]		
Voltage up to and including V		Basic or supplementary insulation	Reinforced insulation	Voltage up to and including V	Basic or supplementary insulation	Reinforced insulation
Pollution degrees 1 and 2	Pollution degree 3			Pollution degrees 1, 2 and 3		
210	210	0,0	0,0	420	0,0	0,0
298	294	0,1	0,2	493	0,1	0,2
386	379	0,2	0,4	567	0,2	0,4
474	463	0,3	0,6	640	0,3	0,6
562	547	0,4	0,8	713	0,4	0,8
650	632	0,5	1,0	787	0,5	1,0
738	715	0,6	1,2	860	0,6	1,2
826	800	0,7	1,4	933	0,7	1,4
914	885	0,8	1,6	1 006	0,8	1,6
1 002	970	0,9	1,8	1 080	0,9	1,8
1 090	1 055	1,0	2,0	1 153	1,0	2,0
1 178	1 140	1,1	2,2	1 226	1,1	2,2
1 266	1 225	1,2	2,4	1 300	1,2	2,4
1 354	1 310	1,3	2,6	1 374	1,3	2,6

For voltages above the peak value of the **working voltage** given in the table, linear extrapolation is permitted.

For voltages within the peak value of the **working voltage** given in the table, linear interpolation is permitted between the nearest two points, the calculated minimum additional **clearance** being rounded up to the next higher 0,1 mm increment.

[a] The relationship between **mains transient voltage** and AC **mains** supply voltage is given in Table 12.

Annex Y
(normative)

Construction requirements for outdoor enclosures

Y.1 General

Protection against corrosion shall be provided by the use of suitable materials or by the application of a protective coating applied to the exposed surface, taking into account the intended conditions of use.

Parts, such as dials or connectors, that serve as a functional part of an **outdoor enclosure** shall comply with the same environmental protection requirements as for the **outdoor enclosure**.

NOTE 1 Aspects affecting safety that influence the integrity of the **outdoor enclosure** through the life of the product include:

– continued protection against access to class 2 and class 3 energy sources, including after mechanical strength tests;
– continued protection against ingress of dust and water; and
– continued provision of **protective earthing** continuity.

An **outdoor enclosure** shall not be used to carry current during **normal operating conditions** if this could cause corrosion that would impair safety. This does not preclude connection of a conductive part of an **outdoor enclosure** to **protective earthing** for the purpose of carrying fault currents.

NOTE 2 The action of a current flowing through a joint can increase corrosion under wet conditions.

Where a conductive part of an **outdoor enclosure** is connected to **protective earthing** for the purpose of carrying fault currents, the resulting connection shall meet the requirements of 5.6, after the appropriate weather conditioning tests, see Clause Y.3.

Compliance is checked by inspection and, if necessary, by the tests of 5.6 after the tests of Clause Y.3.

Y.2 Resistance to UV radiation

Non-metallic parts of an **outdoor enclosure** required for compliance with this document shall be sufficiently resistant to degradation by UV radiation.

Compliance is checked by examination of the construction and of available data regarding the UV resistance characteristics of the ***outdoor enclosure*** *material and any associated protective coating. If such data is not available, Annex C applies.*

Y.3 Resistance to corrosion

Y.3.1 General

Metallic parts of **outdoor enclosures**, with or without protective coatings, shall be resistant to the effects of water-borne contaminants.

Compliance is checked by either:

– *inspection and by evaluation of data provided by the manufacturer; or*
– *the tests and criteria as specified in Y.3.2 through Y.3.5; or*

– *the applicable performance level (A1, A2 or A3) of IEC 61587-1.*

Y.3.2 Test apparatus

The apparatus for the salt spray test shall consist of a test chamber and spraying **devices** as described in IEC 60068-2-11.

The apparatus for the test in a water-saturated sulphur dioxide atmosphere shall consist of an inert, hermetically sealed, chamber containing a water-saturated sulphur dioxide atmosphere in which the test specimens and their supports are held. The chamber shall be as described in ISO 22479.

Y.3.3 Water – saturated sulphur dioxide atmosphere

If the test chamber has an internal volume of 300 l ± 30 l the water-saturated sulphur dioxide atmosphere is created by the introduction of 0,2 l of sulphur dioxide with a concentration of 0,067 % by volume into the closed test chamber. The sulphur dioxide may either be introduced from a gas cylinder or by creating a specific reaction within the chamber. For test chambers having a different internal volume the quantity of sulphur dioxide is varied accordingly.

The procedure given in ISO 22479 is considered acceptable.

Sulphur dioxide can be formed inside the test apparatus by treating sodium pyrosulphite ($Na_2S_2O_5$) with a relatively strong acid, sulphamic acid (HSO_3NH_2).

NOTE 1 The method consists of dissolving excess sodium pyrosulphite in water, giving the reaction:

$$Na_2S_2O_5 + H_2O \rightarrow 2\ NaHSO_3$$

A stoichiometric quantity of sulphamic acid is then added giving the reaction:

$$NaHSO_3 + HSO_3NH_2 \rightarrow NaSO_3NH_2 + H_2O + SO_2$$

The resulting overall reaction is:

$$Na_2S_2O_5 + 2\ HSO_3NH_2 \rightarrow 2\ NaSO_3NH_2 + H_2O + 2\ SO_2$$

To obtain 1 l of SO_2 under normal conditions of 0 °C temperature and $1{,}013\ 3 \times 10^5$ Pa, air pressure, 4,24 g sodium pyrosulphite and 4,33 g sulphamic acid are needed.

NOTE 2 Sulphamic acid is the only solid mineral acid that is easy to conserve.

Y.3.4 Test procedure

The test shall consist of two identical and successive 12 day periods.

Each 12 day period consists of test a) followed by test b):

test a) *168 h of exposure to the salt spray atmosphere. The concentration of the saline solution forming the salt spray atmosphere is 5 % ± 1 % by weight and the temperature of the test chamber is maintained at 35 °C ± 2 °C.*

test b) *5 exposure cycles each consisting of an 8 h exposure to a water-saturated sulphur dioxide-rich atmosphere (see Y.3.3), during which the temperature of the test chamber is maintained at 40 °C ± 3 °C , followed by 16 h at rest with the test chamber door open.*

After each 12 day period, the test specimens are washed with demineralized water.

Alternatively, the test procedures as described in the following standards may be used to show compliance:

– *ISO 21207 Method B; or*
– *ISO 14993; or*
– *any other equivalent standard.*

Y.3.5 Compliance criteria

Compliance is checked by visual inspection. The ***outdoor enclosure*** *shall not show rust or oxidation of the protective coating, cracking or other deterioration that will jeopardize the safety aspects as follows:*

– *continued protection against access to class 2 and class 3 energy sources, including after mechanical strength tests; and*
– *continued protection against ingress of dust and water; and*
– *continued provision of* ***protective earthing*** *continuity.*

However, surface corrosion of the protective coating is disregarded.

Y.4 Gaskets

Y.4.1 General

When gaskets are used as the method providing protection against the ingress of potential contaminants, Y.4.2 through Y.4.6 shall apply as appropriate.

NOTE In Canada and the United States, **enclosure** types are specified in the Canadian Electrical Code and the U.S. National Electrical Code.

Joints for all **devices** closing openings into the equipment cavity of an **outdoor enclosure** subjected to splashing or seepage of oil, as well as any door or cover for such an **outdoor enclosure**, shall include a gasket in the full length of the joint.

A gasket of elastomeric or thermoplastic material, or a composition gasket utilizing an elastomeric material that is provided on an **outdoor enclosure** subjected to water or dust, shall meet requirements of this document.

Compliance is checked by inspection and by applying the relevant tests of Y.4.2 through Y.4.6.

Y.4.2 Gasket tests

The relevant tests specified in Y.4.3 or Y.4.4, depending on the type of gasket material used, are applicable to gaskets employed on an **outdoor enclosure** subjected to water or dust. The additional test of Y.4.5 is applicable to gaskets employed on an **outdoor enclosure** subjected to oil or **coolant**. A set of three specimens of the gasket material shall be subjected to the relevant tests.

Y.4.3 Tensile strength and elongation tests

This test is applicable to gaskets, which can stretch (such as O-rings). Gasket material shall be of such quality that samples subjected to a temperature of 69 °C to 70 °C in circulating air for 168 h have a tensile strength of not less than 75 % and an elongation of not less than 60 % of values determined for unaged samples. At the conclusion of the temperature conditioning, there shall be no visible deterioration, deformation, melting, or cracking of the material and the material shall not harden as determined by normal hand flexing.

As an alternative, the tensile strength and elongation tests as given in ISO 37, ISO 1798, ASTM D412 or ASTM D3574 may be used.

Y.4.4 Compression test

This test is applicable to gaskets with closed cell construction. The set of specimens of gasket material shall be tested to the requirements of a), b) and c) (see Figure Y.1). On completion of each test, the specimens shall not show signs of deterioration or cracks that can be seen with normal or corrected vision.

- *A cylindrical weight sufficient to apply 69 kPa shall be placed on the middle portion of each specimen for a period of 2 h. At the end of that time the weight shall be removed and the specimen allowed to rest at a room temperature of 25 °C ± 3 °C for 30 min. The thickness of the gasket shall then be determined and compared with a measurement obtained before the application of the weight. The compression set shall not exceed 50 % of the initial thickness of the specimen.*
- *Following the test specified in a), the same specimens shall be suspended in an air oven at a temperature of 70° C for a period of 5 days. The specimens shall then be tested for compliance with a), approximately 24 h after removal from the oven.*
- *Following the test specified in b), the same specimens shall be cooled for a period of 24 h to the minimum temperature as specified in 4.1.4 and then subjected to an impact from a hammer of 1,35 kg mass falling from a height of 150 mm upon removal from the cold chamber. The hammer head shall be steel, 28,6 mm in diameter and have a flat striking surface, 25,4 mm in diameter with slightly rounded edges. The specimens being tested shall be placed on short lengths of 50 mm by 100 mm minimum wooden pieces (clear spruce) when being impacted. Following the impact the specimens shall be examined for evidence of cracking or other adverse effects. The test shall be continued and the specimens impacted every 24 h for two more days. The specimens shall then be removed from the cold chamber, allowed to rest at a room temperature of 25 °C ± 3 °C for approximately 24 h, and then again tested for compliance with a).*

Dimensions in millimetres

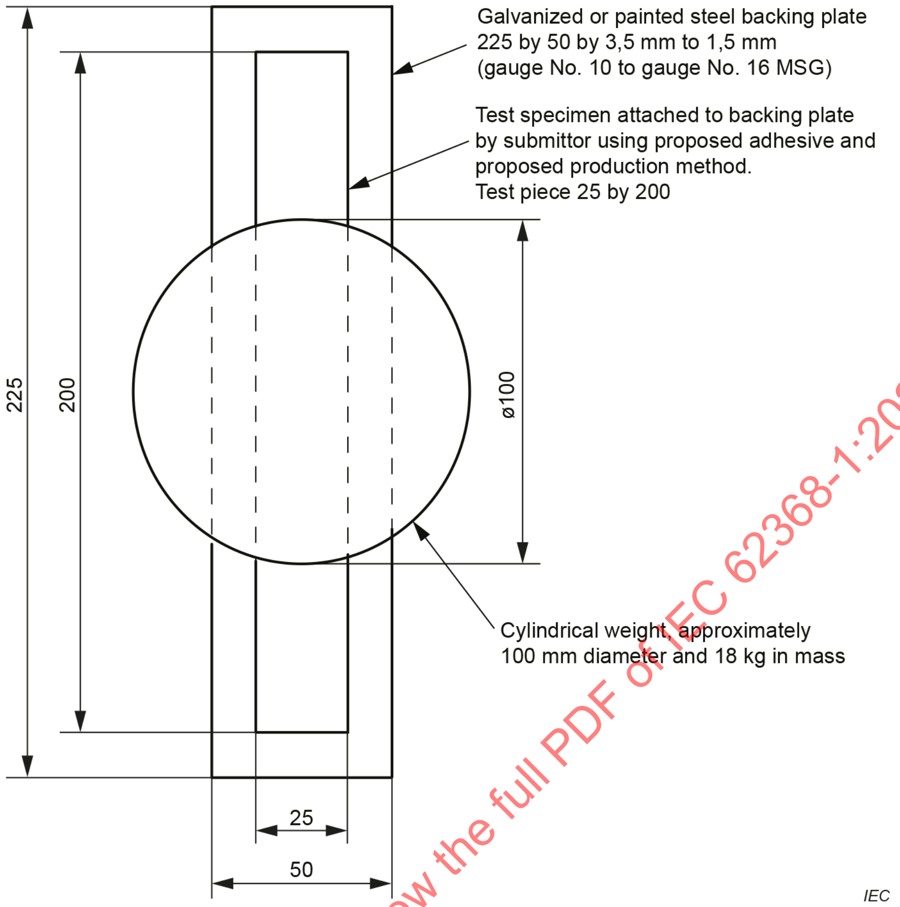


Figure Y.1 – Gasket test

Y.4.5 Oil resistance

A gasket provided on an **outdoor enclosure** subjected to oil or **coolant** shall be oil resistant.

Compliance is checked by inspection and by the following oil immersion test.

Gasket material shall not swell more than 25 % or shrink more than 1 % as a result of immersion in oil for 70 h at a room temperature of 25 °C ± 3 °C. Specifications are provided in ISO 1817:2022 or ASTM D471-98.

NOTE In Canada and United States, IRM Immersion Oil No. 903 is accepted.

Y.4.6 Securing means

A gasket shall be secured with adhesive or by mechanical means. The gasket and its securing means shall not be damaged when the joint is opened.

Where a gasket is secured by adhesive alone without mechanical securement, and the specific part(s) associated with the gasket can be subjected to opening or similar movement on a periodic basis, the gasket and adhesive shall be subjected to the testing in Clause P.4. Compliance is checked by inspection and available manufacturer's data. If data is not available, then the tests according to Clause P.4 are conducted, as applicable.

Y.5 Protection of equipment within an outdoor enclosure

Y.5.1 General

Equipment within an **outdoor enclosure** shall have adequate protection from the effects of moisture and excessive dust.

See Table Y.1 for examples for provisions of **pollution degree** environments. To establish a **pollution degree**, both considerations for "Method of achievement Dust" and "Method of achievement Moisture" as in dicated in Table Y.1 shall be met.

Table Y.1 – Examples of the provision of pollution degree environments

Pollution degree	Method of achievement Dust (Y.5.5)	Method of achievement Moisture (Y.5.2 to Y.5.3)
Pollution degree 3	Default	The use of an **enclosure** meeting IPX4 or the requirements of Y.5.3 relating to the ingress of water is considered to provide a **pollution degree** 3 environment within the **outdoor enclosure**.
Reduction of **pollution degree** 3 to **pollution degree** 2	Reduction of **pollution degree** 3 to **pollution degree** 2 may be accomplished by either: – providing continuous energization of the enclosed equipment; or – providing separate climate conditioning which prevents condensation within the **outdoor equipment** or **outdoor enclosure**; or – IP5X – IP6X – Y.5.5.2 – Y.5.5.3 equivalent (for, example NEMA).	Reduction of the **pollution degree** 3 environment to **pollution degree** 2 may be accomplished by either: – providing continuous energization of the enclosed equipment; or – providing separate climate conditioning which prevents condensation within the **outdoor equipment** or **outdoor enclosure**; or – the use of an **enclosure** meeting IPX4.
Reduction to **pollution degree** 1	See 5.4.1.5.2, Test for **pollution degree** 1 environment and for an insulating compound.	Control of the environment at the insulation surface to **pollution degree** 1 may be accomplished for example by, encapsulation, potting or coating.

Compliance is checked by inspection of the construction, available data and, if necessary, by the tests in Y.5.2 to Y.5.5.

Y.5.2 Protection from moisture

The **outdoor enclosure** shall provide adequate protection from the effect of moisture on the enclosed equipment.

NOTE 1 This does not preclude **outdoor enclosure** or **outdoor equipment** being constructed with segmented volumes, each providing a different **pollution degree**.

NOTE 2 For consideration of the effects of the presence of conductive pollution, as opposed to non-conductive pollution which can become conductive only due to the presence of moisture, see the relevant requirements in IEC 60529.

Where necessary, the **outdoor enclosure** shall be provided with drain holes to control the accumulation of moisture due to:

– entrance of water through openings; and

– condensation, when this is likely to occur (for example, keeping the equipment energized or separately heating the equipment is considered to keep it free of condensation).

The provision of drain holes and their location shall be taken into consideration when determining the IP rating.

Compliance is checked by inspection and, if necessary, by the relevant tests of IEC 60529 or Y.5.3.

Prior to testing, the equipment shall be mounted, so far as is reasonably practicable, according to the manufacturer's installation instructions. If fans or other means for ventilation are provided, which could affect the ingress of water, the test shall be conducted with the ventilation means both on and off unless it is evident that one of the modes of operation will produce the most unfavourable result.

At the conclusion of the test the following conditions shall exist:

– For **outdoor enclosures**, no water shall have entered the **outdoor enclosure**.

– For **outdoor equipment**, water is permitted to enter the **outdoor enclosure** provided it does not:

  • deposit on insulation where it could lead to tracking along the **creepage distance**,

  • deposit on bare live parts or bare wiring, or on windings not designed to operate when wet, or

  • enter any supply wiring space, see G.7.6.

Y.5.3 Water spray test

*The water-spray test apparatus, using fresh water, is to consist of three spray heads mounted in a water supply pipe rack as shown in Figure Y.2. Spray heads are to be constructed in accordance with the details shown in Figure Y.3. The **outdoor enclosure** is to be positioned in the focal area of the spray heads so that the greatest quantity of water is likely to enter the **outdoor enclosure**. The water pressure shall be maintained at 34,5 kPa at each spray head. The **outdoor enclosure** shall be exposed to the water spray for 1 h.*

*Unless the construction is such that a test on one side of the **outdoor enclosure** is representative of a test on another side, the test shall be repeated on other sides of the **outdoor enclosure** as necessary.*

*The water spray is to produce a uniform spray over the surface or surfaces under test. The various vertical surfaces of an **outdoor enclosure** may be tested separately or collectively, provided that a uniform spray is applied.*

*The top surface of the **outdoor enclosure** shall be tested by applying a uniform spray from nozzles located at proper heights (see the focal point in Figure Y.2), if*

– *there are openings in the top surface; or*

– *from an examination of the construction, it is determined that run-off from the top surface could cause water ingress at a vertical surface which would not be detected by the test of the vertical surface.*

If there are openings in a vertical surface, located less than 250 mm above ground level, such that water ingress from rain bouncing upwards from the ground surface might occur, a test shall be performed, spraying water on the ground surface in front of such openings, over such distance necessary to cause the deflected spray to reach the ***outdoor enclosure****. This test is not carried out if, from an examination of the construction, it is determined that the test of the vertical surface adequately assures compliance.*

Dimensions in millimetres, unless indicated otherwise

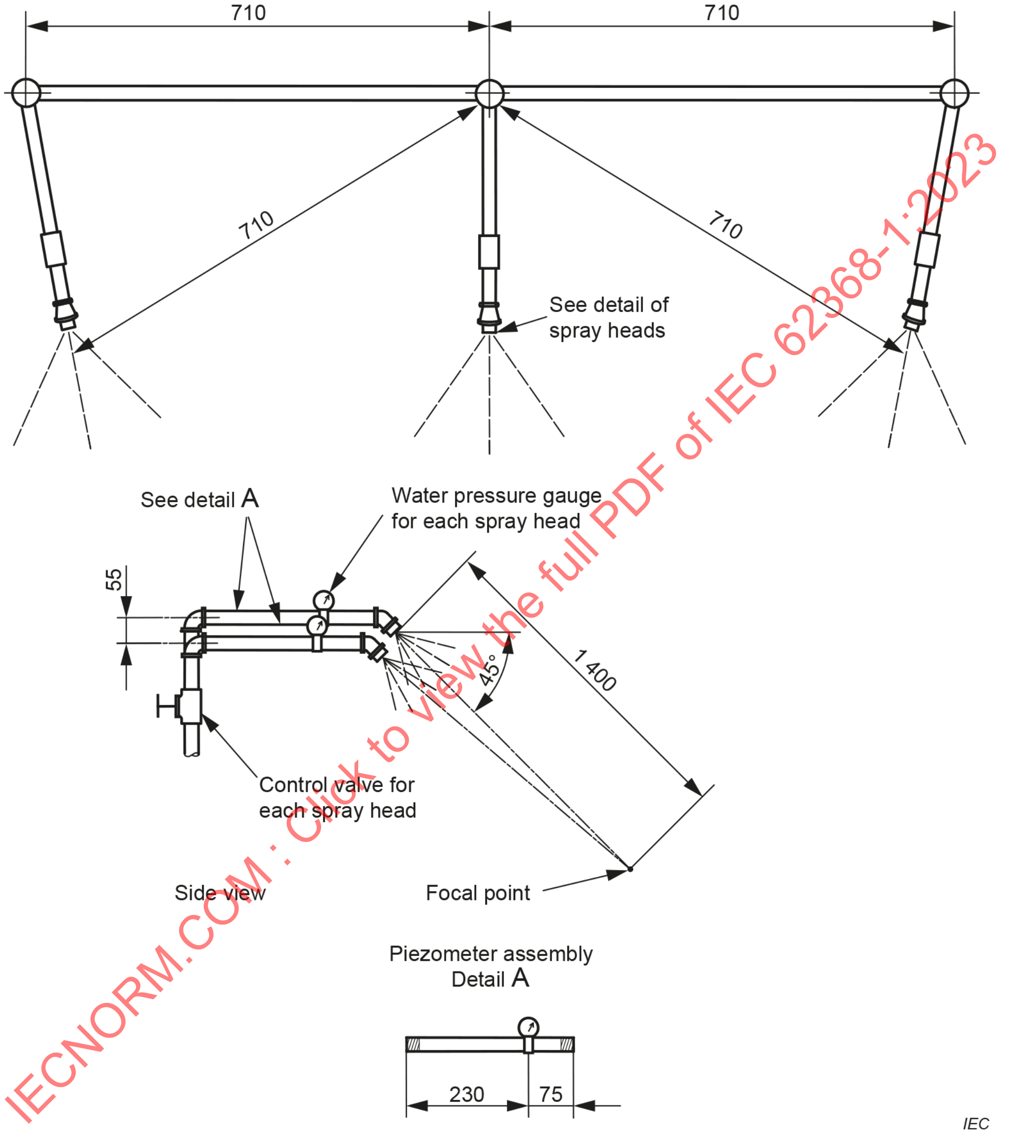


Figure Y.2 – Water-spray test spray-head piping

Dimensions in millimetres, unless indicated otherwise

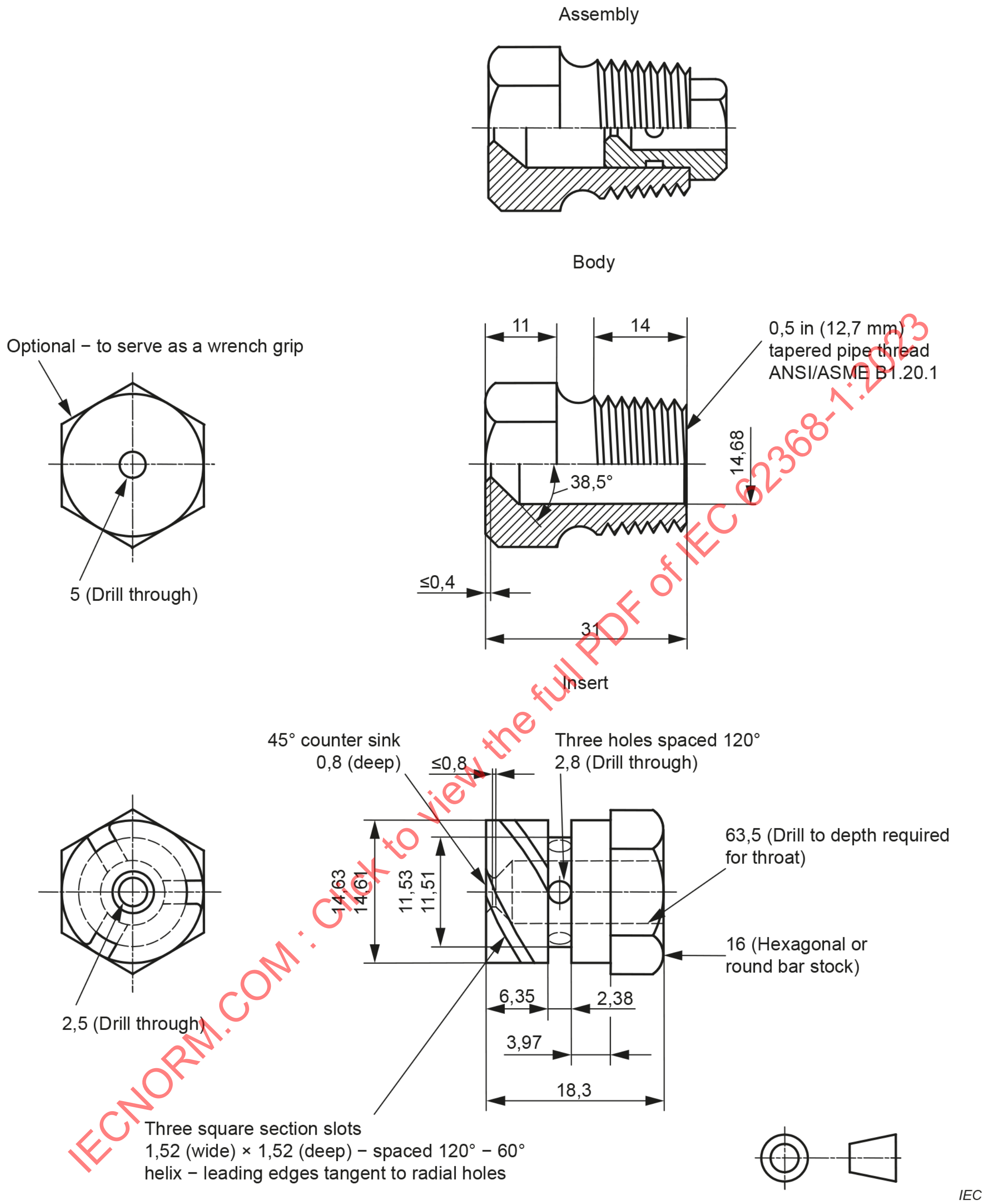


Figure Y.3 – Water-spray test spray head

Y.5.4 Protection from plants and vermin

If entry by plants and vermin is a consideration, **outdoor equipment** shall have adequate protection.

NOTE For protection against plants and vermin, see IEC 61969-3.

Compliance is checked by inspection.

Y.5.5 Protection from excessive dust

Y.5.5.1 General

Unless the **clearances** and **creepage distances** comply with the requirements as given in 5.4 for **pollution degree** 3, **outdoor equipment** shall have adequate protection against the ingress of the dust through the use of an appropriately rated IP5X or IP6X **enclosure***,* or equivalent (for example, an equivalent NEMA rated **enclosure**).

NOTE Dust from road vehicles is not considered to be conductive.

Compliance is checked by inspection and, if necessary, by the relevant tests of IEC 60529 or alternatively, by the tests of Y.5.5.2 or Y.5.5.3 using the acceptance conditions of Clause 5, 13.5.2 and 13.6.2 of IEC 60529:1989.

If the ***enclosure*** *complies with the dust chamber test for IP5X or IP6X, the examination for spherical objects mentioned in the note of 13.3 of IEC 60529:1989 and IEC 60529:1989/AMD1:1999 can be considered done and complied with.*

Y.5.5.2 IP5X equipment

Dust-proof equipment (first characteristic IP numeral 5) shall be tested in a dust chamber similar to that shown in Figure 2 of IEC 60529:1989, in which talcum powder is maintained in suspension by an air current. The chamber shall contain 2 kg of powder for every cubic meter of its volume. The talcum powder used shall be able to pass through a square-meshed sieve whose nominal wire diameter is 50 μm and whose nominal free distance between wires is 75 μm. It shall not have been used for more than 20 tests.

The test shall proceed as follows:

a) *The equipment is suspended outside the dust chamber and operated at* ***rated voltage*** *until operating temperature is achieved.*
b) *The equipment, whilst still operating, is placed with the minimum disturbance in the dust chamber.*
c) *The door of the dust chamber is closed.*
d) *The fan/blower causing the talcum powder to be in suspension is switched on.*
e) *After 1 min, the equipment is disconnected and allowed to cool for 3 h whilst the talcum powder remains in suspension.*

NOTE The 1 min interval between switching on the fan/blower and switching off the equipment is to ensure that the talcum powder is properly in suspension around the equipment during initial cooling, which is most important with smaller equipment. The equipment is operated initially as in item a) to ensure the test chamber is not overheated.

Y.5.5.3 IP6X equipment

Dust-tight equipment (first characteristic IP numeral 6) shall be tested in accordance with Y.5.5.2.

Y.6 Mechanical strength of enclosures

Y.6.1 General

Outdoor enclosures and **outdoor equipment** shall have adequate mechanical strength and shall provide protection against access to class 3 energy sources within the equipment throughout the intended ambient operating range.

Compliance is checked by the inspection of the construction and available data and, if necessary, by the test of Y.6.2. After the test, the level of protection shall remain in accordance with Y.5.1 and 4.4.3.10.

Y.6.2 Impact test

For equipment with an ***outdoor enclosure*** *made of polymeric material, the* ***outdoor enclosure*** *of the equipment shall be subjected to the low temperature conditioning before the impact test. Subsequently* ***outdoor enclosures*** *and* ***outdoor equipment*** *shall be subjected to the impact test of Clause T.6. Where the* ***outdoor enclosure*** *is made of polymeric material, the test is carried out after conditioning the test piece for 24 h at an ambient temperature equal to the minimum ambient temperature as specified in 4.1.4. The test may be applied to a portion of the* ***enclosure*** *representing the largest unreinforced area, supported in its normal position.*

The impacts are applied to doors, covers, seams and the like which could affect the ingress of dust and moisture. The test is performed whether or not failure would give direct access to class 3 energy sources. The impacts are applied within 2 min of removal from the climatic chamber.

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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ÉQUIPEMENTS DES TECHNOLOGIES DE L'AUDIO/VIDÉO, DE L'INFORMATION ET DE LA COMMUNICATION –

Partie 1: Exigences de sécurité

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L'IEC 62368-1 a été établie par le comité d'études 108 de l'IEC: Sécurité des appareils électroniques dans le domaine de l'audio, de la vidéo, du traitement de l'information et des technologies de la communication. Il s'agit d'une Norme internationale.

Cette quatrième édition annule et remplace la troisième édition parue en 2018. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) un nouveau tableau d'exigences pour les circuits externes;
b) les exigences ont été revues pour les ouvertures dans les enveloppes ignifuges;
c) les exigences ont été revues pour les composants remplis de liquide;

d) les exigences de charge des batteries ont été revues.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
108/800/FDIS	108/804/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/publications.

Une liste de toutes les parties de la série IEC 62368, publiées sous le titre général *Equipements des technologies de l'audio/vidéo, de l'information et de la communication*, se trouve sur le site web de l'IEC.

Les notes indiquant "dans certains pays" relatives aux différentes pratiques nationales sont contenues dans les articles, paragraphes et tableaux suivants:

0.2.1, Article 1, 3.3.8.1, 3.3.8.3, 4.1.15, 4.7.3, 5.4.2.3.2.4, 5.4.2.5, 5.4.5.1, 5.4.10.2.1, 5.4.10.2.2, 5.4.10.2.3, 5.5.2.1, 5.5.6, 5.6.4.2.1, 5.6.8, 5.7.6, 5.7.7.1, 8.5.4.2.3, 10.5.3, 10.6.1, F.3.3.4, F.3.3.6, Y.4.1, Y.4.5, Tableau 12, Tableau 13 et Tableau 38.

Dans le présent document, les caractères d'imprimerie ou formats suivants sont utilisés:

– exigences proprement dites et annexes normatives: caractères romains;
– énoncés de conformité et modalités d'essai: *caractères italiques*;
– notes/commentaires: petits caractères romains;
– conditions normatives à l'intérieur des tableaux: petits caractères romains;
– termes définis en 3.3: **gras**.

Dans les figures et les tableaux, si la couleur est disponible:

– le vert indique une source d'énergie de classe 1;
– le jaune indique une source d'énergie de classe 2;
– le rouge indique une source d'énergie de classe 3.

L'Annexe W fournit une comparaison des termes définis dans le présent document, qui sont différents de ceux d'autres documents existants de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous webstore.iec.ch dans les données relatives au document recherché. A cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée; ou
- amendé.

NOTE Des informations explicatives relatives à l'IEC 62368-1 sont données dans l'IEC TR 62368-2. Celle-ci comporte des justifications, ainsi que des informations explicatives relatives au présent document.

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 l'IEC 62368 est une norme relative à la sécurité des produits qui classifie les sources d'énergie, spécifie les **protections** contre ces sources d'énergie, et fournit des recommandations concernant l'application de ces **protections**, ainsi que les exigences associées.

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 inhérents afin de concevoir des équipements sûrs. Ces principes sont informatifs et ne constituent pas une alternative aux exigences détaillées du présent document.

0.2 Personnes

0.2.1 Généralités

Le présent document décrit des **protections** pour trois types de personnes: les **personnes ordinaires**, les **personnes averties** et les **personnes qualifiées**. Sauf spécification contraire dans le présent document, les exigences relatives aux **personnes ordinaires** s'appliquent. Le présent document part du principe qu'une personne ne crée jamais volontairement des conditions ou des situations susceptibles de provoquer une douleur ou une blessure.

NOTE 1 En Australie, les opérations effectuées par une **personne avertie** ou par une **personne qualifiée** peuvent nécessiter la délivrance d'une licence formelle par les autorités de réglementation.

NOTE 2 En Allemagne, une personne peut uniquement être considérée comme une **personne avertie** ou une **personne qualifiée** si certaines exigences légales sont respectées.

0.2.2 Personne ordinaire

Le terme **personne ordinaire** désigne 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 éventuellement avoir accès à l'équipement ou se trouver à proximité de l'équipement. Dans les **conditions normales de fonctionnement** ou les **conditions anormales de fonctionnement**, il convient que les **personnes ordinaires** ne soient pas exposées à des parties composées de 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

Le terme **personne avertie** désigne les personnes qui ont été formées et entraînées par une **personne qualifiée**, ou qui sont supervisées par une **personne qualifiée**, pour identifier les sources d'énergie pouvant provoquer des douleurs (voir Tableau 1) et pour prendre des précautions afin d'éviter toute exposition ou tout contact involontaire avec ces sources d'énergie. Dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** ou les **conditions de premier défaut**, il convient que les **personnes averties** ne soient pas exposées à des parties composées de sources d'énergie pouvant provoquer des blessures.

0.2.4 Personne qualifiée

Le terme **personne qualifiée** désigne les 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. Par hypothèse, une **personne qualifiée** utiliser 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 ou l'exposition involontaires 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 Figure 1).

Figure 1 – Modèle en trois blocs pour les douleurs et les blessures

La présente norme de sécurité spécifie trois classes de sources d'énergie qui sont définies par les amplitudes et les durées des paramètres de sources relatifs aux réponses du corps aux sources d'énergie électrique ou thermique (voir Tableau 1). Les paramètres des sources relatifs aux réponses à des **matériaux combustibles**, aux sources d'énergie mécanique et aux sources d'énergie de rayonnement sont spécifiés en fonction de l'expérience et des normes de sécurité fondamentales.

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 faible, 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, il est possible qu'une douleur ou une blessure due à une réaction chimique ou physiologique ne se manifeste pas pendant des jours, des semaines, des mois ou des années.

0.4 Sources d'énergie

Les sources d'énergie sont traitées par le présent document 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 (**réseau d'alimentation**, par exemple), à un bloc d'alimentation électrique externe, ou à 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 (parties mobiles d'une imprimante, images sur un écran d'affichage visuel, 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 électrique telles que des parties mobiles ou des produits chimiques. 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, l'énergie chimique peut être convertie en énergie électrique par le biais d'une **batterie**, ou une partie du corps mobile transfère son énergie cinétique vers une arête vive).

Le Tableau 2 fournit des exemples des types de formes d'énergie et des blessures et dommages matériels associés traités dans le présent document.

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
Energie électrique (par exemple, parties conductrices alimentées)	Douleur, fibrillation, arrêt cardiaque, arrêt respiratoire, brûlure de la peau, ou brûlure d'un organe interne	5
Energie thermique (par exemple, inflammation électrique et propagation du feu)	Incendie d'origine électrique provoquant une douleur ou une blessure liée à une brûlure ou un dommage matériel	6
Réaction chimique (par exemple, électrolyte, poison)	Endommagement de la peau, d'autres organes, ou empoisonnement	7
Energie cinétique (par exemple, parties mobiles de l'équipement ou une partie mobile du corps 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
Energie thermique (par exemple, parties **accessibles** chaudes)	Brûlure de la peau	9
Energie 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 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 une blessure et une partie du corps; et
– réduit la probabilité d'un transfert d'énergie pouvant provoquer une douleur ou une blessure sur une partie du corps.

NOTE Les mécanismes de **protection** contre un transfert d'énergie pouvant provoquer 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 un ensemble d'éléments.

Généralement, le présent document privilégie l'ordre suivant pour procurer les **protections** en fonction des exigences établies dans le Guide 51 de l'ISO/IEC:

– **protections de l'équipement**: sont toujours utiles dans la mesure où elles n'exigent 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 doit être boulonné au sol pour des raisons de stabilité);
– **protections** de comportement: sont utiles lorsque l'équipement exige 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, ainsi que les 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 **double protection** 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, même si dans certains cas, des **protections de l'installation** peuvent être spécifiées dans les instructions d'installation de l'équipement.

En général, pour l'équipement, une **protection de l'installation** est une **protection supplémentaire**.

NOTE Par exemple, la **protection supplémentaire** qui assure la **mise à la terre de protection** est située en partie dans l'équipement et en partie dans l'installation. La **protection supplémentaire** qui assure la **mise à la terre de protection** n'est pas effective tant que l'équipement n'est pas connecté à la **mise à la terre de protection** de l'installation.

Les exigences relatives aux **protections de l'installation** ne sont pas traitées dans le présent document. Cependant, le présent document admet par hypothèse 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 le présent document. Cependant, le présent document admet par hypothèse que les **protections individuelles** sont disponibles pour une utilisation conforme aux spécifications du 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**, d'une **protection de l'installation** ou d'une **protection 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.

Le présent document 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**.

Dans la mesure où une **protection de l'équipement** assure une protection de toute personne, elle est privilégiée par rapport à une **protection** de comportement. Cependant, dans certaines situations, une **protection de précaution** ou une **protection mise en place grâce à l'expérience acquise** est acceptée pour remplacer une **protection de l'équipement**.

0.5.5.2 Protection par instructions

Une **protection par instructions** est un moyen de fournir des informations, en décrivant l'existence et l'emplacement d'une source d'énergie pouvant provoquer une douleur ou une blessure, et visant à solliciter un comportement spécifique de la part d'une personne afin de réduire la probabilité d'un transfert d'énergie vers une partie du corps (voir l'Annexe F).

Une **protection 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'équipement nécessite d'être alimenté pour effectuer une activité d'entretien, de telle sorte que la personne sache comment éviter un contact avec une 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 déterminer s'il convient 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 prendre des précautions pour protéger la **personne avertie** contre les sources d'énergie de classe 2. Les **protections de précaution** ne sont pas spécifiquement précisées dans le présent document mais sont considérées comme effectives lorsque le terme **personne avertie** est utilisé.

Pendant l'entretien de l'équipement, il est possible qu'une **personne avertie** ait besoin de retirer ou de mettre en échec une **protection de l'équipement**. Dans ce cas, une **personne avertie** est sensée alors utiliser son expérience comme **protection** pour éviter les expositions aux sources d'énergie de classe 2.

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 le présent document mais sont considérées comme effectives lorsque le terme **personne qualifiée** est utilisé.

Pendant l'entretien de l'équipement, il est possible qu'une **personne qualifiée** ait besoin de retirer ou de mettre en échec 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 s'appliquer. 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 grandes dimensions, 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 en cas de défaillance de la **protection principale**	Effective dans les **conditions normales de fonctionnement** et dans le cas d'une **condition de premier défaut** dans une autre partie de l'équipement
	Exemple: **isolation principale**	Exemple: **isolation supplémentaire**	Exemple: **isolation renforcée**
	Exemple: températures normales inférieures aux températures d'inflammation	Exemple: **enveloppe ignifuge**	non applicable
Protection de l'installation: partie physique d'une installation réalisée par l'homme	Effective dans les **conditions normales de fonctionnement**	Effective en cas de défaillance de la **protection principale** d'un 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 en cas de défaillance de la **protection principale** d'un 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: des gants	Exemple: tapis de sol isolant	Exemple: gant isolé électriquement permettant de manipuler des conducteurs alimentés
Protection par instructions comportement volontaire ou averti destiné à réduire la probabilité de transfert d'énergie à une partie du corps	En l'absence de toute **protection de l'équipement** effective dans les **conditions normales de fonctionnement**	Effective en cas de défaillance de la **protection principale** d'un équipement	Effective uniquement de manière exceptionnelle, lorsque 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 les 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 Figure 3).

Un transfert d'énergie électrique se produit lorsqu'il existe au moins deux contacts électriques avec le corps:

- le premier contact électrique se situe entre une partie du corps et une partie conductrice de l'équipement;
- le deuxième contact électrique se situe entre une autre partie du corps et
  - la terre; ou
  - une autre partie conductrice de l'équipement.

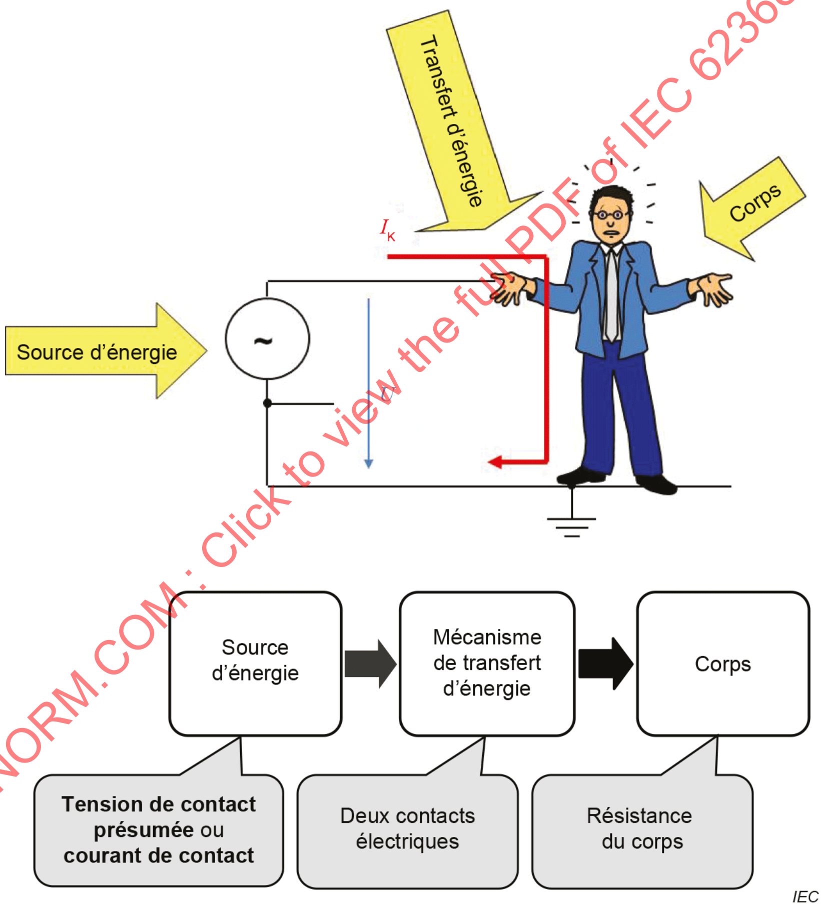

Figure 3 – Schéma et modèle pour les douleurs ou les blessures dues à l'électricité

En fonction de l'amplitude, de la durée, de la forme d'onde et de la fréquence du courant, l'effet sur le corps humain peut être indétectable, détectable ou douloureux et peut aller jusqu'à provoquer une blessure.

0.6.2 Modèles de protection contre les douleurs ou les blessures dues à l'électricité

Une ou plusieurs **protections** sont interposées entre la source d'énergie électrique pouvant provoquer des douleurs ou des blessures et une partie du corps pour se protéger contre les douleurs ou les blessures dues à l'électricité (voir Figure 4).

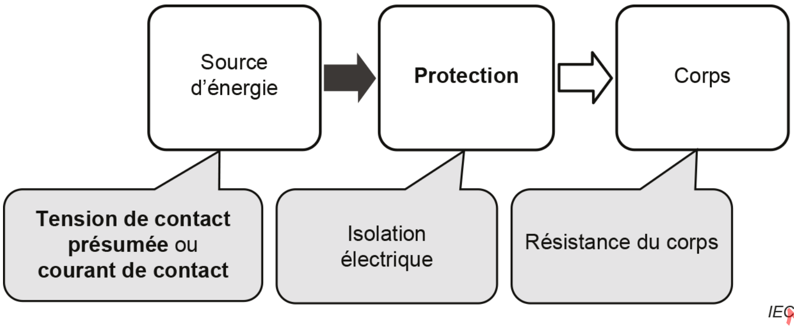

Figure 4 – Modèle de protection contre les douleurs ou les blessures dues à l'électricité

Une protection contre les douleurs dues à l'électricité est fournie dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement**. Pour une protection de ce type, dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, une **protection principale** est 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.

Une protection contre les blessures dues à l'électricité est fournie dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut**. Pour une protection de ce type, dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement**, une **protection principale** et une **protection supplémentaire** sont 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 défaillance de l'une des **protections**, l'autre **protection** devient effective. La **protection supplémentaire** contre une source d'énergie électrique pouvant provoquer une blessure est placée 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 de protection, voire une autre construction qui réalise la même fonction.

Une autre **protection** contre une source d'énergie électrique pouvant provoquer une blessure est l'isolation électrique (également appelée **double isolation** ou **isolation renforcée**) placée entre la source d'énergie et une partie du corps.

De même, une **protection renforcée** peut être placée 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 Figure 5), lorsque l'énergie thermique chauffe un matériau combustible, entraînant son inflammation et sa combustion.

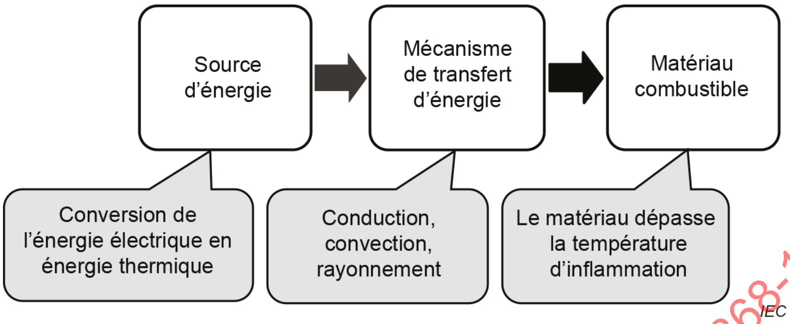

Figure 5 – Modèles pour les incendies d'origine électrique

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. A 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 atteint sa température d'inflammation. Lorsque le gaz atteint sa température d'inflammation spontanée, l'inflammation de ce dernier est automatique. Les deux cas entraînent un incendie.

0.7.2 Modèles de protection contre les incendies d'origine électrique

La **protection principale** contre les incendies d'origine électrique (voir Figure 6) consiste à maintenir le matériau, dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement**, à une température 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.

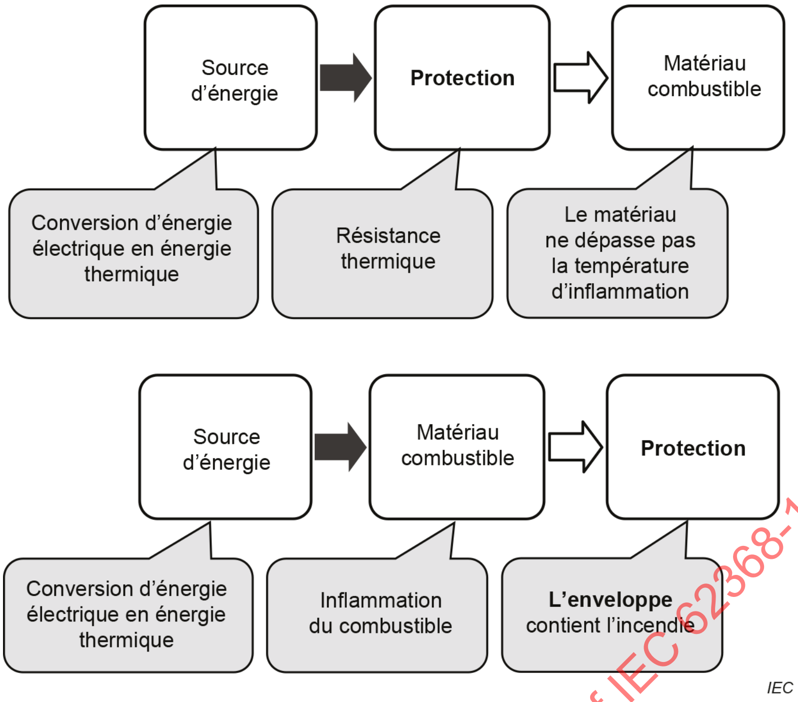

Figure 6 – Modèles de protection contre les incendies

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 de l'amplitude et de la durée de l'exposition, ainsi que de la sensibilité de la partie du corps exposée 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** similaire à la classification des autres sources d'énergie dans le présent document. 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 la partie du corps 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 une défaillance du mur, du plafond ou du moyen de montage;
– mouvement de l'équipement dû à une défaillance de la poignée;
– mouvement d'une partie dû à une explosion de la **batterie**;
– mouvement de l'équipement dû à une instabilité ou à une défaillance 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 robustes;
– des moyens de montage robustes;
– 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 des formations;
– des **enveloppes** ou des barrières supplémentaires;
– des **verrouillages de sécurité**.

La **protection renforcée** contre les blessures dues à un choc mécanique dépend de la source d'énergie spécifique. Les **protections renforcées** peuvent être:

– du verre extra épais à l'avant d'un tube cathodique;
– des rails de baies 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 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.

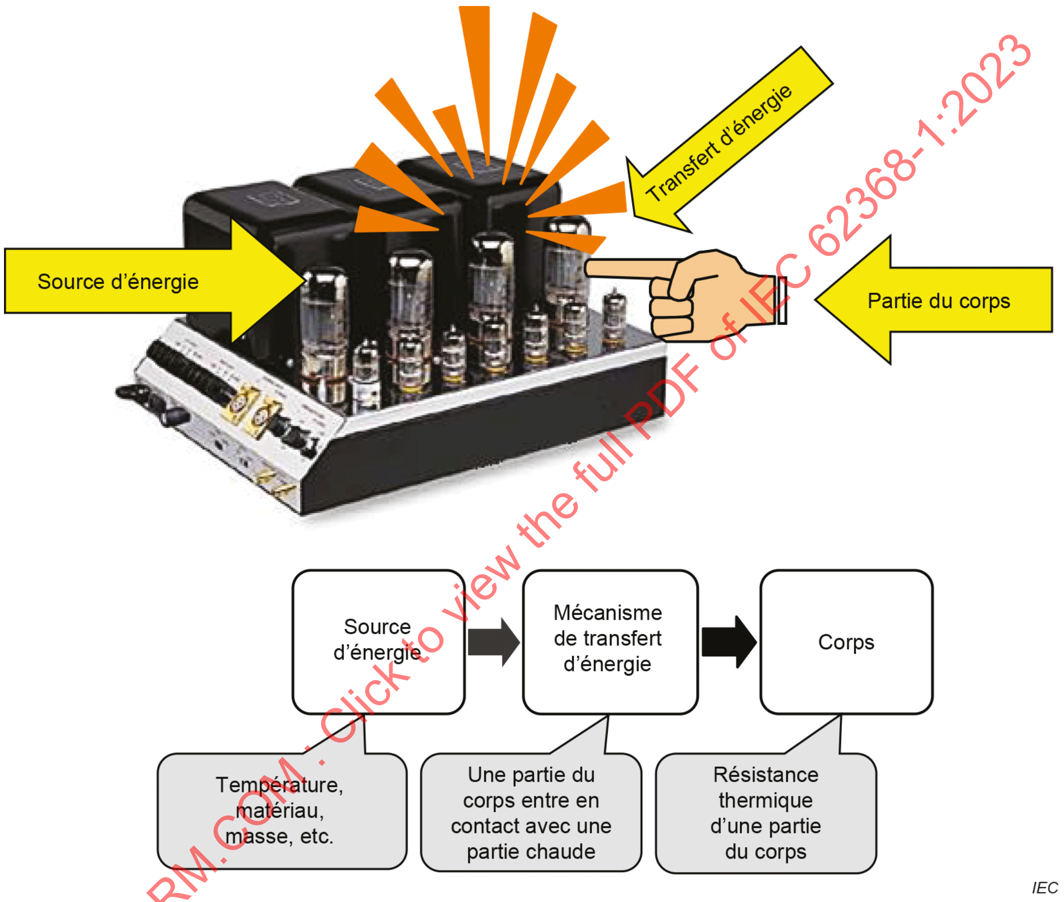

Figure 7 – Schéma et modèle pour les blessures dues à la chaleur

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 de protection contre les douleurs ou les blessures dues à la chaleur

Une ou plusieurs **protections** sont interposées entre une source d'énergie thermique pouvant provoquer une douleur ou une blessure et une **personne ordinaire** (voir Figure 8).

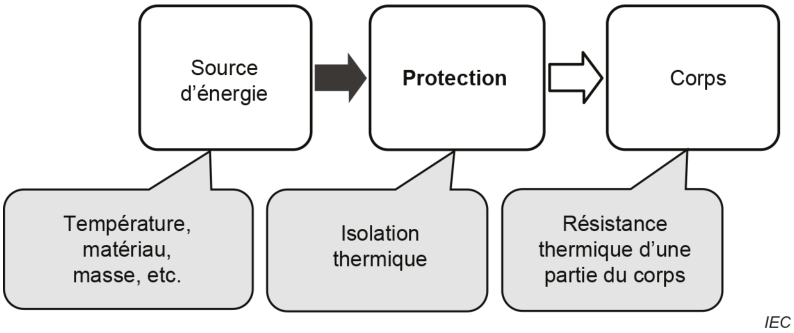

Figure 8 – Modèle de protection contre les blessures dues à la chaleur

Dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement**, une protection contre les douleurs dues à la chaleur est fournie. Pour une protection de ce type, une **protection principale** est interposée entre une source d'énergie thermique pouvant provoquer une douleur et une **personne ordinaire**.

Dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut**, une protection contre les blessures dues à la chaleur est fournie. Pour une protection de ce type, une **protection principale** et une **protection supplémentaire** sont 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 (**thermostat**, par exemple);
– 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 aux rayonnements

Les blessures dues aux rayonnements relevant du domaine d'application du présent document sont généralement attribuées à l'un des mécanismes de transfert d'énergie suivants:

- échauffement d'un organe du corps provoqué par une exposition à un rayonnement non ionisant, comme l'énergie fortement localisée d'un laser dirigé sur la rétine; ou
- blessure auditive provoquée par une surstimulation de l'oreille par des pics excessifs ou des sons intenses prolongés, entraînant un endommagement physique ou nerveux; ou
- rayonnement X; ou
- rayonnement UV.

L'énergie rayonnée est transférée par l'impact d'une onde émise sur une partie du corps.

La **protection principale** contre les blessures dues aux rayonnements est le confinement de l'énergie dans une **enveloppe** opaque à l'énergie rayonnée.

Il existe plusieurs **protections supplémentaires** contre les blessures dues aux rayonnements. 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 le niveau de sortie acoustique des lecteurs de musique individuels et de leurs casques et écouteurs associés.

Des exemples de **protections supplémentaires** 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 l'IEC 62368 s'applique à la sécurité de l'équipement électrique et électronique dans le domaine des technologies audio, vidéo, d'information et de communication, ainsi que des machines commerciales ou de bureau dont la **tension assignée** est inférieure ou égale à 600 V. Le présent document ne contient ni les exigences de performances ni les caractéristiques fonctionnelles de ces équipements.

NOTE 1 Des exemples d'équipements relevant du domaine d'application du présent document sont donnés à l'Annexe A.

NOTE 2 Une **tension assignée** de 600 V est considérée comme couvrant les équipements de tension assignée 400/690 V.

Des informations explicatives relatives au présent document sont données dans l'IEC TR 62368-2. Celle-ci comporte des justifications, ainsi que des informations explicatives qui peuvent être utiles à l'application du présent document.

Le présent document s'applique également:

– aux composants et aux **sous-ensembles** destinés à être intégrés dans cet équipement. Ces composants et **sous-ensembles** peuvent ne pas satisfaire à l'ensemble des exigences spécifiées dans le présent document, sous réserve que l'équipement complet, y compris ses composants et **sous-ensembles**, respecte ces exigences;
– aux blocs d'alimentation externes destinés à alimenter essentiellement des équipements relevant du domaine d'application du présent document;
– aux accessoires destinés à être utilisés avec des équipements relevant du domaine d'application du présent document;
– aux équipements de grandes dimensions dans les **zones à accès limité**. Pour les équipements de grandes dimensions, des exigences supplémentaires peuvent s'appliquer; et
– aux équipements à utiliser dans des régions tropicales.

Le présent document contient également des exigences relatives aux équipements des technologies de l'audio/vidéo, de l'information et de la communication destinés à être installés dans un **emplacement pour installation extérieure**. Les exigences relatives au **matériel pour installation extérieure** s'appliquent également, le cas échéant, aux **enveloppes extérieures** prévues pour l'installation directe sur site et fournies pour recevoir l'équipement de technologie de l'audio/vidéo, de l'information et de la communication à installer dans un **emplacement pour installation extérieure**. Pour connaître les exigences de construction spécifiques non couvertes dans les autres parties du présent document, consulter l'Annexe Y.

Le présent document s'aligne sur l'IEC 61140 et traite de l'installation électrique par une mise en correspondance adéquate avec les aspects communs liés à la sécurité de l'installation.

Chaque installation peut faire l'objet d'exigences particulières. De plus, les exigences de protection du **matériel pour installation extérieure** contre les effets des coups de foudre directs ne sont pas traitées dans le présent document.

NOTE 3 Pour plus d'informations, consulter l'IEC 62305-1.

Sauf spécification contraire par le fabricant, le présent document prend pour hypothèse une altitude maximale de 2 000 m.

Des exigences supplémentaires pour les équipements capables de fournir ou de recevoir une alimentation en courant continu à l'aide des câbles de communication couramment utilisés comme les câbles USB ou Ethernet (PoE), sont données dans l'IEC 62368-3. L'IEC 62368-3 ne s'applique pas:

– aux équipements qui fournissent ou reçoivent la puissance à l'aide de connecteurs propriétaires; ou
– aux équipements qui utilisent un protocole propriétaire pour activer le transfert de puissance.

Le présent document 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 4 En Australie, les opérations effectuées par une **personne avertie** ou par une **personne qualifiée** peuvent nécessiter la délivrance d'une licence formelle par les autorités de réglementation.

NOTE 5 En Allemagne, dans la plupart des cas, une personne peut uniquement être considérée comme une **personne avertie** ou une **personne qualifiée** si certaines exigences légales sont respectées.

Le présent document ne s'applique pas:

– aux matériels qui comportent des parties mobiles dangereuses qui ne sont pas autonomes (équipements robotiques, par exemple);

  NOTE 6 Pour connaître les exigences relatives aux équipements robotiques dans un environnement industriel, consulter l'IEC 60204-1, l'IEC 60204-11, l'ISO 10218-1 et l'ISO 10218-2.

– aux robots de soins personnels, y compris les robots d'assistance à la personne mobiles, les robots d'assistance physique et les robots de transport de personne;

  NOTE 7 Pour les exigences relatives aux robots de soins personnels, consulter l'ISO 13482.

– aux systèmes d'alimentation électrique ne faisant pas partie intégrante de l'équipement (les groupes convertisseurs, les systèmes de **batterie** de secours et les transformateurs de distribution, par exemple);
– aux équipements qui doivent être utilisés dans des zones humides en intérieur.

Le présent document ne traite pas:

- des processus de fabrication, à l'exception des **essais individuels de série**;
- des effets pouvant provoquer des blessures des gaz libérés par la décomposition ou la combustion thermique;
- des processus d'élimination;
- des effets du transport (autres que ceux spécifiés dans le présent document);
- 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 l'utilisation de l'équipement dans des atmosphères enrichies en oxygène ou **explosives**;
- de l'exposition à des substances chimiques autres que celles spécifiées à l'Article 7;
- des décharges électrostatiques;
- de l'exposition aux champs électromagnétiques;
- des aspects environnementaux;
- des exigences en matière de sécurité fonctionnelle, à l'exception de celles liées aux **cellules de travail**.

NOTE 8 Pour connaître les exigences spécifiques relatives à la sécurité fonctionnelle et à la sûreté logicielle des systèmes électroniques liés à la sécurité (circuits électroniques de protection, par exemple), consulter l'IEC 61508-1.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60027-1, *Symboles littéraux à utiliser en électrotechnique – Partie 1: Généralités*

IEC 60038, *Tensions normales de la CEI*

IEC 60068-2-6, *Essais d'environnement – Partie 2-6: Essais – Essai Fc: Vibrations (sinusoïdales)*

IEC 60068-2-11, *Essais d'environnement – Partie 2-11: Essais – Essai Ka: Brouillard salin*

IEC 60068-2-78, *Essais d'environnement – Partie 2-78: Essais – Essai Cab: Chaleur humide, essai continu*

IEC 60073, *Principes fondamentaux et de sécurité pour l'interface homme-machine, le marquage et l'identification – Principes de codage pour les indicateurs et les organes de commande*

IEC TR 60083, *Prises de courant pour usages domestiques et analogues normalisées par les pays membres de l'IEC*

IEC 60085, *Isolation électrique – Évaluation et désignation thermiques*

IEC 60086-4, *Piles électriques – Partie 4: Sécurité des piles au lithium*

IEC 60086-5, *Piles électriques – Partie 5: Sécurité des piles à électrolyte aqueux*

IEC 60107-1:1997, *Méthodes de mesures applicables aux récepteurs de télévision – Partie 1: Considérations générales – Mesures aux domaines radiofréquences et vidéofréquences*

IEC 60112, *Méthode de détermination des indices de résistance et de tenue au cheminement des matériaux isolants solides*

IEC 60127 (toutes les parties), *Coupe-circuit miniatures*

IEC 60127-8, *Coupe-circuit miniatures – Partie 8: Résistances de protection avec protection particulière contre les surintensités*

IEC 60227-1, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 1: Exigences générales*

IEC 60227-2:1997[1], *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 2: Méthodes d'essais*
IEC 60227-2:1997/AMD1:2003

IEC 60243-1, *Rigidité diélectrique des matériaux isolants – Méthodes d'essai – Partie 1: Essais aux fréquences industrielles*

IEC 60245-1, *Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V – Partie 1: Exigences générales*

IEC 60268-1:1985, *Équipements pour systèmes électroacoustiques – Partie 1: Généralités*
IEC 60268-1:1985/AMD1:1988
IEC 60268-1:1985/AMD2:1988

IEC 60309 (toutes les parties), *Fiches, socles fixes de prise de courant, prises mobiles et socles de connecteur pour usages industriels*

IEC 60317 (toutes les parties), *Spécifications pour types particuliers de fils de bobinage*

IEC 60317-0-7:2017, *Spécifications pour types particuliers de fils de bobinage – Partie 0-7: Exigences générales – Fil de section circulaire, isolé en continu (FIW), en cuivre émaillé, sans défaut d'isolation électrique*

IEC 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*

IEC 60317-56, *Spécifications pour types particuliers de fils de bobinage – Partie 56: Fil brasable de section circulaire, isolé en continu, en cuivre émaillé avec polyuréthane sans défaut électrique, classe 180*

IEC 60320 (toutes les parties), *Connecteurs pour usages domestiques et usages généraux analogues*

IEC 60320-1, *Connecteurs pour usages domestiques et usages généraux analogues – Partie 1: Exigences générales*

[1] Cette publication a été supprimée et remplacée par l'IEC 63294:2021.

IEC 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*

IEC 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*

IEC 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 60384-14:2013, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 14: Spécification intermédiaire – Condensateurs fixes d'antiparasitage et raccordement à l'alimentation*
IEC 60384-14:2013/AMD1:2016

IEC 60417, *Symboles graphiques utilisables sur le matériel*, disponible à l'adresse: http://www.graphical-symbols.info/equipment

IEC 60529:1989, *Degrés de protection procurés par les enveloppes (Code IP)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC 60664-1:2020, *Coordination de l'isolement des matériels dans les réseaux d'énergie électrique à basse tension – Partie 1: Principes, exigences et essais*

IEC 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*

IEC 60691:2015, *Protecteurs thermiques – Exigences et guide d'application*

IEC 60695-2-11, *Essais relatifs aux risques du feu – Partie 2-11: Essais au fil incandescent/chauffant – Méthode d'essai d'inflammabilité pour produits finis (GWEPT)*

IEC 60695-10-2, *Essais relatifs aux risques du feu – Partie 10-2: Chaleurs anormales – Essai à la bille*

IEC 60695-10-3, *Essais relatifs aux risques du feu – Partie 10-3: Chaleur anormale – Essai de déformation par réduction des contraintes de moulage*

IEC 60695-11-5:2016, *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*

IEC 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*

IEC 60695-11-20:2015, *Essais relatifs aux risques du feu – Partie 11-20: Flammes d'essai – Méthodes d'essai à la flamme de 500 W*

IEC 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 60728-11:2016, *Réseaux de distribution par câbles pour signaux de télévision, signaux de radiodiffusion sonore et services interactifs – Partie 11: Sécurité*

IEC 60730 (toutes les parties), *Dispositifs de commande électrique automatiques*

IEC 60730-1:2022, *Dispositifs de commande électrique automatiques – Partie 1: Exigences générales*

IEC 60738-1:2022, *Thermistances – Coefficient de température positif à chauffage direct – Partie 1: Spécification générique*

IEC 60747-5-5:2020, *Dispositifs à semiconducteurs – Partie 5-5: Dispositifs optoélectroniques – Photocoupleurs*

IEC 60825-1:2014, *Sécurité des appareils à laser – Partie 1: Classification des matériels et exigences*

IEC 60825-2, *Sécurité des appareils à laser – Partie 2: Sécurité des systèmes de télécommunications par fibres optiques (STFO)*

IEC 60825-12, *Sécurité des appareils à laser – Partie 12: Sécurité des systèmes de communication optique en espace libre utilisés pour la transmission d'informations*

IEC 60851-3:2009, *Fils de bobinage – Méthodes d'essai – Partie 3: Propriétés mécaniques*
IEC 60851-3:2009/AMD1:2013
IEC 60851-3:2009/AMD2:2019

IEC 60851-5:2008, *Fils de bobinage – Méthodes d'essai – Partie 5: Propriétés électriques*
IEC 60851-5:2008/AMD1:2011
IEC 60851-5:2008/AMD2:2019

IEC 60884-1, *Prises de courant pour usages domestiques et analogues – Partie 1: Exigences générales*

IEC 60896-11, *Batteries stationnaires au plomb – Partie 11: Batteries au plomb du type ouvert – Prescriptions générales et méthodes d'essai*

IEC 60896-21:2004, *Batteries stationnaires au plomb – Partie 21: Types étanches à soupapes – Méthodes d'essai*

IEC 60896-22, *Batteries stationnaires au plomb – Partie 22: Types étanches à soupapes – Exigences*

IEC 60906-1, *Système CEI de prises de courant pour usages domestiques et analogues – Partie 1 Prises de courant 16 A 250 V c.a.*

IEC 60906-2, *Système CEI de prises de courant pour usages domestiques et analogues – Partie 2: Prises de courant 15 A 125 V courant alternatif et 20 A 125 V courant alternatif*

IEC 60947-1, *Appareillage à basse tension – Partie 1: Règles générales*

IEC 60947-5-5, *Appareillage à basse tension – Partie 5-5: Appareils et éléments de commutation pour circuits de commande – Appareil d'arrêt d'urgence électrique à accrochage mécanique*

IEC 60990:2016, *Méthodes de mesure du courant de contact et du courant dans le conducteur de protection*

IEC 60998-1, *Dispositifs de connexion pour circuits basse tension pour usage domestique et analogue – Partie 1: Règles générales*

IEC 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)*

IEC 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)*

IEC 61051-1, *Varistances utilisées dans les équipements électroniques – Partie 1: Spécification générique*

IEC 61051-2:2021, *Varistances utilisées dans les équipements électroniques– Partie 2: Spécification intermédiaire pour varistances pour limitations de surtensions transitoires*

IEC 61056-1, *Batteries d'accumulateurs au plomb-acide pour usage général (types à soupapes) – Partie 1: Exigences générales et caractéristiques fonctionnelles – Méthodes d'essai*

IEC 61056-2, *Batteries d'accumulateurs au plomb-acide pour usage général (types à soupapes) – Partie 2: Dimensions, bornes et marquage*

IEC 61058-1:2016, *Interrupteurs pour appareils – Partie 1: Exigences générales*

IEC 61204-7, *Alimentations à découpage basse tension– Partie 7: Exigences de sécurité*

IEC 61260-1:2014, *Électroacoustique – Filtres de bande d'octave et de bande d'une fraction d'octave – Partie 1: Spécifications*

IEC 61293, *Marquage des matériels électriques avec des caractéristiques assignées relatives à l'alimentation électrique – Exigences de sécurité*

IEC 61427 (toutes les parties), *Accumulateurs pour le stockage de l'énergie renouvelable – Exigences générales et méthodes d'essais*

IEC 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*

IEC 61434, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Guide pour l'expression des courants dans les normes d'accumulateurs alcalins*

IEC 61558-1:2017, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et des combinaisons de ces éléments – Partie 1: Exigences générales et essais*

IEC 61558-2-16, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et combinaisons de ces éléments – Partie 2-16: Exigences particulières et essais pour les blocs d'alimentation à découpage et les transformateurs pour blocs d'alimentation à découpage pour applications d'ordre général*

IEC 61587-1:2022, *Structures mécaniques pour les équipements électriques et électroniques – Essais pour les séries IEC 60917 et IEC 60297 – Partie 1: Exigences environnementales, montages d'essai et aspects liés à la sécurité*

IEC 61643-11:2011, *Parafoudres à basse tension – Partie 11: Parafoudres connectés aux systèmes basse tension – Exigences et méthodes d'essai*

IEC 61643-331:2020, *Composants pour parafoudres basse tension – Partie 331: Exigences de performance et méthodes d'essai pour les varistances à oxyde métallique (MOV)*

IEC 61810-1:2015, *Relais électromécaniques élémentaires – Partie 1: Exigences générales et de sécurité*
IEC 61810-1:2015/AMD1:2019

IEC 61959, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Essais mécaniques pour accumulateurs portables étanches*

IEC 61965:2003, *Sécurité mécanique des tubes cathodiques*

IEC 61984, *Connecteurs – Exigences de sécurité et essais*

IEC 62061, *Sécurité des machines – Sécurité fonctionnelle des systèmes de commande relatifs à la sécurité*

IEC 62133-1, *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 – Partie 1: Systèmes au nickel*

IEC 62133-2:2017, *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 – Partie 2: Systèmes au lithium*
IEC 62133-2:2017/AMD1:2021

IEC 62230, *Câbles électriques – Méthode d'essai au défilement à sec (sparker)*

IEC 62281, *Sécurité des piles et des accumulateurs au lithium pendant le transport*

IEC 62440:2008, *Câbles électriques avec une tension assignée n'excédant pas 450/750 V – Guide d'emploi*

IEC 62471:2006, *Sécurité photobiologique des lampes et des appareils utilisant des lampes*

IEC 62471-5:2015, *Sécurité photobiologique des lampes et des appareils utilisant des lampes – Partie 5: Projecteurs d'images*

IEC 62485-2, *Exigences de sécurité pour les batteries d'accumulateurs et les installations de batteries – Partie 2: Batteries stationnaires*

IEC 62619:2022, *Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Exigences de sécurité pour les accumulateurs au lithium pour utilisation dans des applications industrielles*

IEC 62821-1, *Câbles électriques – Câbles à isolation et gaine thermoplastique sans halogène, à faible dégagement de fumée, de tension assignée au plus égale à 450/750 V – Partie 1: Exigences générales*

IEC 62821-2[2], *Câbles électriques – Câbles à isolation et gaine thermoplastique sans halogène, à faible dégagement de fumée, de tension assignée au plus égale à 450/750 V – Partie 2: Méthodes d'essais*

IEC 62821-3, *Câbles électriques – Câbles à isolation et gaine thermoplastique sans halogène, à faible dégagement de fumée, de tension assignée au plus égale à 450/750 V – Partie 3: Câbles souples (cordons)*

IEC 63010-1, *Halogen-free thermoplastic insulated and sheathed flexible cables of rated voltages up to and including 300/300 V – Part 1: General requirements and cables* (disponible en anglais seulement)

IEC 63010-2[3], *Halogen-free thermoplastic insulated and sheathed flexible cables of rated voltages up to and including 300/300 V – Part 2: Test methods* (disponible en anglais seulement)

IEC 63294:2021, *Méthodes d'essais pour les câbles électriques de tension assignée au plus égale à 450/750 V*

ISO 37, *Caoutchouc vulcanisé ou thermoplastique – Détermination des caractéristiques de contrainte-déformation en traction*

ISO 178, *Plastiques – Détermination des propriétés en flexion*

ISO 179-1, *Plastiques – Détermination de la résistance au choc Charpy – Partie 1: Essai de choc non instrumenté*

ISO 180, *Plastiques – Détermination de la résistance au choc Izod*

ISO 306, *Plastiques – Matières thermoplastiques – Détermination de la température de ramollissement Vicat (VST)*

ISO 527 (toutes les parties), *Plastiques – Détermination des propriétés en traction*

ISO 871, *Plastiques – Détermination de la température d'allumage au moyen d'un four à air chaud*

ISO 1798, *Matériaux polymères alvéolaires souples – Détermination de la résistance à la traction et de l'allongement à la rupture*

ISO 1817:2022, *Caoutchouc vulcanisé ou thermoplastique – Détermination de l'action des liquides*

ISO 2719, *Détermination du point d'éclair – Méthode Pensky-Martens en vase clos*

[2] Cette publication a été supprimée et remplacée par l'IEC 63294:2021.

[3] Cette publication a été supprimée et remplacée par l'IEC 63294:2021.

ISO 3679, *Détermination du point d'éclair – Méthode de l'éclair de type passe/ne passe pas et méthode du point d'éclair en vase clos à petite échelle*

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: Lignes directrices générales*

ISO 4892-2:2013, *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, *Symboles graphiques utilisables sur le matériel – Symboles enregistrés,* disponible à l'adresse: http://www.graphical-symbols.info/equipment

ISO 7010, *Symboles graphiques – Couleurs de sécurité et signaux de sécurité – Signaux de sécurité enregistrés*

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*

ISO 13849-1, *Sécurité des machines – Parties des systèmes de commande relatives à la sécurité – Partie 1: Principes généraux de conception*

ISO 14993, *Corrosion des métaux et alliages – Essais accélérés comprenant des expositions cycliques à des conditions de brouillard salin, de séchage et d'humidité*

ISO 21207, *Essais de corrosion en atmosphères artificielles – Essais de corrosion accélérée par expositions alternées à des gaz corrosifs ou au brouillard salin neutre et à un séchage*

ISO 22479, *Corrosion des métaux et alliages – Essai au dioxyde de soufre en atmosphère humide (méthode avec volume fixe de gaz)*

ASTM D412, *Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension*

ASTM D471-98, *Standard Test Method for Rubber Property – Effect of Liquids*

ASTM D3574, *Standard Test Methods for Flexible Cellular Materials – Slab, Bonded, and Molded Urethane Foams*

EN 50332-1:2013, *Équipement de systèmes acoustiques: Casques et écouteurs associés avec un baladeur – Méthode de mesure de niveau maximal de pression acoustique – 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 – Partie 2: Adaptation des équipements avec des écouteurs provenant de différents fabricants, ou provenant d'un équipement complet mais avec des connecteurs normalisés entre les deux, permettant d'associer des composants provenant de différents fabricants ou bien de conception différente*

EN 50332-3:2017, *Équipements de diffusion sonore: Casques et écouteurs associés avec un lecteur de musique individuel – Méthode de mesure de niveau maximal de pression acoustique – Partie 3: Méthode de mesure pour la gestion de la dose de bruit*

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 de puissance	voir 6.2
PS1	Source de puissance de classe 1	
PS2	Source de puissance de classe 2	
PS3	Source de puissance de classe 3	
RS	Source d'énergie de rayonnement	voir 10.2
RS1	Source d'énergie de rayonnement de classe 1	
RS2	Source d'énergie de rayonnement de classe 2	
RS3	Source d'énergie de 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
AIT (Auto Ignition Temperature)	température d'autoinflammation
ASI	alimentation sans interruption
AWG	American Wire Gauge
CD (Compact Disc)	disque compact
CD-ROM (Compact Disc Read-Only Memory)	disque optique compact
CRT (Cathode Ray Tube)	tube cathodique
CSD (Calculated Sound Dose)	**dose de bruit calculée**
CTP	coefficient de température positif
dBFS (digital signal level relative to Full Scale)	**niveau de signal numérique par rapport à la pleine échelle**
DVD (Digital Versatile Disc)	disque numérique polyvalent
E	exposition au bruit
EIS (Electrical Insulation System)	système d'isolation électrique
EPI	équipement de protection individuelle
EUT (Equipment Under Test)	matériel à l'essai
FIW (Fully Insulated Winding Wire)	**fil de bobinage totalement isolé**
IC (Integrated Circuit)	circuit intégré
ICX (Integrated Circuit with X-capacitor function)	circuit intégré avec fonction X du condensateur
IR	infrarouge
IRC	indice de résistance au cheminement
ITC	indice de tenue au cheminement
LED (Light Emitting Diode)	diode électroluminescente
LEL (Lower Explosion Limit)	limite inférieure d'explosivité
LFC (Liquid Filled Component)	**composant rempli de liquide**
LFL (Lower Flammability Limit)	limite inférieure d'inflammabilité
LPS (Limited Power Source)	source à puissance limitée
MEL (Momentary Exposure Level)	**niveau d'exposition momentané**
MOV (Metal Oxide Varistor)	varistance à oxyde métallique
NEMA	National Electrical Manufacturers Association
NiCd	nickel-cadmium
PIS (Potential Ignition Source)	**source potentielle d'incendie**
PMP (Personal Music Player)	lecteur de musique individuel
PoE (Power over Ethernet)	alimentation électrique par câble Ethernet
RC	résistance-capacité
RG (Risk Group)	groupe de risque
Sb	antimoine
SEL (Sound Exposure Level)	**niveau d'exposition au bruit**
SRME (Slide Rail Mounted Equipment)	équipement monté sur rails
TDG	tube à décharge dans un gaz
TSS (Thyristor Surge Suppressor)	parafoudre à thyristor
USB (Universal Serial Bus)	bus série universel
UV	ultraviolet
VDR (Voltage Dependent Resistor)	résistance sensible à la tension
VRLA (Valve Regulated Lead Acid Battery)	batterie étanche à soupapes

3.3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

Pour le confort de l'utilisateur, les termes définis sont énumérés ci-dessous dans l'ordre alphabétique, avec indication du numéro associé au terme défini.

Sauf spécification contraire dans le présent document, lorsque les mots "tension" et "courant" ou leurs abréviations sont utilisés, il s'agit de valeurs efficaces.

accessible	3.3.6.1
accumulateur bouton	3.3.17.3
amplificateur audio	3.3.1.1
batterie	3.3.17.1
batterie d'accumulateurs au lithium	3.3.17.8
bruit rose	3.3.1.4
câble d'alimentation fixé à demeure	3.3.6.13
caractéristique assignée du courant de protection	3.3.10.6
cellule de travail	3.3.6.25
circuit externe	3.3.1.2
classe d'inflammabilité du matériau	3.3.4.2
composant rempli de liquide, LFC	3.3.6.9
composant rempli de liquide modulaire, LFC modulaire	3.3.6.12
condition anormale de fonctionnement	3.3.7.1
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condition normale de fonctionnement	3.3.7.4
conducteur de liaison de protection	3.3.11.9
conducteur de mise à la terre de protection	3.3.11.12
conducteur de protection	3.3.11.10
construction de classe II	3.3.15.2
courant assigné	3.3.10.1
courant dans le conducteur de protection	3.3.14.4
courant de charge maximal spécifié	3.3.17.6
courant de contact	3.3.6.23
degré de pollution	3.3.6.15
disjoncteur thermique	3.3.13.2
dispositif	3.3.6.5
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distance d'isolement	3.3.12.1
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double isolation	3.3.5.2
double protection	3.3.11.3
élément	3.3.17.2
émetteur de puissance sans fil	3.3.3.12

3.3.1 Termes relatifs aux circuits

3.3.1.1
amplificateur audio
dispositif d'amplification des signaux audio destiné à actionner les haut-parleurs et les casques d'écoute

3.3.1.2
circuit externe
circuit électrique externe à l'équipement et qui n'est pas un **réseau d'alimentation**

Note 1 à l'article: Un **circuit externe** est classifié ES1, ES2 ou ES3 et PS1, PS2 ou PS3.

3.3.1.3
réseau d'alimentation
système de distribution d'alimentation en courant alternatif ou en courant continu (externe à l'équipement) qui fournit la puissance de fonctionnement à l'équipement

Note 1 à l'article: Un **réseau d'alimentation** comprend des services publics ou privés et, sauf spécification contraire dans le présent document, des sources équivalentes à des générateurs motorisés et des alimentations sans interruption.

Note 2 à l'article: L'alimentation de **circuits externes** au moyen de câbles et de circuits de communication isolés du **réseau d'alimentation** (par exemple, données, voix, PoE, USB, HDMI, coaxial, RFT et circuits analogues du Tableau 13) n'est pas considérée comme appartenant au **réseau d'alimentation**.

3.3.1.4
bruit rose
signal aléatoire stationnaire affichant une distribution de probabilité normale des valeurs instantanées, et dont l'énergie par unité de bande passante ($\Delta W/\Delta f$) est inversement proportionnelle à la fréquence

Note 1 à l'article: Sauf indication contraire, la valeur moyenne est de zéro.

Note 2 à l'article: Voir E.2.1

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: IEC 60050-195:2021, 195-06-13, modifié – 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: IEC 60050-195:2021, 195-02-35]

3.3.2.3
enveloppe ignifuge
enveloppe assurant la **protection** contre la propagation du feu depuis l'intérieur de l'**enveloppe** vers l'extérieur de l'**enveloppe**

Note 1 à l'article: En français, une **enveloppe ignifuge** est aussi appelée "enveloppe contre le feu".

3.3.2.4
enveloppe mécanique
enveloppe assurant la **protection** contre les douleurs et blessures dues à un choc mécanique

3.3.2.5
enveloppe extérieure
enveloppe destinée à assurer la protection contre des conditions particulières dans un **emplacement pour installation extérieure**

Note 1 à l'article: Une **enveloppe extérieure** peut également assurer les fonctions d'une autre **enveloppe**, par exemple: une **enveloppe ignifuge**, une **enveloppe électrique**, une **enveloppe mécanique**.

Note 2 à l'article: Une enceinte ou un boîtier séparé où est placé l'équipement peut faire office d'**enveloppe extérieure**.

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 fixe
équipement attaché à un support ou fixé d'une autre manière à un endroit précis par des moyens définis par le fabricant dans les instructions d'installation

Note 1 à l'article: Les équipements qui comportent des trous de vis ou d'autres moyens permettant à une **personne ordinaire** de fixer l'équipement, comme la fixation à une table ou dans le cadre d'une protection sismique, ne sont pas considérés comme des **équipements fixes**.

Note 2 à l'article: Généralement, l'**équipement fixe** est monté au mur, au plafond ou posé au sol.

[SOURCE: IEC 60050-826:2022, 826-16-07, modifié – L'exigence de définition des moyens de fixation dans les instructions d'installation a été ajoutée, et les notes à l'article ont été ajoutées.]

3.3.3.3
équipement portatif
équipement mobile ou partie d'un équipement de type indifférent, destiné à être tenu à la main en utilisation normale

3.3.3.4
équipement mobile
équipement:

– de masse inférieure ou égale à 18 kg et qui n'est pas un **équipement fixe**; ou
– équipé de roues, roulettes ou d'autres moyens permettant de faciliter le déplacement du matériel par une **personne ordinaire**, comme cela est exigé dans le cadre de son utilisation prévue

3.3.3.5
matériel pour installation extérieure
matériel installé ou exposé dans un **emplacement pour installation extérieure**, spécifié par le fabricant pour satisfaire en tout ou partie à des conditions particulières

Note 1 à l'article: Un **équipement transportable**, comme un ordinateur portable ou un téléphone, n'est pas un **matériel pour installation extérieure**, sauf si cela est spécifié par le fabricant dans le cadre d'une utilisation continue dans un **emplacement pour installation extérieure**.

3.3.3.6
équipement relié en permanence
équipement pouvant uniquement être connecté électriquement au ou déconnecté électriquement du **réseau d'alimentation** à l'aide d'un **outil**

3.3.3.7
équipement enfichable de type A
équipement prévu pour 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 les socles de prises de courant couverts par des normes comme l'IEC TR 60083 et l'IEC 60320-1.

3.3.3.8
équipement enfichable de type B
équipement prévu pour 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 les socles de prises de courant couverts par des normes comme l'IEC 60309-1.

3.3.3.9
équipement professionnel
équipement destiné à être utilisé dans les échanges commerciaux, dans les professions ou dans l'industrie, et qui n'est pas destiné à être vendu au grand public

[SOURCE: IEC 60050-161:1990, 161-05-05, modifié – La Note a été supprimée.]

3.3.3.10
équipement stationnaire

– **équipement fixe**; 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**.

3.3.3.11
équipement transportable
équipement prévu pour être régulièrement transporté

Note 1 à l'article: Les ordinateurs portables, les lecteurs CD et les accessoires portables, y compris leurs blocs d'alimentation externes, en sont des exemples.

3.3.3.12
émetteur de puissance sans fil
équipement qui utilise les champs électromagnétiques pour transférer la puissance électrique afin de charger des **appareils** portatifs alimentés par **batterie**

3.3.4 Termes relatifs à l'inflammabilité

3.3.4.1
matériau combustible
matériau susceptible de s'enflammer ou de brûler

Note 1 à l'article: Tous les matériaux thermoplastiques sont considérés comme susceptibles de s'enflammer ou de brûler, 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 lorsqu'ils sont soumis à l'essai conformément à l'IEC 60695-11-10, à l'IEC 60695-11-20, à l'ISO 9772 ou à l'ISO 9773.

3.3.4.2.1
matériau de classe 5VA
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié 5VA conformément à l'IEC 60695-11-20

3.3.4.2.2
matériau de classe 5VB
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié 5VB conformément à l'IEC 60695-11-20

3.3.4.2.3
matériau de classe HB40
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié HB40 conformément à l'IEC 60695-11-10

3.3.4.2.4
matériau de classe HB75
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié HB75 conformément à l'IEC 60695-11-10

3.3.4.2.5
matériau plastique cellulaire de classe HBF
matériau plastique cellulaire soumis à l'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 l'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 l'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 l'essai dans l'épaisseur significative la plus fine utilisée et classifié V-0 conformément à l'IEC 60695-11-10

3.3.4.2.9
matériau de classe V-1
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié V-1 conformément à l'IEC 60695-11-10

3.3.4.2.10
matériau de classe V-2
matériau soumis à l'essai dans l'épaisseur significative la plus fine utilisée et classifié V-2 conformément à l'IEC 60695-11-10

3.3.4.2.11
matériau de classe VTM-0
matériau soumis à l'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 l'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 l'essai dans l'épaisseur significative la plus fine utilisée et classifié VTM-2 conformément à l'ISO 9773

3.3.5 Isolation électrique

3.3.5.1
isolation principale
isolation qui assure 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: IEC 60050-195:2021, 195-06-08]

3.3.5.3
isolation fonctionnelle
isolation entre parties conductrices qui est uniquement nécessaire pour le bon fonctionnement du matériel

3.3.5.4
isolant liquide
matériau isolant entièrement constitué d'un liquide

[SOURCE: IEC 60050-212:2010, 212-11-04]

3.3.5.5
isolation renforcée
système d'isolation unique qui procure un degré de protection contre les chocs électriques équivalant à une **double isolation**

3.3.5.6
isolation solide
isolation entièrement constituée d'un matériau solide

[SOURCE: IEC 60050-212:2015, 212-11-02, modifié – "matériau isolant" a été remplacé par "isolation" et "solide" a été remplacé par "matériau solide".]

3.3.5.7
isolation supplémentaire
isolation indépendante appliquée en plus de l'**isolation principale** pour fournir une **isolation supplémentaire** afin de procurer une protection en cas de défaut contre les chocs électriques

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 à l'Annexe V.

3.3.6.2
retour de tension en entrée
condition dans laquelle une tension ou une énergie disponible dans l'alimentation de secours par **batterie** est renvoyée vers l'une des bornes d'entrée, soit directement, soit en suivant une voie de courant de fuite pendant le **mode de fonctionnement en autonomie** et lorsque la puissance du **réseau d'alimentation** n'est pas disponible

3.3.6.3
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.

3.3.6.4
fluide de refroidissement
fluide, liquide ou gaz, par l'intermédiaire duquel la chaleur est transférée

[SOURCE: IEC 60050-441:1996, 411-44-02]

3.3.6.5
dispositif
élément matériel ou assemblage d'éléments matériels destiné à remplir une fonction déterminée

Note 1 à l'article: Un **dispositif** peut faire partie d'un système plus important (par exemple, un nœud de serveur dans un système de baie).

[SOURCE: IEC 60050-151:2001, 151-11-20, modifié – Le texte entre parenthèses de la Note 1 à l'article a été ajouté.]

3.3.6.6
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

3.3.6.7
mise à la terre fonctionnelle
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: IEC 60050-195:2021, 195-01-13, modifié – "d'un ou de plusieurs points d'un réseau, d'une installation ou d'un matériel" a été ajouté; le terme traduisant "earthing" a été mis en accord avec la définition 195-01-24.]

3.3.6.8
système de refroidissement par liquide
système qui fait circuler un liquide et le refroidit, utilisé pour abaisser la température d'un **dispositif**

[SOURCE: IEC 60050-851:2008, 851-14-48, modifié – "du matériel de soudage à l'arc et de procédés connexes" a été remplacé par "d'un dispositif".]

3.3.6.9
composant rempli de liquide
LFC

partie constitutive d'un **dispositif** qui ne peut être fractionnée matériellement sans perdre sa fonction particulière et à travers laquelle circule le **fluide de refroidissement**

Note 1 à l'article: L'abréviation "LFC" est dérivée du terme anglais développé correspondant "liquid filled component".

EXEMPLE: Plaque froide, tuyaux, raccords et interconnexions.

[SOURCE: IEC 60050-151:2001, 151-11-21, modifié – Le terme principal "composant" a été remplacé par "composant rempli de liquide", "et à travers laquelle circule le **fluide de refroidissement**" a été ajouté dans la définition, et les exemples ont été ajoutés.]

3.3.6.10
ensemble de composants remplis de liquide
ensemble de LFC
ensemble de composants, dont l'un au moins est un **composant rempli de liquide**, réunis en une seule unité

EXEMPLE: Ensemble de plaque froide, de tuyaux, de raccords et d'interconnexions ou toute combinaison de ces éléments.

[SOURCE: IEC 60050-904:2014, 904-01-08, modifié – Le terme principal "ensemble électronique" a été remplacé par "ensemble de composants remplis de liquide", et "un composant électronique" a été remplacé par "un composant rempli de liquide" dans la définition.]

3.3.6.11
haut-parleur
transducteur permettant d'obtenir des ondes acoustiques à partir des ondes oscillantes électriques et conçu pour faire rayonner une puissance acoustique dans le milieu environnant

3.3.6.12
composant rempli de liquide modulaire
LFC modulaire
dispositif qui contient un **ensemble de composants remplis de liquide** et utilise des connexions externes pour compléter le **système de refroidissement par liquide**

EXEMPLE: L'unité de distribution du refroidissement ou le système d'eau de l'installation afin d'en assurer le fonctionnement constituent des exemples.

3.3.6.13
câble d'alimentation fixé à demeure
câble d'alimentation souple fixé ou monté sur l'équipement, qui ne peut pas être retiré de l'équipement sans l'aide d'**outils**

3.3.6.14
emplacement pour installation extérieure
emplacement pour un matériel pour lequel la protection contre les intempéries et autres influences extérieures, assurée par un bâtiment ou une autre structure, est limitée ou inexistante

3.3.6.15
degré de pollution
nombre caractérisant la pollution attendue du microenvironnement

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

3.3.6.16
zone à accès limité
zone **accessible** uniquement aux **personnes qualifiées** et aux **personnes averties** qui possèdent l'autorisation adéquate

3.3.6.17
essai individuel de série
essai effectué sur chaque **dispositif** en cours ou en fin de fabrication afin de vérifier qu'il satisfait à des critères définis

[SOURCE: IEC 60664-1:2020, 3.1.42, modifié – "essai de conformité" a été remplacé par "essai", "entité" a été remplacé par "dispositif", et "afin de vérifier qu'il satisfait à des critères définis" a été ajouté.]

3.3.6.18
essai sur prélèvement
essai effectué sur un certain nombre de **dispositifs** prélevés au hasard dans un lot

[SOURCE: IEC 60664-1:2020, 3.1.43]

3.3.6.19
LFC autonome
dispositif qui contient un **système de refroidissement par liquide** complet

Note 1 à l'article: Un **LFC autonome** constitué de plusieurs **LFC modulaires** est considéré comme un **LFC modulaire** au sens de l'Article G.15.

3.3.6.20
mode de fonctionnement en autonomie
mode stable de fonctionnement que l'alimentation de secours par **batterie** atteint dans les conditions spécifiées

Note 1 à l'article: Conformément à l'IEC 62040-1:2017, les conditions suivantes sont spécifiées:

– l'alimentation en courant alternatif d'entrée est déconnectée ou en dehors des tolérances exigées;
– la puissance de fonctionnement et la puissance de sortie proviennent du **dispositif** de stockage de l'énergie;
– la charge est conforme aux caractéristiques assignées spécifiées de l'alimentation de secours par **batterie**.

3.3.6.21
sous-ensemble
unité assemblée séparément, conçue pour être incorporée à d'autres unités au sein d'un produit manufacturé plus grand, et qui ne peut fonctionner indépendamment du produit final

Note 1 à l'article: Un **sous-ensemble** doit être considéré comme un composant du produit final.

3.3.6.22
outil
objet qui peut être utilisé pour fixer ou libérer une vis, un verrou ou un moyen de fixation analogue

Note 1 à l'article: Les **outils** peuvent être par exemple des pièces de monnaie, de la vaisselle, un tournevis, une pince, etc.

3.3.6.23
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

3.3.6.24
essai de type
essai réalisé sur un échantillon représentatif dans le but de déterminer si celui-ci peut satisfaire aux exigences du présent document, de par sa conception et sa fabrication

3.3.6.25
cellule de travail
espace situé à l'intérieur du matériel d'une taille telle qu'une personne peut y pénétrer complètement ou en partie (par exemple en y entrant tout un membre ou toute la tête) pour procéder à l'entretien ou au fonctionnement de l'équipement et à l'intérieur duquel peuvent exister des dangers mécaniques

Note 1 à l'article: Une **cellule de travail** peut contenir plusieurs compartiments. Un compartiment peut être utilisé à des fins d'exploitation ou de maintenance.

Note 2 à l'article: L'équipement contenant la **cellule de travail** est en général installé dans une **zone à accès limité**.

3.3.6.26
papier mousseline
papier de soie 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
condition anormale de fonctionnement
condition de fonctionnement temporaire qui ne constitue pas une **condition normale de fonctionnement** ni une **condition de premier défaut** de l'équipement proprement dit

Note 1 à l'article: Les **conditions anormales de fonctionnement** sont spécifiées à l'Article 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 la défaillance 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, le mesurage étant effectué à la fréquence d'essai à l'apparition de l'écrêtage de l'une ou l'autre des crêtes

Note 1 à l'article: Voir Annexe E.

3.3.7.4
condition normale de fonctionnement
mode de fonctionnement qui reflète le mieux le domaine d'utilisation normale qu'il peut être raisonnable d'attendre

Note 1 à l'article: Sauf spécification contraire dans le présent document, les conditions d'utilisation normale les plus rigoureuses sont les valeurs par défaut les plus défavorables spécifiées à l'Article B.2.

Note 2 à l'article: Le **mauvais usage raisonnablement prévisible** 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
fréquence de réponse de 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.

3.3.7.6
impédance assignée de charge
impédance ou résistance, spécifiée par le fabricant par laquelle il convient de terminer un circuit de sortie

3.3.7.7
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 comme une forme de **conditions anormales de fonctionnement**.

[SOURCE: Guide 51:2014 de l'ISO/IEC, 3.7, modifié – Dans la définition, "d'un produit ou d'un système" a été remplacé par "d'un produit, procédé ou service". Les Notes à l'article ont été remplacées.]

3.3.7.8
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 température ambiante

3.3.7.9
condition de premier défaut
condition de défaut de l'équipement dans les **conditions normales de fonctionnement** d'une **protection** unique (mais pas 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 à l'Article B.4.

3.3.8 Personnes

3.3.8.1
personne avertie
personne avertie ou supervisée 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: Au sens de la présente définition, l'adjectif "supervisé" signifie qui est dirigé et dont les performances sont contrôlées par une autre personne.

Note 2 à l'article: En Allemagne, dans la plupart des cas, une personne peut uniquement être considérée comme une **personne avertie** si certaines exigences légales sont respectées.

3.3.8.2
personne ordinaire
personne qui n'est ni une **personne qualifiée** ni une **personne formée**

[SOURCE: IEC 60050-826:2022, 826-18-03]

3.3.8.3
personne qualifiée
personne qui a acquis la formation ou l'expérience nécessaire pour lui permettre d'identifier les dangers et d'adopter les mesures adéquates afin de réduire les risques de blessures pour elle-même et les autres

Note 1 à l'article: En Allemagne, dans la plupart des cas, une personne peut uniquement être considérée comme a **personne qualifiée** si certaines exigences légales sont respectées.

[SOURCE: IEC 60050-826:2022, 826-18-01, modifié – La définition a été revue pour couvrir tous les types de dangers, et une nouvelle Note 1 à l'article a été ajoutée.]

3.3.9 Sources potentielles d'incendie

3.3.9.1
source potentielle d'incendie
PIS
emplacement dans lequel une énergie électrique peut provoquer une inflammation

Note 1 à l'article: L'abréviation "PIS" est dérivée du terme anglais développé correspondant "potential ignition source".

3.3.9.2
source potentielle d'incendie causé par la formation d'un arc électrique
PIS dans laquelle 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 constitue une **source potentielle d'incendie causé par la formation d'un arc électrique**.

Note 2 à l'article: Un faux contact ou l'interruption d'une connexion électrique pouvant se produire dans les impressions conductrices de 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
PIS dans laquelle un composant peut s'enflammer en raison d'une puissance dissipée excessive

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 constitue une **source potentielle d'incendie causé par un phénomène résistif**.

3.3.10 Caractéristiques assignées

3.3.10.1
courant assigné
courant d'entrée de l'équipement, déclaré par le fabricant dans les **conditions normales de fonctionnement**

3.3.10.2
fréquence assignée
fréquence d'alimentation ou plage de fréquences déclarée par le fabricant

3.3.10.3
puissance assignée
puissance d'entrée de l'équipement, 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: Les matériels peuvent avoir plus d'une valeur de **tension assignée** ou une plage de **tensions assignées**.

[SOURCE: IEC 60664-1:2020, 3.1.17]

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
caractéristique assignée du courant de protection
caractéristique assignée 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 contre le retour de tension en entrée
schéma de commande permettant de réduire le risque de choc électrique dû à un retour de tension en entrée

3.3.11.2
protection principale
protection fournie dans les **conditions normales de fonctionnement** et les **conditions anormales de fonctionnement** lorsque l'équipement comporte une source d'énergie pouvant provoquer des douleurs ou des blessures

3.3.11.3
double protection
protection qui comprend une **protection principale** et une **protection supplémentaire**

3.3.11.4
protection de l'équipement
protection constituant une partie physique de l'équipement

3.3.11.5
protection de l'installation
protection qui constitue une partie physique d'une installation réalisée par l'homme

3.3.11.6
protection par instructions
instruction qui sollicite un comportement spécifié

3.3.11.7
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: Les exemples sont des écrans faciaux, des lunettes et des masques de protection, des gants, des tabliers, des appareils de protection respiratoires.

3.3.11.8
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 d'une **personne qualifiée** ou d'après les instructions fournies par celle-ci

3.3.11.9
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: Le **conducteur de liaison de protection** est un composant interne à l'équipement.

3.3.11.10
conducteur de protection
conducteur prévu à des fins de sécurité (protection contre les chocs électriques, par exemple)

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: IEC 60050-195:2021, 195-02-09, modifié – Un exemple a été ajouté dans la définition, ainsi qu'une nouvelle Note 1 à l'article.]

3.3.11.11
mise à la terre de protection
action de mettre à la terre un ou plusieurs points d'un réseau, d'une installation ou d'un matériel à des fins de sécurité électrique

[SOURCE: IEC 60050-195:2021, 195-01-11, modifié – "un ou plusieurs points d'un réseau, d'une installation ou d'un matériel" a été ajouté.]

3.3.11.12
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**

3.3.11.13
protection renforcée
protection unique qui assure la protection dans:

– les **conditions normales de fonctionnement**;
– les **conditions anormales de fonctionnement**; et
– **les conditions de premier défaut**

3.3.11.14
protection
partie physique, système ou instruction fournie dans le but spécifique de réduire la probabilité de douleurs ou de blessures ou, en cas d'incendie, de 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**.

3.3.11.15
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.

3.3.11.16
protection mise en place grâce à l'expérience acquise
comportement d'une **personne avertie** visant à éviter tout contact ou exposition à une source d'énergie de classe 2 ou de classe 3, en s'appuyant sur sa formation et son expérience

3.3.11.17
protection supplémentaire
protection appliquée en plus de la **protection principale** qui est ou devient opérationnelle en cas de défaillance de la **protection principale**

3.3.12 Distances

3.3.12.1
distance d'isolement
plus petite distance dans l'air entre deux parties conductrices

[SOURCE: IEC 60664-1:2020, 3.1.4]

3.3.12.2
ligne de fuite
distance la plus courte, le long de la surface d'un isolant, entre deux parties conductrices

[SOURCE: IEC 60664-1:2020, 3.1.5, modifié – Dans la définition, "solide" a été supprimé.]

3.3.13 Commandes de température

3.3.13.1
limiteur de température
dispositif qui limite la température d'un système au-dessus ou au-dessous d'une valeur particulière en contrôlant, directement ou indirectement, le flux d'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 qui limite la température d'un système, dans les **conditions de premier défaut** en contrôlant, directement ou indirectement, le flux d'une énergie thermique à l'intérieur ou à l'extérieur du système

3.3.13.3
thermostat
dispositif qui maintient la température d'un système à l'intérieur d'une plage en contrôlant, directement ou 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 de crête à crête inférieure ou égale à 10 % de la valeur moyenne

Note 1 à l'article: Lorsqu'une ondulation de crête à crête dépasse 10 % de la valeur moyenne, les exigences liées à la tension de crête s'appliquent.

3.3.14.2
tension transitoire du réseau d'alimentation
tension de crête la plus élevée attendue à l'entrée du **réseau d'alimentation** dans l'équipement, causée par des transitoires externes

3.3.14.3
tension de contact présumée
tension apparaissant entre des parties conductrices simultanément **accessibles** ou entre une partie conductrice **accessible** et la terre quand ces parties conductrices ne sont pas touchées

[SOURCE: IEC 60050-195:2021, 195-05-09, modifié – Dans la définition, "ou entre une partie conductrice **accessible** et la terre" a été ajouté, et "par un être humain ou un animal" a été supprimé.]

3.3.14.4
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".

3.3.14.5
tension de tenue requise
tension de crête que l'isolation considérée doit supporter

3.3.14.6
tension de service efficace
valeur efficace vraie de la **tension de service**

Note 1 à l'article: La valeur efficace vraie de la **tension de service** comprend une composante continue 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 une tension à composante continue "B" est déterminée à l'aide de la formule suivante:

$$\text{valeur efficace} = (A^2 + B^2)^{1/2}$$

3.3.14.7
surtension temporaire
surtension à la fréquence industrielle du **réseau d'alimentation** de durée relativement longue

3.3.14.8
tension de service
tension appliquée à une isolation particulière lorsque l'équipement est alimenté à la **tension assignée** ou à une tension comprise dans la **plage de tensions assignées** dans les **conditions normales de fonctionnement**

Note 1 à l'article: Les tensions transitoires externes ne sont pas prises en considération.

Note 2 à l'article: Les tensions de crête récurrentes ne sont pas prises en considération.

3.3.15 Classes d'équipements par rapport à la protection contre les chocs électriques

3.3.15.1
matériel de classe I
matériel dont l'**isolation principale** est utilisée comme une **protection principale**, et dont la liaison de protection et la **mise à la terre de protection** sont utilisées comme **protection supplémentaire**

Note 1 à l'article: Les **matériels de classe I** peuvent posséder une **construction de classe II**.

[SOURCE: IEC 60050-851:2008, 851-15-10, modifié – La définition a été revue pour l'adapter au principe de **protection**, et une nouvelle Note 1 à l'article a été ajoutée.]

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
matériel 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
matériel 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

Note 1 à l'article: Les filtres à air ne sont pas considérés comme des matériaux consommables.

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 une défaillance 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'un ou de plusieurs **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 aptitude au débit

Note 1 à l'article: Un bloc de **batteries** est considéré comme étant équivalent à une **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
pile ou accumulateur bouton
batterie a un **élément** de petites dimensions dont le diamètre est supérieur à la hauteur

3.3.17.4
température de charge spécifiée la plus élevée
température de surface la plus élevée sur les **éléments** de la **batterie** spécifiée par le fabricant pendant la charge d'un accumulateur (**batterie** secondaire)

Note 1 à l'article: Par hypothèse, le fabricant du produit fini est tenu de spécifier la température de sécurité, la tension de sécurité ou le courant de sécurité de la **batterie** à partir des spécifications fournies par le fournisseur de la **batterie**.

3.3.17.5
température de charge spécifiée la moins élevée
température de surface la plus faible sur les **éléments** de la **batterie** spécifiée par le fabricant pendant la charge d'un accumulateur (**batterie** secondaire)

Note 1 à l'article: Par hypothèse, le fabricant du produit fini est tenu de spécifier la température de sécurité, la tension de sécurité ou le courant de sécurité de la **batterie** à partir des spécifications fournies par le fournisseur de la **batterie**.

3.3.17.6
courant de charge maximal spécifié
courant de charge le plus élevé spécifiée par le fabricant pendant la charge d'un accumulateur (**batterie** secondaire)

3.3.17.7
tension de charge maximale spécifiée
tension de charge la plus élevée spécifiée par le fabricant pendant la charge d'un accumulateur (**batterie** secondaire)

3.3.17.8
batterie d'accumulateurs au lithium
batterie qui comprend un ou plusieurs **éléments** accumulateurs au lithium

Note 1 à l'article: Les **batteries** rechargeables au lithium-ion, les **batteries** rechargeables polymère-lithium et les **batteries** rechargeables au lithium ou en alliage sont des exemples de **batteries d'accumulateurs au lithium**.

3.3.18 Termes relatifs aux fils de bobinage totalement isolés

3.3.18.1
fil de bobinage totalement isolé
FIW
fil de cuivre rond émaillé de polyuréthane de classe 180

Note 1 à l'article: Les propriétés isolantes sont conformes à l'IEC 60317-0-7, l'IEC 60317-56 et l'IEC 60851-5:2008. Dans ces normes, ce fil est également appelé "sans défaut d'isolation électrique", qu'elles définissent comme un "fil de bobinage qui ne présente pas de discontinuité électrique lorsqu'il est soumis aux essais dans des conditions spécifiques".

Note 2 à l'article: Le terme "sans défaut d'isolation électrique" est souvent utilisé pour désigner un **fil de bobinage totalement isolé**.

Note 2 à l'article: L'abréviation "FIW" est dérivée du terme anglais développé correspondant "fully insulated winding wire".

3.3.18.2
grade FIW
plage de diamètres globaux d'un fil (FIW3 à FIW9)

3.3.19 Exposition au bruit

3.3.19.1
dose de bruit calculée
CSD
estimation sur une semaine glissante de l'**exposition au bruit**, exprimée en pourcentage de la valeur maximale considérée comme sûre

Note 1 à l'article: Pour plus d'informations, consulter l'Article B.4 de l'EN 50332-3:2017.

Note 2 à l'article: L'abréviation "CSD" est dérivée du terme anglais développé correspondant "calculated sound dose".

3.3.19.2
niveau d'exposition momentané
MEL
mesure de l'estimation du niveau d'**exposition au bruit** de 1 s déterminée à partir d'un signal d'essai spécifique appliqué aux deux canaux, selon l'EN 50332-1:2013, 4.2

Note 1 à l'article: **MEL** est mesuré en dB(A).

Note 2 à l'article: Pour plus d'informations, consulter l'Article B.3 de l'EN 50332-3:2017.

Note 3 à l'article: L'abréviation "MEL" est dérivée du terme anglais développé correspondant "momentary exposure level".

3.3.19.3
exposition au bruit
E
pression acoustique pondérée A (p) au carré et intégrée sur une période établie, T

$$E = \int_0^T p(t)^2 \mathrm{d}t$$

Note 1 à l'article: L'unité SI est Pa^2 s.

3.3.19.4
niveau d'exposition au bruit
SEL
mesure logarithmique de l'**exposition au bruit** par rapport à une valeur de référence, E_0

$$\mathrm{SEL} = 10\log_{10}\left(\frac{E}{E_0}\right)$$

Note 1 à l'article: **SEL** est mesuré en dB(A).

Note 2 à l'article: La valeur de référence E_0 est en général le seuil auditif de 1 kHz chez l'être humain.

Note 3 à l'article: Pour plus d'informations, consulter l'Article B.4 de l'EN 50332-3:2017.

Note 4 à l'article: L'abréviation "SEL" est dérivée du terme anglais développé correspondant "sound exposure level".

3.3.19.5
niveau de signal numérique par rapport à la pleine échelle
dBFS
niveau de l'onde sinusoïdale de 997 Hz sans composante en courant continu dont la valeur de crête positive limitée est une pleine échelle numérique positive, où le code correspondant à la pleine échelle numérique négative n'est pas utilisé

Note 1 à l'article: Les niveaux indiqués en **dBFS** sont toujours des valeurs efficaces.

Note 2 à l'article: Il n'est pas correct d'utiliser l'unité **dBFS** pour des niveaux non efficaces. Etant donné que la définition de la pleine échelle repose sur une onde sinusoïdale, le niveau des signaux dont le facteur de crête est inférieur à celui de l'onde sinusoïdale peut dépasser 0 **dBFS**. En particulier, les signaux carrés peuvent atteindre +3,01 **dBFS**.

Note 3 à l'article: L'abréviation "dBFS" est dérivée du terme anglais développé correspondant "digital signal level relative to full scale".

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.

La classification est utilisée dans l'ensemble du document afin d'identifier clairement les sources d'énergie, le nombre de **protections** exigées ainsi que les exigences applicables à chaque **protection**.

Lorsque la conformité des matériaux, des composants ou des **sous-ensembles** est démontrée par examen, cette conformité peut être vérifiée par une revue des données publiées ou des résultats d'essais antérieurs.

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 satisfaire aux exigences du présent document ou, lorsque cela est spécifié dans un article d'exigences, aux aspects relatifs à la sécurité des normes de composants IEC applicables.

NOTE 1 Une norme de composant IEC est considérée comme applicable uniquement si le composant considéré relève clairement de son domaine d'application.

NOTE 2 L'essai applicable pour la conformité à une norme de composant est généralement réalisé séparément.

Lorsqu'il est admis d'utiliser une norme de composant IEC, 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 de composant IEC applicable a été démontrée doit être soumis aux essais applicables du présent document en tant que partie de l'équipement, à l'exception des essais relevant de la norme de composant IEC applicable;
– un composant dont la conformité à une norme applicable comme cela est susmentionné n'a pas été démontrée doit être soumis aux essais applicables du présent document, en tant que partie de l'équipement, et aux essais applicables de la norme de composant, dans les conditions présentes dans l'équipement;
– lorsque les composants sont utilisés dans des circuits non conformes à leurs caractéristiques assignées spécifiées, les composants doivent être soumis aux essais applicables de la norme de composant, dans les conditions présentes dans l'équipement. Le nombre d'échantillons exigé pour l'essai est généralement identique à celui exigé par la norme de composant.

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** spécifiées à l'Article B.2, les **conditions anormales de fonctionnement** spécifiées à l'Article B.3 et les **conditions de premier défaut** spécifiées à l'Article B.4, des **protections** soient prévues pour réduire la probabilité de blessures ou, en cas d'incendie, de dommages matériels. Les conditions générales d'essai sont données à l'Article B.1.

Les parties d'équipement pouvant provoquer des blessures doivent être équipées de **protections** conformes au 4.3.

Lorsque le fabricant spécifie l'utilisation d'un **outil** par une **personne ordinaire** ou une **personne avertie** afin d'accéder à une zone, les sources d'énergie de classe 2 et de classe 3 ne doivent pas être **accessibles**. Sont incluses les sources d'énergie contenues dans l'ensemble des autres compartiments de la zone concernée, en utilisant le même **outil**, à l'exception:

– pour l'entretien par une **personne ordinaire**, des sources d'énergie de classe 2 conformes au 4.3.2.3, où une **protection par instructions** doit être fournie conformément à l'Article F.5, excepté que l'élément 3 est facultatif; ou
– pour les **personnes averties**, des sources d'énergie de classe 2 conformes au 4.3.3.2.

La conformité est vérifiée par examen et par les essais appropriés.

4.1.4 Installation de l'équipement

A l'exception des indications du 4.1.6, l'évaluation de l'équipement conformément au présent document doit tenir compte des instructions des fabricants concernant l'installation, le déplacement, l'entretien et le fonctionnement, le cas échéant.

Les **enveloppes extérieures** assurant une fonction de **protection** doivent satisfaire à l'Annexe Y. Le **matériel pour installation extérieure** et les **enveloppes extérieures** doivent être adaptés à une utilisation à toutes les températures se trouvant dans la plage spécifiée par le fabricant. Si le fabricant n'a spécifié aucune plage, il doit alors s'agir:

– de la température ambiante minimale: -33 °C;
– de la température ambiante maximale: +40 °C.

La conformité est vérifiée par examen et par une évaluation des données fournies par le fabricant.

NOTE 1 Les valeurs de température reposent sur l'IEC 60721-3-4, Classe 4K2. Ces températures ne tiennent pas compte des environnements sévères (froid ou chaleur extrême, par exemple), ni n'incluent les dispositions en matière de chauffage par rayonnement solaire (charge solaire).

NOTE 2 Pour obtenir des informations supplémentaires sur les niveaux de performances C1, C2 et C3, consulter l'IEC 61587-1.

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 qui ne sont pas traités spécifiquement dans le présent document, l'équipement doit être équipé de **protections** qui correspondent au moins à celles généralement prévues par le présent document 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. Toutefois, si l'équipement comporte des moyens de fixation par une **personne ordinaire** (trous de vis pour la fixation directe à une surface de montage ou par l'utilisation de fixations ou d'éléments analogues, par exemple) qui sont soit fournis avec l'équipement soit aisément disponibles dans le commerce, toutes les positions probables de l'orientation de l'équipement doivent être prises en compte, y compris la possibilité de montage sur une surface non verticale, quelles que soient les instructions d'installation ou d'utilisation fournies par le fabricant.

En outre, pour les **équipements transportables**, toutes les orientations de transport doivent être prises en compte.

4.1.7 Choix de critères

Lorsque le présent document 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, fluides frigorigènes et composants remplis de liquide (LFC)

Sauf s'ils sont spécifiés comme des **isolants liquides**, les liquides doivent être traités comme des matériaux électriquement conducteurs.

Pour les équipements qui utilisent des fluides frigorigènes, consulter l'IEC 60335-2-40 et l'IEC 61010-2-011.

Les exigences de construction et d'essai pour les **LFC** sous pression utilisés à l'intérieur de l'équipement afin d'éviter toute blessure pouvant être provoquée par des fuites de liquide dans le **LFC** au sens du présent document doivent être conformes à l'Article G.15. Toutefois, l'Article G.15 ne s'applique à aucun des éléments suivants:

– **LFC** étanche, mais ouvert à l'atmosphère dans l'équipement;
– composants contenant de faibles quantités de liquides non susceptibles d'engendrer une blessure (par exemple, écrans à cristaux liquides, condensateurs électrolytiques, caloducs refroidisseurs de liquide, etc.);
– **batteries à piles** liquides (pour les **batteries à piles** liquides, voir l'Annexe M);
– **LFC** et ses parties associées qui sont conformes au P.3.3.

4.1.9 Instruments de mesure électriques

Les instruments de mesure électriques doivent disposer d'une bande passante suffisante pour effectuer des lectures exactes en 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 sinusoïdales et non sinusoïdales.

Les mesurages doivent être réalisés à l'aide d'un instrument de mesure dont l'impédance d'entrée influence de façon négligeable les mesures. Sauf indication contraire, l'instrument de mesure utilisé pour mesurer la tension doit avoir une impédance minimale de 1 MΩ.

4.1.10 Mesures de température

Sauf spécification contraire dans le présent document, 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 doit être prise en compte. Lorsqu'un essai est réalisé à une température ambiante spécifique (T_{amb}), une extrapolation (supérieure et inférieure) des résultats de l'essai peut être utilisée afin de tenir compte de l'impact de la plage de températures ambiantes spécifiée 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 l'essai. Les données d'essai et les spécifications du fabricant appropriées peuvent être examinées afin de déterminer l'effet des variations de température sur un composant ou un **sous-ensemble**. Les mesurages de température sont réalisés conformément au B.1.5.

4.1.11 Conditions de régime établi

Les conditions de régime établi sont les conditions, où l'équilibre thermique est considéré comme étant atteint (voir B.1.5).

4.1.12 Hiérarchie des protections

Les **protections** nécessaires pour les **personnes ordinaires** sont acceptables, mais ne sont pas toujours exigées pour les **personnes averties** et les **personnes qualifiées**. De même, les **protections** nécessaires pour les **personnes averties** sont acceptables, mais ne sont pas toujours exigées pour les **personnes qualifiées**.

Une **protection renforcée** peut être utilisée à la place d'une **protection principale**, 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** sont données dans des articles correspondants.

4.1.13 Exemples mentionnés dans le présent document

Lorsque des exemples sont donnés dans le présent document, 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 le présent document, doit:

– porter des marquages; ou
– présenter des instructions; ou
– disposer de **protections par instructions**

doit satisfaire aux exigences appropriées de l'Annexe F.

La conformité est vérifiée par examen.

NOTE En Finlande, en Norvège et en Suède, les **équipements enfichables de type A de classe I** prévus pour être raccordés à un autre équipement ou à un réseau doivent, 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**, comporter un marquage spécifiant que l'équipement doit être connecté à un socle de prise de courant du **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 dans le présent document, 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.

4.2.2 Source d'énergie de classe 2

Sauf spécification contraire dans le présent document, 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** et dans les **conditions de premier défaut**.

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, comme cela est indiqué en 4.2.4.

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.

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 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 Figure 9). Ainsi, une source d'énergie de classe 1 peut être **accessible** à une **personne ordinaire**.

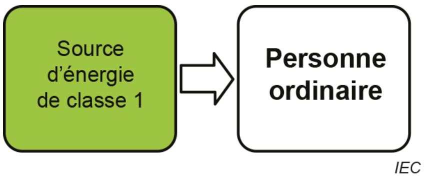


Figure 9 – Modèle de protection d'une personne ordinaire contre une source d'énergie de classe 1

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 Figure 10)

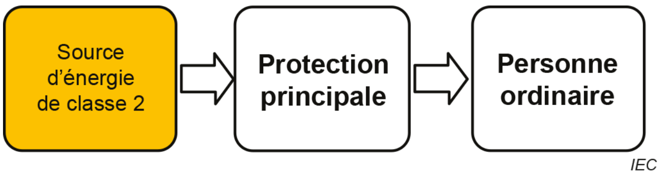


Figure 10 – Modèle de protection d'une personne ordinaire contre une source d'énergie de classe 2

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 le retrait ou la mise en échec d'une **protection principale**, une **protection par instructions** conforme à l'Article F.5 doit être prévue et placée de telle sorte qu'une **personne ordinaire** prenne connaissance des instructions avant de retirer ou de mettre en échec la **protection principale** de l'équipement (voir Figure 11).

La **protection par instructions** (voir l'Article F.5) doit inclure toutes les actions suivantes:

– identifier les parties et les emplacements de la source d'énergie de classe 2;
– spécifier des actions pour protéger les personnes de cette source d'énergie; et
– spécifier des actions pour rétablir ou restaurer la **protection principale**.

Si les conditions d'entretien par une **personne ordinaire** exigent qu'une **protection principale** soit retirée ou mise en échec, et lorsque l'équipement est destiné à un usage domestique, une **protection par instructions** (voir l'Article F.5), à l'attention des adultes, doit constituer un avertissement contre le retrait ou la mise en échec de la **protection principale** par les enfants.

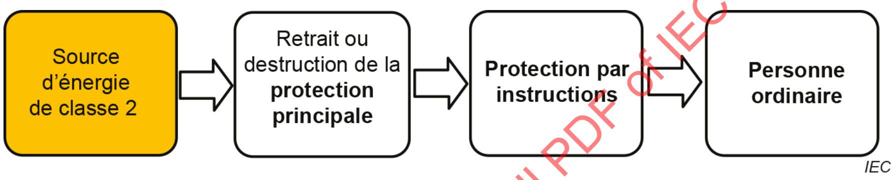


Figure 11 – Modèle de protection d'une personne ordinaire contre une source d'énergie de classe 2 dans les conditions d'entretien par une personne ordinaire

4.3.2.4 Protections entre une source d'énergie de classe 3 et une personne ordinaire

Sauf spécification contraire dans le présent document,

– une **protection principale d'équipement** et une **protection supplémentaire d'équipement** (formant une **double protection**); ou
– une **protection renforcée**

sont exigées entre une source d'énergie de classe 3 et une **personne ordinaire** (voir Figure 12).

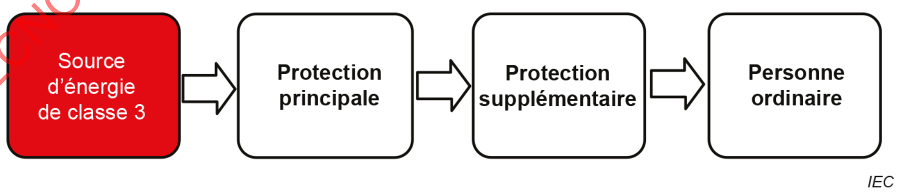


Figure 12 – Modèle de protection d'une personne ordinaire contre une source d'énergie de classe 3

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

Aucune **protection** n'est exigée entre une source d'énergie de classe 1 et une **personne avertie** (voir Figure 13).

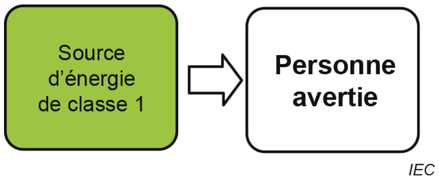


Figure 13 – Modèle de protection d'une personne avertie contre une source d'énergie de classe 1

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 Figure 14). Aucune **protection** additionnelle n'est exigée entre une source d'énergie de classe 2 et une **personne avertie**. Ainsi, une source d'énergie de classe 2 peut être **accessible** à une **personne avertie**.

Figure 14 – Modèle de protection d'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 dans le présent document,

– une **protection principale d'équipement** et une **protection supplémentaire d'équipement** (formant une **double protection**); ou
– une **protection renforcée**

est exigée entre une source d'énergie de classe 3 et une **personne avertie** (voir Figure 15).

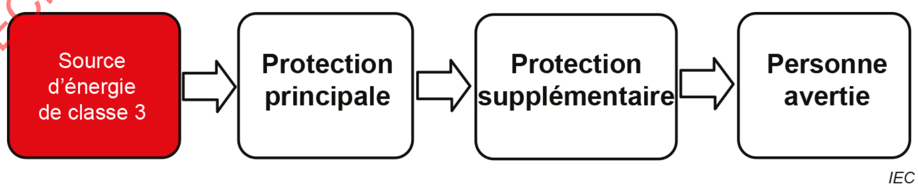


Figure 15 – Modèle de protection d'une personne avertie contre une source d'énergie de classe 3

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 Figure 16).

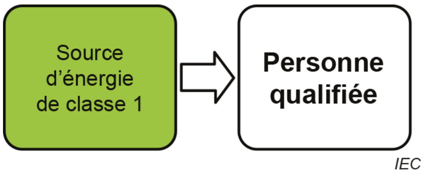


Figure 16 – Modèle de protection d'une personne qualifiée contre une source d'énergie de classe 1

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 Figure 17). Aucune **protection** additionnelle n'est exigée entre une source d'énergie de classe 2 et une **personne qualifiée**. Ainsi, une source d'énergie de classe 2 peut être **accessible** à une **personne qualifiée**.

Figure 17 – Modèle de protection d'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 Figure 18). Sauf spécification contraire dans le présent document (voir 8.5.4, par exemple), aucune **protection** additionnelle n'est exigée entre une source d'énergie de classe 3 et une **personne qualifiée**. Ainsi, une source d'énergie de classe 3 peut être **accessible** à une **personne qualifiée**.

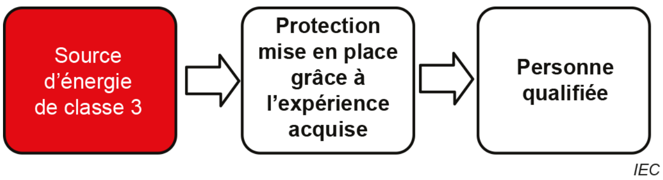


Figure 18 – Modèle de protection d'une personne qualifiée contre une source d'énergie de classe 3

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 Figure 19).

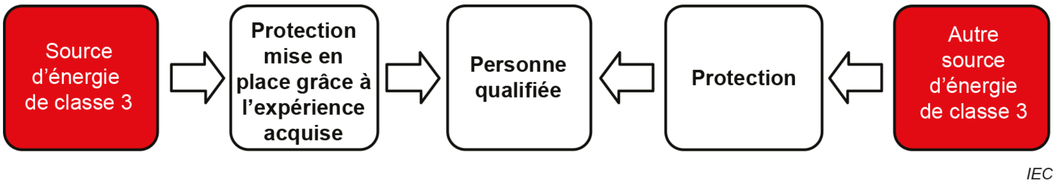


Figure 19 – Modèle de protection d'une personne qualifiée contre des sources d'énergie de classe 3 dans les conditions d'entretien de l'équipement

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 qu'exigées 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 le présent document spécifie un paramètre particulier de **protection**, comme une classe thermique d'isolation ou une **classe d'inflammabilité du matériau**, une **protection** présentant un meilleur paramètre peut être utilisée.

NOTE Pour connaître la hiérarchie des **classes d'inflammabilité des matériaux**, voir le Tableau S.1, le Tableau S.2 et le Tableau S.3.

4.4.2 Composition d'une protection

Une **protection** peut être composée d'un ou de plusieurs éléments.

4.4.3 Robustesse de la protection

4.4.3.1 Généralités

Lorsqu'une **protection** solide (par exemple, **enveloppe**, barrière, **isolation solide**, partie conductrice mise à la terre, verre, etc.) est **accessible** à une **personne ordinaire** ou à une **personne avertie**, la **protection** doit être conforme aux essais de robustesse applicables spécifiés de 4.4.3.2 à 4.4.3.10.

Une **protection solide** constituée de matériau thermoplastique et qui n'est pas **accessible** doit réussir l'essai de relâchement des contraintes du 4.4.3.8.

Pour une **protection accessible** après ouverture d'une **enveloppe** externe, voir 4.4.3.5.

Les exigences concernant:

– l'adhérence des revêtements métallisés; et
– les pièces de fixation adhésives servant de **protections**; et
– les parties qui peuvent mettre en échec une **protection** en cas de défaillance d'un adhésif

sont spécifiées à l'Article P.4.

Sauf spécification contraire, les essais sont réalisés dans la direction la plus défavorable.

4.4.3.2 Essais de force constante

Une **enveloppe** ou barrière qui est **accessible** et qui est utilisée comme une **protection** dans:

– les **équipements transportables**; ou
– les **équipements portatifs**; ou
– les **équipements à enficher directement**

doit être soumise à l'essai de force constante de l'Article T.4.

Une **protection** qui est **accessible** et qui sert uniquement d'**enveloppe ignifuge** ou de barrière contre le feu doit être soumise à l'essai de force constante de l'Article T.3.

Toutes les autres **enveloppes** ou barrières **accessibles** et utilisées comme une **protection** doivent être soumises 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.

Le présent paragraphe ne s'applique pas au verre. Les exigences applicables au verre sont données en 4.4.3.6.

4.4.3.3 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 exige d'être soulevé ou manipulé par une **personne ordinaire** dans le cadre de son utilisation prévue, y compris lors des déplacements ordinaires;

  NOTE Un exemple d'un tel équipement est une déchiqueteuse à papier posée sur un bac à ordure et qui exige le déplacement de la déchiqueteuse pour vider le bac.

– équipement de bureau d'une masse inférieure ou égale à 7 kg, conçu pour être utilisé avec l'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.

4.4.3.4 Essais de choc

Tous les équipements, autres que ceux spécifiés en 4.4.3.3, doivent être soumis à l'essai de choc de l'Article T.6.

L'essai de choc de l'Article T.6 ne s'applique pas aux éléments suivants:

– 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 décrits en 4.4.3.6.

– la surface de l'**enveloppe** de l'**équipement stationnaire**, y compris l'équipement à encastrer, qui
  - n'est pas **accessible**; ou
  - est protégé après l'installation.

4.4.3.5 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 de classe 3 **accessibles**, doit être soumise à l'essai de force constante de l'Article T.3.

4.4.3.6 Essais de choc sur le verre

Les exigences ci-dessous s'appliquent aux parties en verre, à l'exception de ce qui suit:

– une glace d'exposition utilisée sur les photocopieurs, scanneurs et dispositifs analogues, lorsque le verre a été soumis à l'essai de force constante de l'Article T.3 et qu'il comporte un capot ou un **dispositif** de protection de la glace d'exposition;
– les tubes cathodiques: les exigences relatives aux tubes cathodiques sont données à l'Annexe U;
– le verre qui est feuilleté ou dont la construction est telle que les particules de verre ne se séparent pas l'une de l'autre en cas de bris de glace.

  NOTE Le verre feuilleté inclut les constructions telles que le film plastique apposé sur un côté du verre.

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.

4.4.3.7 Essai de fixation du verre

Le verre feuilleté utilisé comme **protection** et empêchant l'accès aux sources d'énergie de classe 3 autres que PS3 doit être soumis aux essais de fixation suivants:

– un essai de choc sur le verre (voir l'Article T.9) avec trois chocs successifs de 1 J chacun; et
– un essai de pousser/tirer de 10 N appliqué au centre du verre dans le sens le moins favorable.

  NOTE Pour procéder à l'essai, toute méthode adaptée peut être utilisée, comme l'emploi de poignées d'aspiration ou le collage d'un support au verre.

4.4.3.8 Essais de matériau thermoplastique

Si une **protection** est composée d'un matériau thermoplastique moulé ou formé, cette **protection** doit être construite de sorte que tout retrait ou déformation du matériau résultant du relâchement des contraintes internes ne doit pas mettre en échec sa fonction de **protection**. Le matériau thermoplastique doit être soumis à l'essai de relâchement des contraintes de l'Article T.8.

4.4.3.9 Protection contenant de l'air

Lorsqu'une **protection** est composée d'air (**distance d'isolement**, par exemple), une barrière ou une **enveloppe** doit empêcher tout déplacement de l'air par une partie du corps ou une partie conductrice. La barrière ou l'**enveloppe** doit satisfaire à l'essai de résistance mécanique spécifié à l'Annexe T, selon le cas.

4.4.3.10 Critères de conformité

Pendant et après les essais du 4.4.3.2 au 4.4.3.9:

– *à 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.*

4.4.4 Déplacement d'une protection par un isolant liquide

Si un **isolant liquide** déplace l'air composant une **protection**:

– les exigences de 5.4.12 et 6.4.9 s'appliquent à l'**isolant liquide**; et
– les exigences du 5.4.2 et du 5.4.3 s'appliquent à l'équipement avec ou sans **isolant liquide** présent.

Une perte partielle ou totale d'**isolant liquide** doit être considérée comme une **condition anormale de fonctionnement** de l'équipement.

Si l'alimentation fournie aux parties plongées dans l'**isolant liquide** est déconnectée en cas de perte partielle ou totale d'**isolant liquide**, les exigences de 6.4.2 à 6.4.8 ne s'appliquent pas aux parties immergées. Un système d'interrupteur à flotteur conforme à l'Annexe K est un exemple de ce type de système de déconnexion.

NOTE Les exigences du présent document ne concernent pas l'utilisation d'**isolants liquides** pour remplacer une **isolation principale**, une **isolation supplémentaire** ou une **isolation renforcée**.

4.4.5 Verrouillages de sécurité

Sauf spécification contraire dans le présent document, si un **verrouillage de sécurité** est utilisé comme **protection** contre:

– une source d'énergie de classe 2 ou de classe 3 pour une **personne ordinaire**; ou
– une source d'énergie de classe 3 pour une **personne avertie**,

le **verrouillage de sécurité** doit satisfaire à l'Annexe K.

4.5 Explosion

4.5.1 Généralités

Une **explosion** peut être provoquée par:

- une réaction chimique;
- une déformation mécanique d'un conteneur étanche;
- une combustion ou décomposition rapide qui entraîne le dégagement d'un volume important de gaz chaud;
- une pression élevée; ou
- une température élevée.

NOTE 1 En fonction du débit d'énergie, une **explosion** peut être catégorisée comme une déflagration, une détonation ou une rupture de pression.

NOTE 2 Un supercondensateur (condensateur double couche, par exemple) est une source d'énergie élevée et peut exploser après une surcharge et une température élevée.

Pour les exigences concernant l'**explosion** des **batteries**, consulter l'Annexe M.

4.5.2 Exigences

Dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement**, aucune **explosion** ne doit se produire.

Si une **explosion** se produit dans les **conditions de premier défaut**, elle ne doit pas provoquer de blessure et l'équipement doit être conforme aux parties appropriées du présent document.

La conformité est vérifiée par examen et par les essais spécifiés à l'Article B.2, à l'Article B.3et à l'Article B.4.

4.6 Fixation des conducteurs et des parties conductrices

4.6.1 Exigences

Les conducteurs et les parties conductrices doivent être positionnés de telle sorte que le déplacement ne puisse pas mettre en échec une **protection**, et notamment réduire les **distances d'isolement** ou les **lignes de fuite** au-dessous des valeurs spécifiées en 5.4.2 et en 5.4.3.

La fixation des conducteurs et des parties conductrices doit être telle que, si un conducteur ou une partie conductrice se desserre ou se détache, le conducteur ou la partie conductrice ne peut pas mettre en échec une **protection**, et notamment réduire les **distances d'isolement** ou les **lignes de fuite** au-dessous des valeurs spécifiées en 5.4.2 et en 5.4.3.

EXEMPLE Les vis, écrous, rondelles, ressorts et pièces analogues sont des exemples de parties conductrices.

Pour les besoins de ces exigences, les hypothèses suivantes sont retenues:

- deux fixations indépendantes ne se desserrent ou ne se détachent pas 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 dispositifs analogues peuvent assurer un verrouillage satisfaisant.

4.6.2 Critères de conformité

La conformité est vérifiée par examen, par mesurage ou, en cas de doute, par l'essai de l'Article T.2 dans la direction la plus défavorable.

EXEMPLE Les constructions suivantes sont considérées comme étant conformes aux exigences:

– les tubes ajustés (gaine thermorétractable ou en caoutchouc, par exemple), appliqués sur le fil et son extrémité;

– 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, sous réserve que l'orifice par lequel passe le conducteur ne soit pas trop 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 équipés d'extrémités peu susceptibles de se libérer (cosses à anneau serties sur les conducteurs, par exemple). Toutefois, le pivotement de ce type d'extrémité est pris en compte; ou

– 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 de prises de courant

4.7.1 Généralités

Les équipements qui comportent des broches intégrées destinées à être insérées dans les socles de prises de courant du **réseau 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 du réseau d'**alimentation** doit être conforme à la norme applicable à la fiche du réseau d'**alimentation** correspondante.

L'équipement est inséré, comme en utilisation normale, dans un socle de prise de courant fixe qui présente la configuration 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 à appliquer au socle de prise de courant pour maintenir la face d'insertion dans le plan vertical ne doit pas dépasser 0,25 Nm. Le couple nécessaire pour maintenir le socle de prise de courant 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 de prise de courant conforme à la norme BS 1363, et la partie fiche doit être évaluée selon les articles applicables de la norme BS 1363.

4.8 Equipement contenant des piles ou des accumulateurs boutons

4.8.1 Généralités

Ces exigences s'appliquent aux équipements et télécommandes qui:

– sont susceptibles d'être **accessibles** aux enfants; et

– contiennent au moins une **pile bouton** ou un **accumulateur bouton** dont le diamètre est inférieur ou égal à 32 mm.

Ces exigences ne s'appliquent pas aux:

– **équipements professionnels**;

– équipements utilisés dans des emplacements où la présence d'enfants est peu probable;
– équipements dont la **pile bouton** ou l'**accumulateur bouton** est peu susceptible d'être retiré par des enfants en raison de l'emplacement de la **batterie** dans l'équipement; dans ces cas, le 4.8.2 s'applique toujours;
– équipements contenant des **piles ou accumulateurs boutons** qui sont brasés en place.

4.8.2 Protection par instructions

Les équipements qui contiennent un ou plusieurs **piles ou accumulateurs boutons** doivent posséder une **protection par instructions** conforme à l'Article F.5.

La **protection par instructions** n'est pas exigée lorsque ces **batteries** ne sont pas destinées à être remplacées ou lorsqu'elles sont **accessibles** uniquement après un endommagement de l'équipement.

La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: non disponible
– élément 2: "Ne pas ingérer la batterie. Danger de brûlure chimique" ou un texte équivalent
– élément 3: le texte suivant ou équivalent

  [La télécommande fournie avec] Ce produit contient une pile ou un accumulateur bouton. En cas d'ingestion, la pile ou l'accumulateur bouton, peut causer en seulement 2 h des brûlures internes sévères qui peuvent être mortelles.
– élément 4: le texte suivant ou équivalent

  Conserver les batteries neuves et usagées hors de portée des enfants.

  Si le compartiment à batteries 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'une batterie ou d'introduction dans une partie quelconque du corps, demander immédiatement un avis médical.

4.8.3 Construction

Les équipements qui disposent d'un compartiment, d'une porte ou d'un couvercle à **piles ou accumulateurs boutons** doivent être conçus de manière à réduire la possibilité que des enfants retirent la **pile ou l'accumulateur bouton**. Les dispositions suivantes sont considérées comme acceptables:

– si un **outil** tel qu'un tournevis ou une pièce est nécessaire pour ouvrir ou retirer le compartiment, la porte ou le couvercle à **piles ou accumulateurs boutons**, l'une des constructions suivantes peut être utilisée:
  - si une ou plusieurs vis ou fixations analogues sont utilisées pour fixer le compartiment, la porte ou le couvercle, au moins deux rotations complètes de la vis ou de la fixation sont nécessaires pour ouvrir ou retirer le compartiment, la porte ou le couvercle à **piles ou accumulateurs boutons**. La vis ou fixation doit être emprisonnée dans le compartiment, la porte, le couvercle à **piles ou accumulateurs boutons** ou l'équipement; ou
  - pour un couvercle dont l'ouverture exige une rotation, un couple minimal de 0,5 Nm doit être nécessaire pour déverrouiller le couvercle et engager sa rotation. Une rotation minimale de 90° doit être nécessaire pour retirer le couvercle; ou
  - pour un couvercle qui est sécurisé par un ou plusieurs verrous, un couple minimal de 0,5 Nm est nécessaire pour libérer les verrous;
– si aucun **outil** n'est nécessaire pour retirer le compartiment, la porte ou le couvercle à **piles ou accumulateurs boutons**, l'une des deux dispositions suivantes doit s'appliquer pour l'ouverture manuelle:

- la réalisation d'au moins deux mouvements différents et interdépendants; ou
- la réalisation de mouvements simultanés pour engager deux mécanismes qui nécessitent l'utilisation de plusieurs doigts.

La conformité est vérifiée par examen, par les mesurages applicables pour les constructions acceptables et par les essais du 4.8.4 avec le critère de conformité du 4.8.5.

4.8.4 Essais

4.8.4.1 Séquence d'essais

Un échantillon doit être soumis aux essais applicables de 4.8.4.2 à 4.8.4.6. S'il s'applique, l'essai du 4.8.4.2 doit être réalisé le premier.

4.8.4.2 Essai de relâchement des contraintes

*Si le compartiment à **batteries** est constitué de 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 de relâchement des contraintes de l'Article T.8.*

*Pendant l'essai, la **batterie** peut être retirée.*

4.8.4.3 Essai de remplacement de la batterie

*Pour les équipements dont le compartiment à **batteries** est protégé par une porte ou un couvercle, le compartiment à **batteries** doit être ouvert et fermé et les **batteries** doivent être retirées et remplacées dix fois pour simuler un remplacement normal conformément aux instructions du fabricant.*

*Si la porte ou le couvercle du compartiment à **batteries** est sécurisé par une ou plusieurs vis, celles-ci sont desserrées puis resserrées en appliquant un couple linéaire continu conformément au Tableau 36, en utilisant un tournevis adapté ou une clé. Les vis doivent être retirées et réinsérées 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 d'exercer la force maximale sur le compartiment à **batteries** 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 ou le couvercle du compartiment à **batteries** doit être soumis à trois chocs appliqués perpendiculairement à la porte ou au couvercle du compartiment à **batteries** conformément à la méthode d'essai de l'Article T.6 en appliquant une force de:*

- *0,5 J (102 mm ± 10 mm de hauteur) pour les lunettes utilisées pour regarder, par exemple, une télévision 3D; ou*
- *2 J (408 mm ± 10 mm de hauteur) pour tous autres portes ou couvercles.*

4.8.4.6 Essai d'écrasement

*Les **dispositifs** de télécommande tenus à la main doivent être placés sur une surface de 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 ± 5) N est appliquée sur les surfaces exposées supérieure et inférieure des **dispositifs** de télécommande placés de* *façon stable au moyen d'une surface plane rigide de dimensions 100 mm x 250 mm environ pendant 10 s.*

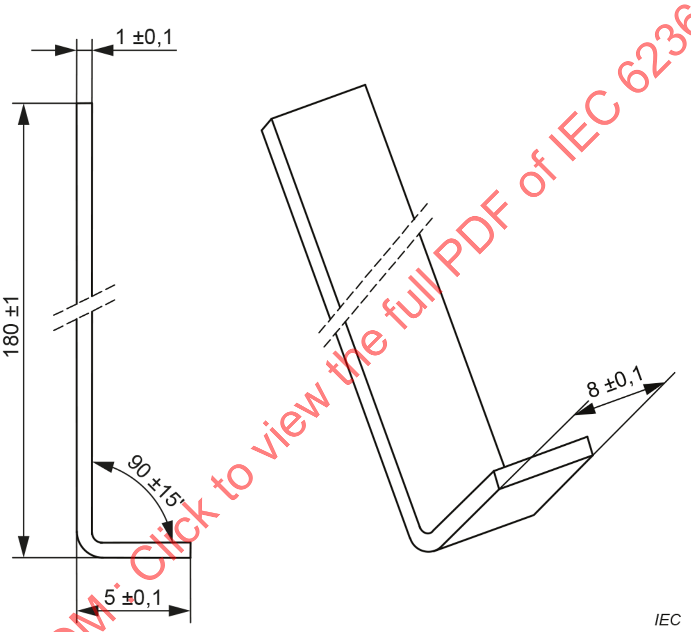
4.8.5 Critères de conformité

La conformité est vérifiée en appliquant une force de 30 N ± 1 N pendant 10 s sur la porte ou le couvercle du compartiment à ***batteries*** *au moyen de la version droite et inarticulée de la sonde d'essai de la Figure V.1 à l'emplacement et dans la direction les plus défavorables. La force doit être appliquée dans une seule direction à la fois.*

La porte ou le couvercle du compartiment à ***batteries*** *doit rester fonctionnel, et:*

- *la* ***batterie*** *ne doit pas devenir* ***accessible****; ou*
- *il ne doit pas être possible de retirer la* ***batterie*** *du produit avec le crochet d'essai de la Figure 20 en appliquant une force d'environ 20 N.*

Dimensions en millimètres



Matériau: acier

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 entre un circuit ES3 et des parties conductrices **accessibles**; ou
- sa mise en parallèle au sein de circuits PS3, sauf s'ils sont protégés par la méthode de maîtrise de la propagation du feu du 6.4.6;

les ouvertures supérieures et latérales au-dessus des circuits ES3 et PS3 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.

4.10 Exigences sur les composants

4.10.1 Dispositif de déconnexion

L'équipement connecté au **réseau d'alimentation** doit comporter un **dispositif de déconnexion** conforme à l'Annexe L.

4.10.2 Interrupteurs et relais

Les interrupteurs et relais situés dans un circuit PS3 ou utilisés comme une **protection** doivent respectivement satisfaire à l'Article G.1 ou à l'Article G.2.

4.10.3 Câbles d'alimentation du réseau d'alimentation

Les câbles d'alimentation permettant la connexion au **réseau d'alimentation** doivent être conformes à l'Article G.7. Un câble d'alimentation permettant la connexion au **réseau d'alimentation** n'est pas considéré comme un câblage externe.

4.10.4 Batteries et circuits de protection associés

Les **batteries** ainsi que leurs circuits de protection doivent être conformes à l'Annexe M.

5 Blessure due à un choc électrique

5.1 Généralités

Pour réduire la probabilité de douleurs et de blessures causées par le passage du courant électrique dans le corps humain, l'équipement doit être équipé des **protections** spécifiées à 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, d'un **dispositif** ou d'une isolation qui n'assure pas une fonction de **protection**; et

– ne dépassent pas les limites de ES2 dans les **conditions de premier défaut** d'une **protection principale** ou d'une **protection supplémentaire**.

Un **conducteur de protection** est une source d'énergie électrique de classe 1.

NOTE Pour les exigences d'accessibilité, voir 5.3.1.

5.2.1.2 ES2

ES2 est une source d'énergie électrique de classe 2 dont:

– la tension et le courant dépassent les limites de ES1; et

– dans
  - les **conditions normales de fonctionnement**; et
  - les **conditions anormales de fonctionnement**; et

- les **conditions de premier défaut**;

la tension ou le courant ne dépassent pas les limites de ES2.

NOTE Pour les exigences d'accessibilité, voir 5.3.1.

5.2.1.3 ES3

ES3 est une source d'énergie électrique de classe 3 dont la tension et le courant dépassent les limites de ES2.

Un conducteur de neutre est considéré comme une source d'énergie électrique de classe 3.

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 à une partie **accessible**.

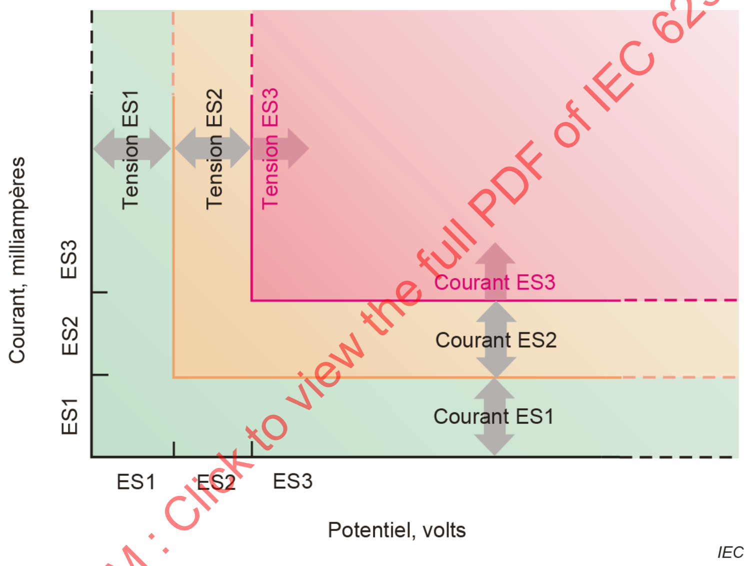


Figure 21 – Représentation des limites ES pour la tension et le courant

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 Figure 21.

La classification des **circuits externes** est réalisée à partir de leur tension ou de leur courant normal de fonctionnement, sans tenir compte des signaux de communication ou de données, à l'exception des signaux de sonnerie (voir 5.2.2.6) et des signaux audio (voir 5.2.2.7).

5.2.2.2 Limites de tension et de courant en régime établi

La classification d'une source d'énergie électrique est déterminée à partir de la **tension en courant continu** ou en courant alternatif et du courant maximal dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement** et dans les **conditions de premier défaut** (voir Tableau 4).

Il s'agit des valeurs maximales pouvant être fournies par la source. Le régime établi est considéré comme étant atteint lorsque les valeurs de tension ou de courant demeurent stables pendant 2 s ou plus. Sinon, les limites du 5.2.2.3, du 5.2.2.4 ou du 5.2.2.5 s'appliquent, selon le cas.

Tableau 4 – Limites de sources d'énergie électrique pour les sources ES1 et ES2 en régime établi

Source d'énergie	**Limites de ES1**		**Limites de ES2**		**ES3**
	Tension	**Courant** [a, c, d]	**Tension**	**Courant** [b, c, e]	
en courant continu [c]	60 V	2 mA	120 V	25 mA	
en courant alternatif jusqu'à 1 kHz	$U_{efficace}$ = 30 V $U_{crête}$ = 42,4 V		$U_{efficace}$ = 50 V $U_{crête}$ = 70,7 V		
en courant alternatif > 1 kHz jusqu'à 100 kHz	$U_{efficace} = (30 + 0{,}4\ f)$ V $U_{crête} = \left(42{,}4 + 0{,}4\sqrt{2}\ f\right)$ V	$I_{efficace}$ = 0,5 mA $I_{crête}$ = 0,707 mA	$U_{efficace} = (50 + 0{,}9\ f)$ V $U_{crête} = \left(70{,}7 + 0{,}9\sqrt{2}\ f\right)$ V	$I_{efficace}$ = 5 mA $I_{crête}$ = 7,07 mA	> ES2
en courant alternatif au-dessus de 100 kHz	$U_{efficace}$ = 70 V $U_{crête}$ = 99 V		$U_{efficace}$ = 140 V $U_{crête}$ = 198 V		
en courants alternatif et continu combinés [f]	$\frac{U_{continu}\ (V)}{60} + \frac{U_{alternatif\ efficace}\ (V)}{U_{efficace\ limite}} \le 1$ $\frac{U_{continu}\ (V)}{60} + \frac{U_{alternatif\ crête}\ (V)}{U_{crête\ limite}} \le 1$	$\frac{I_{continu}\ (mA)}{2} + \frac{I_{alternatif\ efficace}\ (mA)}{0{,}5} \le 1$ $\frac{I_{continu}\ (mA)}{2} + \frac{I_{alternatif\ crête}\ (mA)}{0{,}707} \le 1$	Voir Figure 23	Voir Figure 22	

En variante des exigences ci-dessus, les valeurs ci-dessous peuvent être utilisées pour les formes d'onde purement sinusoïdales.

Source d'énergie	**Limites de ES1**	**Limites de ES2**	**ES3**
	Courant [a, c] efficace	**Courant** [b, c] efficace	
en courant alternatif jusqu'à 1 kHz	0,5 mA	5 mA	
en courant alternatif > 1 kHz jusqu'à 100 kHz	$I_{efficace} = (0{,}5\ f)$ mA [d]	$I_{efficace} = (5 \times 0{,}95\ f)$ mA [e]	> ES2
en courant alternatif au-dessus de 100 kHz	50 mA [d]	100 mA [e]	

Les valeurs de crête doivent être utilisées pour les tensions et les courants non sinusoïdaux. Les valeurs efficaces peuvent être utilisées uniquement les tensions et les courants sinusoïdaux.

Pour le mesurage de la **tension de contact présumée** et du **courant de contact**, voir 5.7.

Les limites de courant de choc électrique sont issues de l'IEC 60479-1 et de l'IEC 60479-2.

f est exprimée en kHz.

[a]	Le courant est mesuré en utilisant le réseau de mesure spécifié à la Figure 4 de l'IEC 60990:2016.
[b]	Le courant est mesuré en utilisant le réseau de mesure spécifié à la Figure 5 de l'IEC 60990:2016.
[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-dessus de 22 kHz, la surface **accessible** est limitée à 1 cm^2.
[e]	Au-dessus de 36 kHz, la surface **accessible** est limitée à 1 cm^2.
[f]	$U_{\text{efficace limite}}$ est déterminée à partir de la limite de tension efficace correspondant à la fréquence applicable et $U_{\text{crête limite}}$ est déterminée à partir de la limite de tension de crête correspondant à la fréquence applicable.

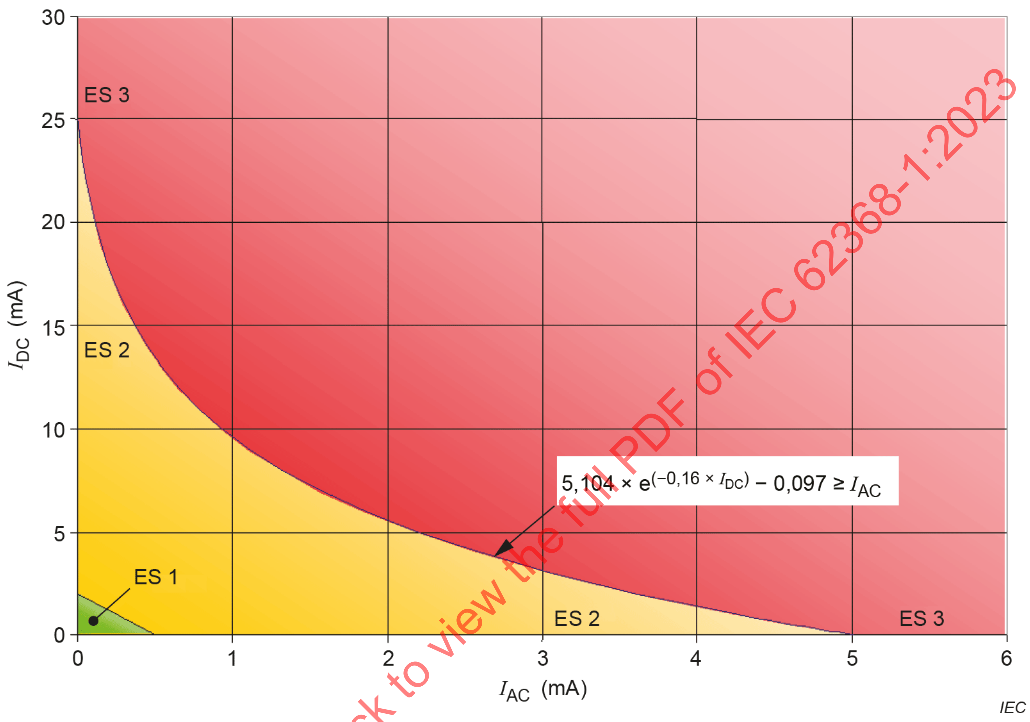


Figure 22 – Valeurs maximales pour les courants alternatif et continu mixtes

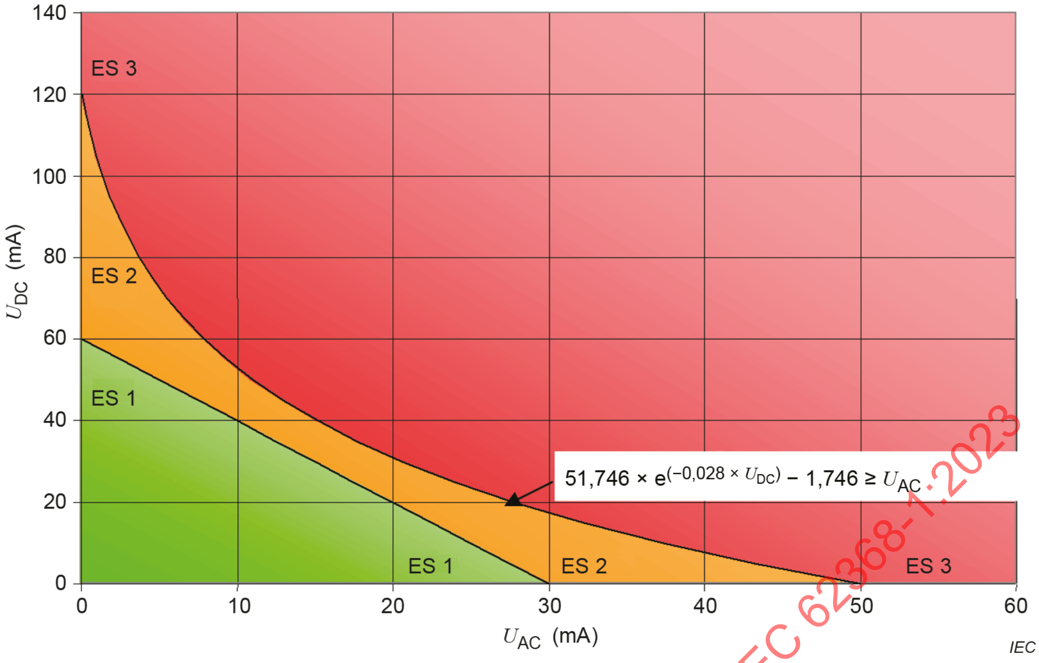


Figure 23 – Valeurs maximales pour les tensions mixtes en courant alternatif et en courant continu

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 sont issues du Tableau A.2 de l'IEC TS 61201:2007.

NOTE 2 Les valeurs de ES1 sont calculées en divisant les valeurs du Tableau A.2 de l'IEC TS 61201:2007 par deux (2).

Tableau 5 – Limites de sources d'énergie électrique pour un condensateur chargé

C nF	ES1 $U_{crête}$ V	ES2 $U_{crête}$ V	ES3 $U_{crête}$ V
300 ou plus	60	120	> ES2
170	75	150	
91	100	200	
61	125	250	
41	150	300	
28	200	400	
18	250	500	
12	350	700	
8,0	500	1 000	
4,0	1 000	2 000	
1,6	2 500	5 000	
0,8	5 000	10 000	
0,4	10 000	20 000	
0,2	20 000	40 000	
0,133 ou moins	30 000	60 000	
Une interpolation linéaire peut être utilisée entre les deux points les plus proches.			

5.2.2.4 Limites d'impulsion unique

Lorsque la source d'énergie électrique est une impulsion unique, la source d'énergie est classifiée à partir de la tension et de la durée ou 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, 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 au 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 à partir de la Figure 22 et du Tableau 10 de l'IEC 60479-1:2018.

NOTE 2 Ces impulsions uniques ne comprennent pas de tensions transitoires.

NOTE 3 La durée d'impulsion est considérée comme le temps qui s'écoule jusqu'au moment, où la tension ou le courant dépasse les limites de ES1.

Tableau 6 – Limites de tension pour les impulsions uniques

Durée d'impulsion inférieure ou égale à ms	ES1 $U_{\text{crête}}$ V	ES2 $U_{\text{crête}}$ V	ES3 $U_{\text{crête}}$ V
10	60	196	> ES2
20		178	
50		150	
80		135	
100		129	
200 ou plus		120	

Si la durée se situe entre les valeurs de deux des lignes, la valeur ES2 la plus faible de $U_{\text{crête}}$ doit être utilisée ou une interpolation linéaire peut être utilisée entre deux lignes contiguës, en arrondissant la valeur de tension de crête calculée au volt inférieur.

Si la tension de crête pour ES2 se situe entre les valeurs de deux des lignes, la valeur de la durée la plus courte peut être utilisée ou une interpolation linéaire peut être utilisée entre deux lignes contiguës avec la durée calculée, arrondie à la milliseconde inférieure.

Tableau 7 – Limites de courant pour les impulsions uniques

Durée d'impulsion inférieure ou égale à ms	ES1 $I_{\text{crête}}$ mA	ES2 $I_{\text{crête}}$ mA	ES3 $I_{\text{crête}}$ mA
10	2	200	> ES2
20		153	
50		107	
100		81	
200		62	
500		43	
1 000		33	
2 000 et plus		25	

Si la durée se situe entre les valeurs de deux des lignes, la valeur ES2 la plus faible de $I_{\text{crête}}$ ou une interpolation linéaire entre deux lignes adjacentes peut être utilisée, en arrondissant la valeur calculée au milliampère inférieur.

Si le courant de crête pour ES2 se situe entre les valeurs de deux des lignes, la valeur de la durée la plus courte ou une interpolation linéaire peut être utilisée entre deux lignes contiguës avec la durée calculée, arrondie à la milliseconde inférieure.

5.2.2.5 Limites pour les impulsions répétitives

A l'exception des impulsions traitées à l'Annexe H, une classe de source d'énergie électrique à impulsion répétitive est déterminée à partir de la tension disponible ou du courant disponible. Si la tension dépasse la limite, 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 au 5.7.

Pour les temps de repos de moins de 3 s, les valeurs de crête du 5.2.2.2 s'appliquent. Pour des durées plus longues, les valeurs de 5.2.2.4 s'appliquent.

5.2.2.6 Signaux de sonnerie

Lorsque la source d'énergie électrique est un signal de sonnerie de réseau téléphonique analogique, comme cela est défini à l'Annexe H, la classe de source d'énergie est considérée comme étant de type ES2.

5.2.2.7 Signaux audio

Pour les sources d'énergie électrique qui sont des signaux audio, les limites sont spécifiées à l'Article E.1.

5.3 Protection contre les sources d'énergie électrique

5.3.1 Généralités

Les exigences relatives à la **protection** entre les parties **accessibles** et le **réseau d'alimentation** ES2/ES3 sont données en 4.3.

Les circuits ES1 ou ES2 **accessibles** doivent comporter une **double protection** ou une **protection renforcée** par rapport à une source ES3 directement connectée au **réseau d'alimentation**.

En outre, pour les circuits ES2/ES3 qui ne sont pas des **réseaux d'alimentation** ES2/ES3, les exigences suivantes s'appliquent:

– dans les **conditions de premier défaut** dans le circuit entre les circuits ES2/ES3 non directement reliés au **réseau d'alimentation** et les circuits ES1 **accessibles**, les niveaux de courant ou de tension ne doivent pas dépasser les limites de ES1; et
– dans les **conditions de premier défaut** dans le circuit entre les circuits ES2/ES3 non directement reliés au **réseau d'alimentation** et les circuits ES2 **accessibles**, les niveaux de courant ou de tension ne doivent pas dépasser les limites de ES2.

NOTE Exemples d'une telle construction:

– avec un **réseau d'alimentation** ES3, un redresseur placé dans le circuit (secondaire) isolé d'une alimentation à découpage dans lequel plusieurs composants sont présents;
– pour une construction avec un **réseau d'alimentation** ES2, des matériels de télécommunication de bureau/d'accès dans lesquels le **réseau d'alimentation** ES2 et les circuits ES1 sont mis à la terre;
– pour une construction avec des circuits ES2 dérivés d'un circuit ES1, un convertisseur continu/continu dans les circuits (secondaires) isolés d'une interface téléphonique de poste d'abonné (FXS, *Foreign eXchange Station*) en intérieur et de niveaux ES2 (dérivés des circuits ES1) comprenant de multiples composants.

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 Figure 19).

Pour une alimentation de secours par **batterie** capable d'assurer le retour de tension en entrée vers les bornes en courant alternatif d'entrée, voir 5.8.

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 broche 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.

Concernant les parties nues du **matériel pour installation extérieure** qui sont **accessibles** à une **personne ordinaire** dans leur **emplacement pour installation extérieure** prévu, les éléments suivants ne doivent pas être **accessibles**:

– les parties nues qui dépassent 0,5 fois les limites de tension de ES1 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut** d'un composant, d'un **dispositif** ou d'une isolation qui ne fait pas office de **protection**; et

– les parties nues dépassant les limites de tension de ES1 dans les **conditions de premier défaut** d'une **protection principale** ou d'une **protection supplémentaire** (voir 5.2.1.1).

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 inférieures à 420 V en valeur de crête, la sonde d'essai adaptée décrite à l'Annexe V ne doit pas entrer en contact avec une partie conductrice interne nue.

Pour les tensions ES3 supérieures à 420 V en valeur de crête, la sonde d'essai adaptée décrite à l'Annexe V ne doit pas entrer en contact avec une partie conductrice interne nue et doit garder un intervalle d'air avec cette partie (voir Figure 24).

Cet intervalle d'air doit:

a) satisfaire à un essai de rigidité diélectrique conformément au 5.4.9.1 à une tension d'essai (tension en courant continu ou tension de crête en courant alternatif) égale à la tension d'essai pour l'**isolation principale** du Tableau 26 correspondant à la valeur de crête de la **tension de service**; ou

b) présenter une distance minimale conformément au Tableau 8.

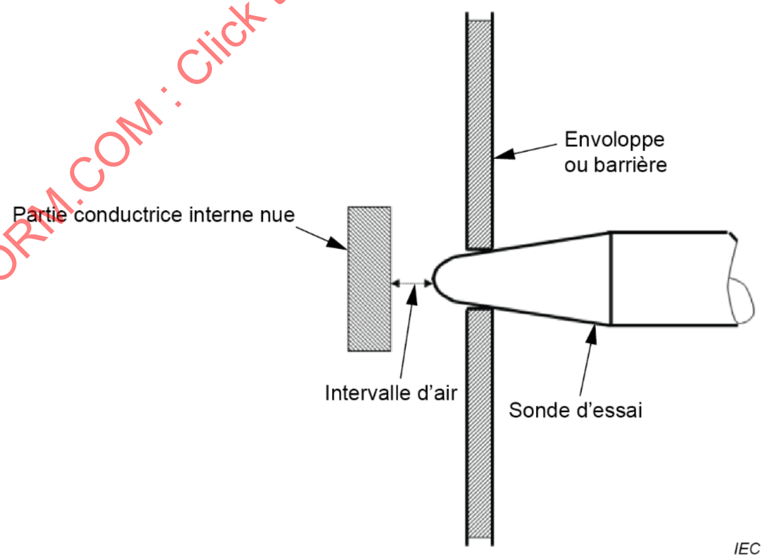


Figure 24 – Exigences en matière de contact avec des parties conductrices internes nues

Tableau 8 – Distance d'intervalle d'air minimale

Tension	Distance d'intervalle d'air mm	
V en valeur de crête ou en courant continu inférieure ou égale à	Degré de pollution	
	2	3
> 420 et ≤ 1 000	0,2	0,8
1 200	0,25	
1 500	0,5	
2 000	1,0	
2 500	1,5	
3 000	2,0	
4 000	3,0	
5 000	4,0	
6 000	5,5	
8 000	8,0	
10 000	11	
12 000	14	
15 000	18	
20 000	25	
25 000	33	
30 000	40	
40 000	60	
50 000	75	
60 000	90	
80 000	130	
100 000	170	

Une interpolation linéaire peut être utilisée entre les deux points les plus proches, en arrondissant la distance d'intervalle d'air minimale calculée au 0,1 mm supérieur ou à la valeur de la ligne suivante, si cette valeur est plus faible.

Pour les équipements destinés à être utilisés à plus de 2 000 m d'altitude, les valeurs de ce tableau sont multipliées par le facteur de multiplication applicable pour l'altitude souhaitée selon le Tableau 16.

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 en valeur de crête, la conformité est vérifiée mesurage de la distance ou par un essai de rigidité diélectrique.

Il n'est pas nécessaire de soumettre à l'essai les composants et les ***sous-ensembles*** *conformes aux normes IEC applicables selon 4.1.2 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; et

– par une **personne avertie** ne doit pas entraîner de contact avec ES3.

Concernant les tensions de signal audio, consulter le Tableau E.1 pour les valeurs de ES2 et de ES3. Les parties des bornes de signaux audio équipées de l'une des **protections** du Tableau E.1 ne sont pas soumises aux essais.

La conformité est vérifiée par l'essai du V.1.6 pour chaque ouverture de borne de contact ainsi que toute ouverture située 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 isolants et exigences

5.4.1 Généralités

5.4.1.1 Isolation

Les matériaux isolants, les **distances d'isolement**, les **lignes de fuite** et l'**isolation 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 sur le plan de la rigidité diélectrique, de la résistance mécanique, des dimensions, des fréquences de la **tension de service** et d'autres propriétés pour l'environnement de fonctionnement (température, pression, humidité et pollution), comme cela est spécifié à l'Article 5 et à l'Annexe T selon 4.4.3.

Le matériau isolant ne doit pas être hygroscopique, comme cela est 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, lorsque 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 considérée 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 indiquée dans le Tableau 9.

Pour les températures maximales inférieures ou égales à 100 °C, aucun système d'isolation classifié n'est nécessaire. Un EIS non classifié est considéré comme étant de la Classe 105 (A).

5.4.1.4.2 Méthode d'essai

Les températures du matériau isolant sont mesurées conformément au B.1.5.

*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 l'obtention des conditions de régime établi; et*

– *pour le **fonctionnement intermittent**, jusqu'à l'obtention des conditions de régime établi, 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 l'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.

5.4.1.4.3 Critères de conformité

La température du matériau isolant électrique ou du système d'isolation électrique (EIS) ne doit pas dépasser les limites du Tableau 9.

Pour un matériau isolant unique, l'indice de température relatif déclaré par le 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 (A), l'EIS doit satisfaire à l'IEC 60085.

Tableau 9 – Limites de températures pour les 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 câbles 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 le 4.1.2
Les classes sont liées aux classes de températures des matériaux isolants électriques et des systèmes isolants électriques conformément à l'IEC 60085. Les lettres d'identification 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 couverts par le présent document 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 A 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

Seule une pollution non conductrice devenant temporairement conductrice en raison de la condensation doit être attendue.

NOTE 2 Le **degré de pollution** 2 est généralement adapté aux équipements couverts par le domaine d'application du présent document.

Degré de pollution 3

Une pollution conductrice ou une pollution sèche non conductrice devenant conductrice en raison de la condensation, doit être attendue.

5.4.1.5.2 Essai pour l'environnement de degré de pollution 1 et pour un isolant

Un échantillon est soumis à la séquence de cycles thermiques de 5.4.1.5.3.

Après refroidissement à température ambiante, l'échantillon est soumis à l'épreuve hygroscopique du 5.4.8.

Si l'essai est réalisé pour la vérification de l'isolant constituant une ***isolation solide****, comme cela est exigé en 5.4.4.3, le conditionnement est immédiatement suivi de l'essai de rigidité diélectrique du 5.4.9.1.*

Pour les cartes imprimées, la conformité est vérifiée par examen visuel. Il ne doit pas y avoir de délaminage qui compromet les ***lignes de fuite*** *exigées pour respecter les exigences du* ***degré de pollution*** *1.*

Pour des éléments autres que les cartes imprimées, la conformité est vérifiée par examen de la section et le matériau isolant ne doit présenter aucun manque, ni fente ou craquelure.

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 d'essais suivante. L'échantillon est soumis 10 fois à la séquence suivante de cycles thermiques:*

68 h	*à*	*(T_1 ± 2) °C;*
1 h	*à*	*(25 ± 2) °C;*
2 h	*à*	*(0 ± 2) °C;*
≥ 1 h	*à*	*(25 ± 2) °C.*

$T_1 = T_2 + T_{ma} - T_{amb}$ + 10 K ou 85 °C, si cette valeur est plus élevée. 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 données en B.2.6.1.

Le temps nécessaire pour passer d'une température à une autre n'est pas spécifié, mais cela peut être effectué progressivement.

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 d'isolement**, 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 plusieurs 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 en courant alternatif, la largeur de l'impulsion est déterminée en mesurant l'écart temporel entre les valeurs de crête de la forme d'onde en courant alternatif.

Les **distances d'isolement** sont déterminées à l'aide de l'une des méthodes suivantes:

– déterminer la **distance d'isolement** 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 exigées 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 subir aucun claquage ni contournement.

5.4.1.8 Détermination de la tension de service

5.4.1.8.1 Généralités

Pour la détermination des **tensions de service**, l'ensemble des exigences suivantes s'appliquent:

a) les parties conductrices **accessibles** non mises à la terre sont par hypothèse mises à la terre;

b) si un enroulement du transformateur ou une autre partie n'est pas connectée à un circuit qui établit son potentiel par rapport à la terre, l'enroulement ou l'autre partie sont par hypothèse reliés à la terre au point où la **tension de service** la plus élevée est obtenue;

c) à l'exception des spécifications du 5.4.1.6, pour une isolation entre deux enroulements du transformateur, la tension la plus élevée entre deux points quelconques 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 du 5.4.1.6, pour l'isolation entre un enroulement du transformateur et une autre partie, la tension la plus élevée entre tout 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 par hypothèse situé au point qui produit la **tension de service** la plus élevée à travers l'autre isolation;

f) lorsque la **tension de service** est déterminée par mesurage, la tension d'entrée fournie 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 tout point du circuit alimenté par le **réseau d'alimentation** et

– toute partie reliée à la terre; et

– tout point d'un circuit isolé du **réseau d'alimentation**;

doit être prise comme la plus grande des deux 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. Les 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 **tension de service** est la valeur de crête des impulsions lorsque la lampe est connectée, mais avant qu'elle ne s'allume. La fréquence de la **tension de service** permettant de déterminer la **distance d'isolement** minimale doit être 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.

5.4.1.8.2 Tension de service efficace

Les conditions à court terme (signaux de sonnerie de téléphone cadencés dans les **circuits externes**, par exemple) et les transitoires non répétitifs (en raison des perturbations atmosphériques, par exemple) ne sont pas pris en compte pour déterminer la **tension de service efficace**.

NOTE Les **lignes de fuite** sont déterminées à partir des **tensions de service efficaces**.

5.4.1.9 Surfaces isolantes

Une surface isolante **accessible** est considérée comme couverte d'une feuille métallique fine pour la détermination des **distances d'isolement**, des **lignes de fuite** et des distances dans l'isolation (voir 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 des parties métalliques conductrices sont montées directement doivent être suffisamment résistantes à l'échauffement si le ramollissement du plastique est susceptible de provoquer la défaillance d'une **protection**.

La conformité est vérifiée par examen des données de l'essai Vicat ou de l'essai à la bille du fabricant du matériau. Si les données ne sont pas disponibles, la conformité est vérifiée par l'essai Vicat du 5.4.1.10.2 ou par l'essai à la bille du 5.4.1.10.3.

5.4.1.10.2 Essai Vicat

La température mesurée dans les ***conditions normales de fonctionnement****, spécifiées à l'Article B.2, doit être au moins inférieure de 15 K à la température de ramollissement Vicat spécifiée pour 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 en soumettant la partie à l'essai à la bille conformément à l'IEC 60695-10-2. L'essai est effectué dans une étuve à une température de ($T - T_{amb} + T_{ma}$ + 15 °C) ± 2 °C (voir B.2.6.1 pour une explication de T, T_{ma} et de T_{amb}). Cependant, une partie thermoplastique soutenant des parties dans un circuit alimenté par le ***réseau d'alimentation*** *est soumise à l'essai à une température minimale de 125 °C.*

Après l'essai, la dimension d (diamètre de l'indentation) ne doit pas dépasser 2 mm.

5.4.2 Distances d'isolement

5.4.2.1 Exigences générales

Les **distances d'isolement** doivent être dimensionnées de manière réduire la probabilité de claquage due aux:

– **surtensions temporaires**; et
– tensions transitoires qui peuvent entrer dans l'équipement; et
– tensions de crête récurrentes et leurs fréquences associées générées à l'intérieur de l'équipement.

Toutes les **distances d'isolement** et tensions d'essai exigées s'appliquent jusqu'à 2 000 m d'altitude. Pour les altitudes supérieures, les facteurs de multiplication fournis en 5.4.2.5 s'appliquent après toute interpolation linéaire, mais avant l'arrondi vers le haut, et avant d'appliquer tout autre facteur de multiplication, comme cela est indiqué dans le Tableau 10, le Tableau 11, le Tableau 14 et le Tableau 15.

NOTE Pour les intervalles d'air entre les contacts des **verrouillages de sécurité**, consulter l'Annexe K. Pour les intervalles d'air entre les contacts des **dispositifs de déconnexion**, consulter l'Annexe L. Pour les intervalles d'air entre les contacts des composants, consulter l'Annexe G. Pour les connecteurs, voir G.4.1.

Sauf spécification contraire du fabricant et si des moyens sont fournis pour assurer les **distances d'isolement** minimales dans toutes les **conditions normales de fonctionnement**, la bobine mobile et les parties conductrices adjacentes d'un haut-parleur sont considérées comme étant en connexion conductrice.

Pour déterminer la **distance d'isolement**, la valeur la plus élevée des deux procédures suivantes doit être utilisée:

– Procédure 1: déterminer les **distances d'isolement** conformément au 5.4.2.2.
– Procédure 2: déterminer les **distances d'isolement** conformément au 5.4.2.3. En variante, le caractère approprié des **distances d'isolement** peut être déterminé en réalisant un essai de rigidité électrique conformément au 5.4.2.4, auquel cas les valeurs selon la procédure 1 doivent être maintenues.

Pour la catégorie de surtension II, les **distances d'isolement** dans les circuits connectés à un **réseau d'alimentation** en courant alternatif dont la tension ne dépasse pas 420 V en valeur de crête (300 V en valeur efficace) peuvent en variante être déterminées conformément à l'Annexe X.

5.4.2.2 Procédure 1 de détermination des distances d'isolement

Pour déterminer la tension à utiliser dans le Tableau 10 et le Tableau 11, la tension la plus élevée est utilisée selon le cas:

– la valeur de crête de la **tension de service** sur la **distance d'isolement**;

– les tensions de crête récurrentes, le cas échéant, sur la **distance d'isolement**;

– pour les circuits reliés au **réseau d'alimentation** en courant alternatif: la **surtension temporaire**, qui est prise égale à 2 000 V en valeur de crête si la tension nominale du système du **réseau d'alimentation** en courant alternatif ne dépasse pas 250 V, et égale à 2 500 V en valeur de crête si la tension nominale du système du **réseau d'alimentation** en courant alternatif dépasse 250 V, sans dépasser 600 V.

  En variante, la **surtension temporaire** peut être déterminée conformément au 5.4.3.2 de l'IEC 60664-1:2020 à la discrétion du fabricant, auquel cas la référence à l'"isolation solide" en 5.4.3.2 de l'IEC 60664-1:2020 est remplacée par "distances d'isolement". De plus, la valeur à court terme égale à U_n + 1 200 V est prise égale à la tension à utiliser dans le Tableau 10.

  NOTE U_n est la tension phase-neutre nominale du système d'alimentation dont le neutre est mis à la terre.

Cette tension doit être utilisée pour déterminer la **distance d'isolement** comme suit:

– les valeurs de **distance d'isolement** du Tableau 10 pour les circuits avec des fréquences fondamentales inférieures à 30 kHz; ou

– les valeurs de **distance d'isolement** du Tableau 11 pour les circuits avec des fréquences fondamentales supérieures à 30 kHz; ou

– les valeurs les plus élevées des **distances d'isolement** du Tableau 10 et du Tableau 11 pour les circuits avec des fréquences inférieures à 30 kHz et supérieures à 30 kHz.

Tableau 10 – Distances d'isolement minimales pour des tensions avec des fréquences jusqu'à 30 kHz

<table>
<tr><th rowspan="3">Tension inférieure ou égale à
Valeur de crête</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, en arrondissant les distances d'isolement à l'incrément spécifié supérieur. Pour les valeurs:
– inférieures ou égales à 0,5 mm, l'incrément spécifié est de 0,01 mm; et
– supérieures à 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 satisfait aux essais du 5.4.1.5.2.</td></tr>
</table>

Tableau 11 – Distances d'isolement minimales pour des tensions avec des fréquences supérieures à 30 kHz

Tension inférieure ou égale à Valeur de crête	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, en arrondissant les **distances d'isolement** à l'incrément spécifié supérieur. Pour les valeurs: – inférieures ou égales à 0,5 mm, l'incrément spécifié est de 0,01 mm; et – supérieures à 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 Procédure 2 de détermination des distances d'isolement

5.4.2.3.1 Généralités

La dimension pour une **distance d'isolement** 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 d'isolement** considérée.

Chaque **distance d'isolement** doit être déterminée comme suit:

– 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 d'isolement** 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 les différentes tensions transitoires ont une incidence sur la même **distance d'isolement**, la valeur la plus élevée de ces tensions est utilisée. Les valeurs ne sont pas ajoutées les unes aux autres.

Le **matériel pour installation extérieure** relié au **réseau d'alimentation** doit être adapté pour la **tension transitoire du réseau d'alimentation** prévue dans l'emplacement d'installation.

Les éléments suivants doivent être pris en compte:

– le courant de défaut présumé de l'alimentation du **matériel pour installation extérieure** peut être supérieur à celui du matériel pour installation intérieure (voir l'IEC 60364-4-43); et
– la **tension transitoire du réseau d'alimentation** du **matériel pour installation extérieure** peut être supérieure à celle du matériel pour installation intérieure.

Les composants à l'intérieur du **matériel pour installation extérieure** qui réduisent la **tension transitoire du réseau d'alimentation** ou le courant de défaut présumé doivent satisfaire aux exigences de la série IEC 61643.

NOTE 1 Le **matériel pour installation extérieure** est présumé appartenir à l'une des catégories de surtension suivantes:

– si l'alimentation est assurée par l'intermédiaire du câblage normal de l'installation des bâtiments, catégorie de surtension II;
– si l'alimentation est assurée par le système de distribution du **réseau d'alimentation**, catégorie de surtension III;
– si le matériel se situe au même emplacement ou à proximité de l'installation électrique, catégorie de surtension IV.

NOTE 2 Pour plus d'informations sur la protection contre les surtensions, consulter l'IEC 60364-5-53.

La conformité est vérifiée par examen de l'équipement, des instructions de l'installation et, le cas échéant, par les essais de composants applicables spécifiés dans l'IEC 61643 (toutes les parties).

5.4.2.3.2.2 Détermination des tensions transitoires du réseau d'alimentation en courant alternatif

Pour les équipements à alimenter 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. Celle-ci est indiquée dans le Tableau 12. En général, les **distances d'isolement**, dans l'équipement prévu pour être raccordé au **réseau d'alimentation** en courant alternatif doivent être conçues pour la catégorie de surtension II.

NOTE Pour obtenir d'autres recommandations concernant la détermination des catégories de surtension, voir l'Annexe I.

Si un équipement est susceptible, après avoir été installé, d'être soumis à des tensions transitoires qui dépassent celles prévues pour la catégorie de surtension pour laquelle il est conçu, une protection additionnelle doit être fournie à l'extérieur ou à l'intérieur de l'équipement. Si elles sont fournies à l'extérieur de l'équipement, les instructions d'installation doivent indiquer la nécessité d'une telle protection externe.

Tableau 12 – Tensions transitoires du réseau d'alimentation

Tension nominale du système d'alimentation [a] selon l'IEC 60038		Tension du réseau d'alimentation en courant alternatif inférieure ou égale à [a c]	Tension transitoire du réseau d'alimentation [b]			
			Catégorie de surtension			
Triphasé	**Monophasé**		**I**	**II**	**III**	**IV**
V en valeur efficace	V en valeur efficace	V en valeur efficace	V en valeur de crête	V en valeur de crête	V en valeur de crête	V en valeur de crête
		50	330	500	800	1 500
		100	500	800	1 500	2 500
120/208	120/240	150	800	1 500	2 500	4 000
230/400 277/480		300	1 500	2 500	4 000	6 000
400/690		600	2 500	4 000	6 000	8 000

[a] Pour l'équipement prévu pour être raccordé 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 de la tension phase-neutre.

[b] La **tension transitoire du réseau d'alimentation** constitue toujours l'une des valeurs du tableau. L'interpolation n'est pas admise.

[c] Au Japon, la valeur des **tensions transitoires du réseau d'alimentation** pour la tension d'alimentation nominale du **réseau d'alimentation** en courant alternatif de 100 V est déterminée à partir des colonnes applicables à la tension d'alimentation nominale du **réseau d'alimentation** en courant alternatif de 150 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 choisie 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 par hypothèse égale à 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 par hypothèse égale à 350 V; ou

NOTE La connexion à la terre de protection peut s'effectuer à la source du système de distribution d'alimentation en courant continu et/ou à l'emplacement de l'équipement (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 qu'il est entièrement installé dans un conduit métallique continu, la valeur de crête de la tension transitoire est par hypothèse égale à 150 V.

Si un système de distribution d'alimentation en courant continu n'est pas mis à la terre ou qu'il n'est pas contenu dans le même bâtiment, la tension transitoire par rapport à la terre doit par hypothèse être égale à la **tension transitoire du réseau d'alimentation** dans le **réseau d'alimentation** qui fournit l'alimentation en courant continu.

Si le système de distribution d'alimentation en courant continu ne se situe pas dans le même bâtiment et qu'il est construit à l'aide de techniques d'installation et de protection similaires à celles des **circuits externes**, la tension transitoire doit être déterminée à l'aide de la classification appropriée fournie en 5.4.2.3.2.4.

Si l'équipement est alimenté par une **batterie** dédiée sans moyen de recharge à partir d'une alimentation du **réseau d'alimentation** sans retrait de l'équipement, la tension transitoire ne doit pas être prise en compte.

Lors de la détermination de la **tension transitoire du réseau d'alimentation** en courant continu, l'installation et la source du **réseau d'alimentation** en courant continu doivent être prises en compte. Si elles ne sont pas connues, la **tension transitoire du réseau d'alimentation** sur le **réseau d'alimentation** en courant continu d'un **matériel pour installation extérieure** doit être prise comme étant égale à 1,5 kV.

Si le système de distribution d'alimentation en courant continu ne se situe pas dans le même bâtiment, le fabricant doit déclarer la **tension transitoire du réseau d'alimentation** sur le **réseau d'alimentation** en courant continu dans les instructions d'installation. La **tension transitoire du réseau d'alimentation** déclarée doit tenir compte des conditions ci-dessus et doit au minimum correspondre à la catégorie de surtension de l'équipement (voir Annexe I).

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 13. Lorsque plusieurs emplacements ou conditions s'appliquent, la tension transitoire la plus élevée est utilisée. 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 de crête du signal de courte durée (comme un signal de sonnerie de téléphone), la tension de 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 13, la valeur connue doit être utilisée.

NOTE 1 L'Australie a publié ses limites de surtension dans l'ACIF G624:2005.

NOTE 2 Il est présumé que des mesures adéquates ont été prises afin de réduire la probabilité que les tensions transitoires présentées à l'équipement dépassent les valeurs spécifiées dans le Tableau 13. Dans les installations où l'équipement est susceptible d'être exposé à des tensions transitoires supérieures aux valeurs spécifiées dans le Tableau 13, des mesures supplémentaires telles qu'une limitation des surtensions peuvent s'appliquer.

NOTE 3 En Europe, l'exigence relative à l'interconnexion avec un **circuit externe** est également donnée dans l'EN 50491-3:2009.

Tableau 13 – Affectation d'un identifiant de circuit externe et tensions transitoires associées

ID	Type de câble	Conditions supplémentaires	Tensions transitoires
1a	Conducteurs à paire[a] symétrique – conducteurs blindés ou à paire[a] asymétrique ou non appariés – exposition aérienne extérieure ou enterrée (câbles de télécommunications extérieurs, par exemple).	Le bâtiment ou la structure contenant l'équipement dispose ou non d'une liaison équipotentielle. Par hypothèse, une protection primaire est installée. "Environnement de réseau 1"	1 500 V 10/700 µs (voir l'IEC 61000-4-5 et l'UIT-T K (toutes les parties))
1b	Conducteurs à paire[a] symétrique ou à paire[a] asymétrique ou non appariés – blindés ou non blindés, généralement courts en extérieur ou restant à l'intérieur d'une structure Longueur généralement inférieure à 300 m.	Le bâtiment ou la structure contenant l'équipement dispose ou non d'une liaison équipotentielle. Par hypothèse, une protection primaire est installée. "Environnement de réseau 1"	1 500 V 1,2/50 µs (voir l'IEC 61000-4-5 et l'UIT-T K (toutes les parties))
1c	Conducteurs à paire[a] symétrique ou à paire[a] asymétrique ou non appariés – blindés ou non blindés, lignes ou circuits d'interconnexion courts entre équipements non reliés au câblage du bâtiment. Le câble peut être connecté à une antenne extérieure. Longueur généralement inférieure à 10 m.	Le bâtiment ou la structure contenant l'équipement dispose ou non d'une liaison équipotentielle. "Environnement de réseau 0"	Les tensions transitoires ne sont pas significatives et ne sont donc pas prises en compte[b]
2	Autres conducteurs à paire[a] ou non appariés avec des lignes ou des circuits d'interconnexion courts. Longueur généralement inférieure à 10 m.	Le bâtiment, la structure ou l'équipement dispose ou non d'une liaison équipotentielle. La protection primaire peut être installée. "Environnement de réseau 0"	Les tensions transitoires ne sont pas significatives et ne sont donc pas prises en compte
3a	Réseau de distribution à câbles coaxiaux dans lequel les câbles peuvent sortir d'un bâtiment ou d'une structure, où une exposition aux transitoires du réseau d'alimentation en courant alternatif ou à des transitoires supérieures est possible. Généralement, ce déploiement est > 30 m des équipements distants ou des grandes antennes extérieures.	Circuits alimentés ou non alimentés. Aucune protection primaire ni aucun dispositif d'isolation installé dans l'équipement soumis à évaluation; ou aucun dispositif de protection primaire/d'isolation n'est spécifié pour être installé à l'extérieur de l'équipement; ou le câble coaxial entrant le bâtiment/la structure n'est pas susceptible d'être mis à la terre de manière fiable à l'entrée du bâtiment. "Environnement de réseau 1"	4 000 V 1,2/50 µs (applications mises à la terre); ou 4 000 V 10/700 µs (applications non mises à la terre) La tension correspond au conducteur central par rapport au blindage/à la terre/aux parties conductrices exposées et au blindage par rapport à la terre/à d'autres parties conductrices
3b	Réseau de distribution à câbles coaxiaux utilisé essentiellement en intérieur, ou pour des connexions courtes vers du matériel pour installation extérieure ou des antennes. Généralement, ce déploiement est < 30 m des équipements pour installation intérieure distants ou des petites antennes extérieures ou en toiture, pour lesquels l'exposition aux transitoires est minime.	Circuits sous tension ou hors tension. Exemples: interconnexions coaxiales entre les équipements résidentiels ou professionnels au sein d'un bâtiment/d'une structure. Ou connexion de câble coaxiale entre un téléviseur, un téléviseur par câble ou un boîtier décodeur satellitaire, ou équipement analogue, et une antenne extérieure. "Environnement de réseau 1"	Les tensions transitoires ne sont pas significatives et ne sont donc pas prises en compte[b]

3c	Câble coaxial utilisé pour les interconnexions des équipements, et entièrement en intérieur. Généralement, ce déploiement est < 10 m lorsque l'exposition aux transitoires est peu probable.	"Environnement de réseau 0"	Les tensions transitoires ne sont pas significatives et ne sont donc pas prises en compte.

Si les tensions transitoires du circuit externe sont réputées supérieures aux valeurs indiquées ci-dessus, la valeur connue doit être utilisée. Pour obtenir des recommandations, consulter l'IEC 61000-4-5 et l'UIT-T K (toutes les parties).

Un conducteur est considéré comme quittant le bâtiment s'il se termine sur un équipement mis à la terre vers un réseau de mise à la terre différent.

Les effets des tensions de régime établi 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 traction électrique) sont contrôlés par les pratiques d'installation. Ces pratiques dépendent de l'application et ne sont pas traitées par le présent document.

Pour qu'un câble blindé entraîne une réduction dans les transitoires, le blindage doit être continu, mis à la terre aux deux extrémités.

L'environnement de réseau 0 (voir l'IECTR 62102) est un **circuit externe** avec une faible probabilité de surtensions et de conditions transitoires électriques significatives. Le réseau est par hypothèse un environnement de réseau 0 si l'une des conditions suivantes s'appliquent à toutes les parties de ce réseau:

a) la connexion du **circuit externe** est cohérente avec la définition de la classe d'installation 0 "Environnement électrique bien protégé, souvent celui d'une salle spéciale" ou de la classe d'installation 1 "Environnement électrique partiellement protégé" selon l'IEC 61000-4-5;

b) la connexion du **circuit externe** entre les équipements n'est pas assurée par le câblage du bâtiment et sa longueur est ≤ 10 m;

c) la connexion du **circuit externe** est un accès d'installation ou de maintenance non relié en utilisation normale;

d) la connexion du **circuit externe** est prévue et documentée pour être située entre des accès, où l'équipement est situé dans (ou sur) la même enceinte, le même bâti, la même baie, le même mur, la même table, etc., ou directement à côté à très courte distance.

L'environnement de réseau 1 est un **circuit externe** qui ne respecte pas les exigences de l'environnement de réseau 0.

NOTE 1 Les appareils domestiques tels que les produits audios, vidéos et multimédias sont désignés ID 1c, 3a, 3b et 3c.

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 Note 1 du 5.7.7.1). Pour les conditions d'installation, consulter l'IEC 60728-11.

[a] Un conducteur à paire comprend une paire torsadée.

[b] Ces câbles ne sont pas soumis à des transitoires, mais les câbles reliés à une antenne extérieure 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 d'isolement**. La conformité est vérifiée par l'essai du 5.4.5.2.

5.4.2.3.2.5 Détermination des niveaux de tension transitoire par mesurage

La tension transitoire à travers la **distance d'isolement** est mesurée à l'aide de la procédure suivante.

Pendant le mesurage, l'équipement n'est pas connecté au **réseau d'alimentation** ni à un **circuit externe**. Seuls les parasurtenseurs internes à l'équipement situés dans les circuits connectés au **réseau d'alimentation** sont déconnectés. Si l'équipement est destiné à être utilisé avec un bloc d'alimentation séparé, ce dernier est connecté à l'équipement pendant le mesurage.

Pour mesurer la tension transitoire à travers une **distance d'isolement**, le générateur d'impulsions d'essai approprié de l'Annexe D est utilisé afin de générer des 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, entre les 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 approprié de l'Annexe D est utilisé pour générer les impulsions applicables et décrites dans le Tableau 13 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 d'isolement** concernée.

S'il existe plusieurs circuits identiques, un seul est soumis à l'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 la borne principale de **mise à la terre de protection** par l'intermédiaire d'un **conducteur de liaison de protection**, la **tension de tenue requise** peut relever d'une catégorie de surtension inférieure ou correspondre à une tension inférieure du **réseau d'alimentation** en courant alternatif (voir Tableau 12). Pour un **réseau d'alimentation** en courant alternatif dont la tension efficace est inférieure ou égale à 50 V, aucun réglage n'est effectué;
- 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 par hypothèse être égale à la valeur de crête de la **tension en courant continu** de la source ou à la valeur de crête de la **tension de service** du circuit isolé du **réseau d'alimentation**, si cette valeur est plus élevée;
- 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 d'isolement avec la tension de tenue requise

Chaque **distance d'isolement** doit être conforme à la valeur applicable du Tableau 14.

Tableau 14 – Distances d'isolement 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 en valeur de crête ou en courant continu
inférieure ou égale à</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 d'isolement minimales calculées doivent être arrondies à l'incrément spécifié supérieur suivant. Pour les valeurs:
– inférieures ou égales à 0,5 mm, l'incrément spécifié est de 0,01 mm; et
– supérieures à 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 satisfait aux essais du 5.4.1.5.2.</td></tr>
</table>

5.4.2.4 Détermination du caractère approprié d'une distance d'isolement établi d'après l'essai de rigidité diélectrique

*Les **distances d'isolement** doivent supporter un essai de rigidité diélectrique. L'essai peut être réalisé à l'aide d'une tension d'impulsion, d'une tension en courant alternatif ou d'une **tension en courant continu**. La **tension de tenue requise** est déterminée selon le 5.4.2.3.*

L'essai de tension de tenue aux chocs est effectué à une tension qui présente une forme d'onde adaptée (voir Annexe D) avec les valeurs spécifiées dans le Tableau 15. 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 en appliquant une tension sinusoïdale avec les valeurs de crête spécifiées dans le Tableau 15 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 15 et appliquée pendant 5 s dans une polarité unique.*

Tableau 15 – Tensions d'essai de rigidité diélectrique

Tension de tenue requise inférieure ou égale à kV en valeur de crête	**Tension d'essai de rigidité diélectrique pour les distances d'isolement de l'isolation principale ou de l'isolation supplémentaire** kV en valeur de crête (impulsion, en courant alternatif ou en courant continu)
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 étant arrondie au 0,01 kV supérieur.

Pour l'**isolation renforcée**, la tension d'essai de rigidité diélectrique représente 160 % de la valeur de celle utilisée pour l'**isolation principale** après laquelle cette tension d'essai calculée est arrondie au 0,01 kV supérieur.

Si l'EUT ne satisfait pas à l'essai en courant alternatif ou en courant continu, l'essai de tension de tenue aux chocs 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.6 de l'IEC 60664-1:2020 peut être utilisé, auquel cas une interpolation linéaire à des altitudes comprises entre 200 m et 500 m et entre les tensions d'essai de choc correspondantes du Tableau F.6 de l'IEC 60664-1:2020 peut être utilisée.

[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 prévus et conçus pour être utilisés à plus de 2 000 m d'altitude au-dessus du niveau de la mer, les **distances d'isolement** minimales spécifiées dans le Tableau 10, le Tableau 11 et le Tableau 14, ainsi que les tensions d'essai de rigidité diélectrique indiquées dans le Tableau 15 sont multipliées par le facteur de multiplication pour l'altitude souhaitée selon le Tableau 16.

NOTE 1 Des altitudes plus élevées peuvent être simulées dans une chambre à vide.

NOTE 2 En Chine, il existe des exigences particulières qui permettent de choisir des facteurs de multiplication pour des altitudes supérieures à 2 000 m.

Tableau 16 – Facteurs de multiplication pour les distances d'isolement et les tensions d'essai

Altitude m	Pression barométrique normale kPa	Facteur de multiplication pour les distances d'isolement	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 étant arrondi au 0,01 supérieur.					

5.4.2.6 Critères de conformité

La conformité est vérifiée par mesurage et par un essai en prenant en compte les articles appropriés de l'Annexe O et de l'Annexe T conformément au 4.4.3.

Les conditions suivantes s'appliquent:

– *les parties mobiles sont placées dans leur position la plus défavorable;*

– les **distances d'isolement** d'une **enveloppe** en 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*;

– *à l'issue des essais de l'Annexe T*:
  - *les dimensions des* ***distances d'isolement*** *sont mesurées; et*
  - *l'essai de rigidité diélectrique approprié doit être appliqué; et*
  - *pour l'essai de choc sur le verre de l'Article T.9, les endommagements de la finition, les petits éclats qui n'entraînent pas une réduction des* ***distances d'isolement*** *au-dessous des valeurs spécifiées, les fissures superficielles et dommages analogues ne sont pas pris en compte. Si une fissure traversante apparaît, les* ***distances d'isolement*** *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 d'isolement*** *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 du 5.5.8.

5.4.3 Lignes de fuite

5.4.3.1 Généralités

Les **lignes de fuite** doivent être dimensionnées de telle sorte que, pour une tension, un **degré de pollution** et un groupe de matériaux donnés, il ne doit se produire ni contournement ou claquage de l'isolation (par exemple, due au cheminement).

Les **lignes de fuite** pour l'**isolation principale** et l'**isolation supplémentaire** pour des fréquences inférieures ou égales à 30 kHz doivent être établies à partir de la **tension de service efficace** et être conformes au Tableau 17. Les **lignes de fuite** pour l'**isolation principale** et l'**isolation supplémentaire** pour des fréquences comprises entre 30 kHz et 400 kHz doivent être déterminées à partir de la valeur de crête de la tension de service et être conformes au Tableau 18.

Les exigences relatives aux **lignes de fuite** pour des fréquences jusqu'à 400 kHz peuvent s'appliquer pour des fréquences de plus de 400 kHz, jusqu'à ce que des données supplémentaires soient disponibles.

NOTE 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 satisfaire aux exigences pour l'**isolation principale** si le connecteur est:

– fixé à l'équipement; et

– situé à l'intérieur de l'**enveloppe électrique** extérieure de l'équipement; et

– **accessible** uniquement après le retrait d'un **sous-ensemble** qui
  - doit être installé dans les **conditions normales de fonctionnement**; et
  - comporte une **protection par instructions** pour replacer le **sous-ensemble** retiré.

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 à 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.

Si la **ligne de fuite** minimale déduite du Tableau 17 ou du Tableau 18 est inférieure à la **distance d'isolement** minimale, cette dernière doit être appliquée comme **ligne de fuite minimale**.

Pour le verre, le mica, la céramique vitrifiée ou les matériaux inorganiques analogues, si la **ligne de fuite** minimale est supérieure à la **distance d'isolement** minimale applicable, la valeur de la **distance d'isolement** 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** du Tableau 17 ou du Tableau 18.

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 mesurages de **lignes de fuite** sont effectués avec des conducteurs d'alimentation de la plus forte section spécifiée à l'Article G.7 et aussi sans conducteurs;*

– *lors du mesurage des **lignes de fuite** depuis la surface extérieure **accessible** d'une **enveloppe en 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** de l'**enveloppe** doit être considérée comme étant 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 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 à l'Annexe T conformément au 4.4.3;*

– *pour l'essai de choc sur le verre de l'Article T.9, les endommagements de la finition, les petits éclats qui n'entraînent pas une réduction des **lignes de fuite** au-dessous des valeurs spécifiées, les fissures superficielles et dommages analogues ne sont pas pris en compte. Si une fissure traversante 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 doit être vérifié par évaluation des données d'essai pour le matériau conformément à l'IEC 60112 en utilisant 50 gouttes de la solution A.

Si le groupe de matériaux n'est pas connu, le groupe de matériaux IIIb doit par hypothèse être utilisé.

Si un IRC supérieur ou égal à 175 est nécessaire et que les données ne sont pas disponibles, le groupe de matériaux peut être établi avec avoir effectué un essai pour l'indice de tenue au cheminement (ITC) conformément à l'IEC 60112. Un matériau peut être inclus dans un groupe si son ITC établi par ces essais est supérieur ou égal à la valeur la plus faible de l'indice de résistance au cheminement (IRC) spécifié pour le groupe.

5.4.3.4 Critères de conformité

La conformité est vérifiée par mesurage, en prenant en compte l'Annexe O, l'Annexe T conformément au 4.4.3 et l'Annexe V.

*Une **ligne de fuite** peut être divisée en plusieurs portions de différents matériaux et/ou afficher différents **degrés de pollution** si l'une des **lignes de fuite** est dimensionnée pour supporter la tension totale ou si la distance totale est dimensionnée en fonction du matériau qui affiche l'indice de résistance au cheminement (IRC) le plus faible et le **degré de pollution** le plus élevé.*

Tableau 17 – Lignes de fuite minimales pour une isolation principale et une isolation supplémentaire, en mm

Tension de service efficace inférieure ou égale à	Degré de pollution						
	1 [a]	2			3		
	Groupe de matériaux						
V	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, en arrondissant les **lignes de fuite** minimales calculées au 0,1 mm supérieur ou à la valeur de la ligne suivante, si cette valeur est plus faible.

Pour une **isolation renforcée**, un arrondi au 0,1 mm supérieur ou le double de la valeur de la ligne suivante est appliqué dès 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 satisfait aux essais du 5.4.1.5.2.

[b] Le groupe de matériaux IIIb n'est pas recommandé pour les applications qui relèvent du **degré de pollution** 3 et dont la **tension de service efficace** est supérieure à 630 V.

Tableau 18 – Valeurs minimales des lignes de fuite (en mm) pour les fréquences supérieures à 30 kHz jusqu'à 400 kHz

Tension de crête kV	30 kHz < f ≤ 100 kHz	100 kHz < f ≤ 200 kHz	200 kHz < f ≤ 400 kHz
0,1	0,016 7	0,02	0,025
0,2	0,042	0,043	0,05
0,3	0,083	0,09	0,09
0,4	0,125	0,13	0,15
0,5	0,183	0,19	0,25
0,6	0,267	0,27	0,4
0,7	0,358	0,38	0,68
0,8	0,45	0,55	1,1
0,9	0,525	0,82	1,9
1	0,6	1,15	3

Les valeurs des **lignes de fuite** indiquées dans le tableau s'appliquent pour le **degré de pollution** 1. Pour le **degré de pollution** 2, un facteur de multiplication de 1,2 doit être utilisé. Pour le **degré de pollution** 3, un facteur de multiplication de 1,4 doit être utilisé.

Une interpolation linéaire peut être utilisée, le résultat étant arrondi au chiffre significatif supérieur.

Les données indiquées dans le Tableau 18 ne prennent pas en compte l'influence des phénomènes de cheminement. Pour cette raison, le Tableau 17 doit être pris en compte. Par conséquent, si les valeurs du Tableau 18 sont inférieures à celles du Tableau 17, les valeurs du Tableau 17 s'appliquent.

5.4.4 Isolation solide

5.4.4.1 Exigences générales

Les exigences du présent paragraphe s'appliquent à l'**isolation solide**, y compris aux composés et aux matériaux gel utilisés comme isolation. Lorsque l'**isolation solide** est exposée à des fréquences supérieures à 30 kHz, les exigences du 5.4.4.9 s'appliquent également.

L'**isolation solide** ne doit pas subir de claquage en raison:

– de surtensions, y compris les transitoires, qui pénètrent dans l'équipement, et de valeurs de crête de la tension qui peuvent être générées à l'intérieur de l'équipement; ni
– de trous d'épingle dans de fines couches d'isolation.

Des revêtements d'émail 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 solide** doit:

– être conforme aux distances minimales à travers l'isolation conformément à 5.4.4.2; ou
– satisfaire aux exigences et aux essais décrits de 5.4.4.3 à 5.4.4.7, selon le cas.

Le verre utilisé comme **isolation solide** doit être conforme à l'essai de choc sur le verre spécifié à l'Article T.9. Les endommagements de la finition, les petits éclats qui n'entraînent pas une réduction des **distances d'isolement** au-dessous des valeurs spécifiées, les fissures superficielles et dommages analogues ne sont pas pris en compte. Si une fissure traversante apparaît, les **distances d'isolement** et les **lignes de fuite** ne doivent pas être réduites au-dessous des valeurs spécifiées.

Pour les cartes imprimées, voir l'Article G.13. Pour les bornes de connexion d'antenne, voir 5.4.5. Pour une **isolation solide** sur le câblage interne, voir 5.4.6.

5.4.4.2 Distance minimale à travers l'isolation

Excepté si 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 Figure O.15 et Figure O.16):

– si la **tension de service** ne dépasse pas les limites de tension de 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 de 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 plusieurs couches, la distance minimale à travers l'isolation doit satisfaire au 5.4.4.6.

5.4.4.3 Isolant constituant une isolation solide

Il n'existe pas de **distance d'isolement** ni de **ligne de fuite** interne minimale si

– l'isolant remplit entièrement le boîtier d'un composant ou d'un **sous-ensemble**, y compris un **dispositif** à semiconducteurs (optocoupleur, par exemple); et
– le composant ou **sous-ensemble** respecte les distances minimales à travers l'isolation fournies en 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'empotage, l'encapsulage 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 semiconducteurs 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. Le matériau isolant ne doit présenter aucun vide apparent.

5.4.4.4 Isolation solide dans des dispositifs à semiconducteurs

Il n'existe pas de **distance d'isolement** ni de **ligne de fuite** interne minimale, ni de distance minimale à travers l'isolation pour une **isolation supplémentaire** ou une **isolation renforcée** dont l'isolant remplit entièrement le boîtier d'un composant à semiconducteurs (optocoupleur, par exemple) à condition que le composant:

– réussisse les **essais de type** et remplisse les 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 5.4.9.2; ou

– respecte l'Article G.12.

De telles constructions contenant des joints scellés doivent aussi satisfaire au 5.4.4.5.

En variante, un semiconducteur peut être évalué conformément au 5.4.4.3.

5.4.4.5 Isolant constituant des joints scellés

Les exigences spécifiées ci-dessous s'appliquent lorsqu'un 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 l'IEC 60747-5-5.

Lorsque le chemin entre des parties conductrices est rempli par un isolant, et que l'isolant constitue un joint scellé entre deux parties non conductrices ou entre une partie non conductrice et lui-même (voir Figure O.14, Figure O.15 et Figure O.16), l'une des exigences a), b) ou c) s'applique.

a) La distance le long du chemin entre les deux parties conductrices ne doit pas être inférieure aux **distances d'isolement** ni aux **lignes de fuite** minimales pour le **degré de pollution** 2. Les exigences relatives à la distance à travers l'isolation décrites en 5.4.4.2 ne s'appliquent pas le long du joint.

b) La distance le long du chemin entre les deux parties conductrices ne doit pas être inférieure aux **distances d'isolement** 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 relèvent de 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 matériau préimprégné 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 multicouche, voir Figure O.14) ou la bobine séparée d'un transformateur dont l'élément central est fixé avec de l'adhésif (voir Figure O.16);

– une isolation enroulée en spirale sur un fil de bobinage, dont l'étanchéité est assurée par un isolant adhésif, est un exemple de PD1; ou

– le joint entre une partie non conductrice (boîtier) et l'isolant lui-même dans un optocoupleur (voir 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 La Figure 29 représente un appareil pour l'essai de rigidité diélectrique sur de fines couches de matériau isolant.

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 du 5.4.4.6.2 (pour les couches séparables) ou 5.4.4.6.3 (pour les couches non séparables) soient respectées.

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
– chaque couche d'isolation peut être composée d'un matériau différent.

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.

Aucune exigence n'établit que toutes les couches de l'isolation doivent posséder 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 du 5.4.4.6.1, les procédures d'essai indiquées dans le Tableau 19 s'appliquent. Aucune exigence n'établit que toutes les couches de l'isolation doivent posséder les mêmes matériaux et épaisseurs.

La conformité est vérifiée par examen et par les essais spécifiés dans le Tableau 19.

Tableau 19 – 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 du 5.4.4.6.4 s'applique.
Isolation renforcée	
Deux couches:	La procédure d'essai du 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 Les essais du 5.4.4.6.5 ont pour objet de s'assurer que le matériau présente 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 sont effectués conformément au 5.4.9.1 sur l'ensemble des couches ensemble. La tension d'essai est:

– *200 % de U_{essai} si deux couches sont utilisées; ou*

– *150 % de U_{essai} si au moins trois couches 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 Sauf si toutes les couches sont composées du même matériau et présentent la même épaisseur, la tension d'essai peut ne pas être répartie de manière homogène entre les couches, ce qui provoque le claquage d'une couche qui aurait réussi l'essai séparément.

5.4.4.6.5 Essai du mandrin

*Les exigences d'essai pour une **isolation renforcée** composée d'au moins trois fines couches isolantes de matériau qui ne sont pas séparables sont spécifiées ci-dessous.*

NOTE L'essai repose sur l'IEC 61558-1 et donne les mêmes résultats.

*Trois échantillons d'essai, chaque échantillon étant composé d'au moins trois couches de matériau en fines couches 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 cela est représenté à la Figure 26.*

Dimensions en millimètres

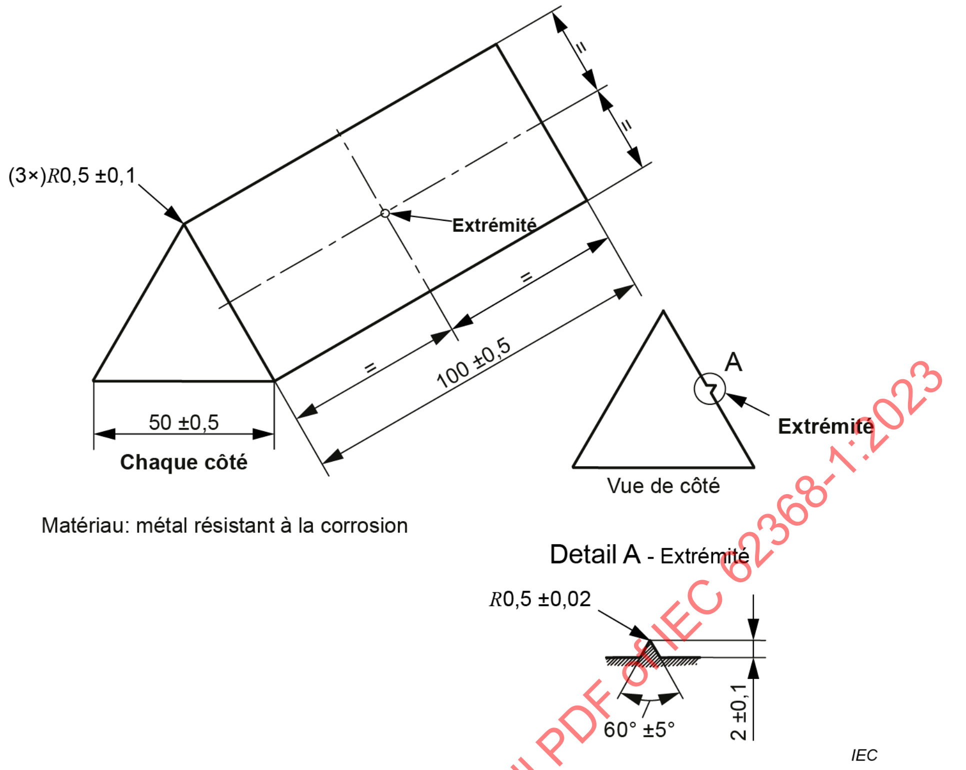


Figure 25 – Mandrin

Dimensions en millimètres

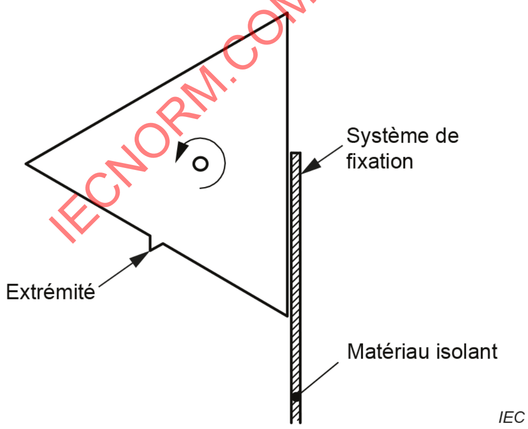
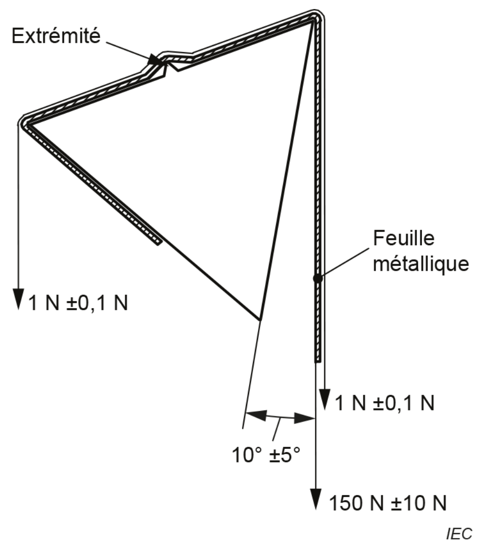


Figure 26 – Position initiale du mandrin



La position finale du mandrin subit une rotation de 230° ± 5° par rapport à la position initiale.

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;*

– *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 une défaillance. Si un échantillon se casse à tout autre endroit, l'essai a échoué.

Après l'essai décrit ci-dessus, une feuille métallique, d'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 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 18 mm des bords de l'échantillon (voir 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

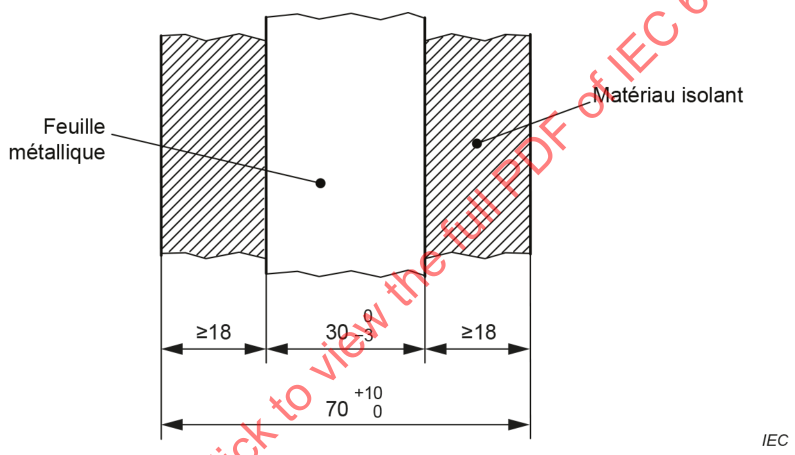


Figure 28 – Position de la feuille métallique sur le matériau isolant

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 est supérieure ou égale à 5 kV en valeur 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 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 du 5.4.4.2 au 5.4.4.7 pour l'adéquation d'une isolation solide est vérifiée par examen et par mesurage, en tenant compte de l'Annexe O, par les essais de rigidité diélectrique du 5.4.9.1 et les essais supplémentaires exigés aux 5.4.4.2 à 5.4.4.7, selon le cas.

5.4.4.9 Exigences relatives à une isolation solide à des fréquences supérieures à 30 kHz

Le caractère approprié d'une **isolation solide** doit être déterminé comme suit:

– Déterminer la valeur du champ électrique de claquage du matériau isolant à la fréquence industrielle du **réseau d'alimentation** E_{P} en kV/mm (valeur efficace) pour le matériau isolant. L'une des méthodes suivantes doit être utilisée pour déterminer la valeur de E_{P}:

- la valeur déclarée par le fabricant en fonction des données fournies par le fabricant concernant le matériau; ou
- la valeur issue du Tableau 20; ou
- la valeur reposant sur l'essai spécifié dans l'IEC 60243-1.

Le fabricant est chargé de déterminer la valeur.

– Déterminer le facteur de réduction K_{R} pour le champ électrique de claquage du matériau isolant à la fréquence applicable du Tableau 21 ou du Tableau 22. Si le matériau ne figure pas dans le Tableau 21 ou le Tableau 22, appliquer le facteur de réduction moyen indiqué dans la dernière colonne du Tableau 21 ou du Tableau 22, selon le cas.

– Déterminer la valeur du champ électrique de claquage à la fréquence applicable E_{F} en multipliant la valeur E_{P} par le facteur de réduction K_{R}.

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

– 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.

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

– Pour une **isolation principale** ou une **isolation supplémentaire**, V_{W} doit être supérieure de 20 % à la valeur de crête de la **tension de service** haute fréquence mesurée V_{PW}.

$$V_{\text{W}} > 1{,}2 \times V_{\text{PW}} / 1{,}41$$

– 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 %.

$$V_{\text{W}} > 1{,}2 \times 2 \times V_{\text{PW}} / 1{,}41$$

En variante des conditions ci-dessus, l'essai de rigidité diélectrique du 5.4.9.1 peut être appliqué, mais la tension d'essai à la fréquence du **réseau d'alimentation** doit être la suivante:

– pour l'**isolation principale**: $1{,}2 \times V_{\text{PW}} / K_{\text{R}}$

– pour l'**isolation renforcée** $1{,}2 \times 2 \times V_{\text{PW}} / K_{\text{R}}$

Aucun claquage ne doit se produire.

Tableau 20 – Résistance du champ électrique E_P pour quelques matériaux couramment utilisés

Matériau	Champ électrique de claquage 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	-	-	-	-
Teflon® [a] [4]	27	-	-	-	-
Mélamine-verre [a]	27	-	-	-	-
Mica [a]	29	-	-	-	-
Papier phénolique [a]	38	-	-	-	-
Polyéthylène [b]	49	-	-	52	-
Polystyrène [c]	55	65	-	-	-
Verre [c]	60	-	-	-	-
Kapton® [a] [5]	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 sont à l'étude.

[a] Pour la distribution du champ électrique de claquage 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 est utilisée pour les isolations d'épaisseur inférieure ou égale à 0,05 mm. La valeur E_P de 0,75 mm est utilisée dans les autres cas.

[c] La valeur E_P de 0,08 mm est utilisée pour les isolations d'épaisseur inférieure ou égale à 0,08 mm. La valeur E_P de 0,75 mm est utilisée dans les autres cas.

[d] La valeur E_P de 0,03 mm est utilisée pour les isolations d'épaisseur inférieure ou égale à 0,03 mm. La valeur E_P de 0,06 mm est utilisée pour les isolations d'épaisseur comprise entre 0,03 mm et 0,06 mm.

4 Teflon® est la marque d'un produit distribué par DuPont. Cette information est donnée à l'intention des utilisateurs du présent document et ne signifie nullement que l'IEC approuve l'emploi du produit ainsi désigné. Des produits équivalents peuvent être utilisés s'il est démontré qu'ils aboutissent aux mêmes résultats.

5 Kapton® est la marque d'un produit distribué par DuPont. Cette information est donnée à l'intention des utilisateurs du présent document et ne signifie nullement que l'IEC approuve l'emploi du produit ainsi désigné. Des produits équivalents peuvent être utilisés s'il est démontré qu'ils aboutissent aux mêmes résultats.

Tableau 21 – Facteurs de réduction pour la valeur de la résistance du champ électrique de claquage 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
Teflon®	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 inférieur.

[a] Ces données correspondent aux matériaux qui ont une épaisseur de 0,75 mm.

Tableau 22 – Facteurs de réduction pour la valeur du champ électrique de claquage 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 inférieur.

5.4.5 Isolation des bornes de connexion d'antenne

5.4.5.1 Généralités

L'isolation

– entre le **réseau d'alimentation** et les bornes de connexion d'antenne; et
– entre le **réseau d'alimentation** et les **circuits externes** fournissant des tensions d'alimentation ne provenant pas du **réseau d'alimentation** à d'autres équipements comportant des bornes de connexion d'antenne

doit être capable de supporter les décharges électrostatiques au niveau des bornes de connexion d'antenne.

Cet essai ne s'applique pas:

– aux équipements dont une borne de connexion d'antenne sur l'équipement est connectée à la terre conformément au 5.6.7;
– aux équipements avec seulement des bornes de connexion d'antenne prévues pour le raccordement à une antenne intérieure uniquement.

NOTE En Chine, la connexion de la télévision par câble à la borne principale de **mise à la terre de protection** de l'équipement n'est pas admise.

5.4.5.2 Méthode d'essai

L'échantillon est soumis à 50 décharges du générateur d'essai d'interface d'antenne (circuit 3) de l'Article D.2, sans dépasser 12 décharges par minute, à une tension U_c égale à 10 kV. L'équipement doit être placé sur une surface isolante. La sortie du générateur d'essai d'interface d'antenne doit être connectée aux bornes de connexion d'antenne connectées ensemble et aux bornes du ***réseau d'alimentation*** *connectées ensemble. Si l'équipement comporte des* ***circuits externes*** *fournissant des tensions d'alimentation ne provenant pas du* ***réseau d'alimentation*** *à d'autres équipements comportant des bornes de connexion d'antenne, l'essai est répété en connectant le générateur aux bornes du* ***réseau d'alimentation*** *connectées ensemble et aux bornes du* ***circuit externe*** *connectées ensemble. L'équipement n'est pas alimenté pendant ces essais.*

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 étant conforme aux exigences si la résistance d'isolement, mesurée après 1 min, n'est pas inférieure aux valeurs indiquées dans le Tableau 23.

Tableau 23 – 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 l'essai de rigidité diélectrique du 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. Aucun claquage de l'isolation ne doit se produire.*

5.4.6 Isolation du câblage interne en tant que partie d'une protection supplémentaire

Les exigences du présent paragraphe s'appliquent lorsque l'isolation d'un câblage interne seule satisfait aux exigences pour une **isolation principale**, mais qu'elle 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 du 5.4.9.1 pour l'**isolation supplémentaire**; et
- la distance à travers l'isolation du fil doit être au moins égale à celle indiquée dans le Tableau 24.

Tableau 24 – 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 en valeur de crête ou en courant continu	V en valeur efficace (sinusoïdale)	mm
> 71 ≤ 350	> 50 ≤ 250	0,17
> 350	> 250	0,31

La conformité est vérifiée par examen, par mesurage et par l'essai du 5.4.9.1.

5.4.7 Essais pour les composants à semiconducteurs et 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 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 l'essai comme suit:

- *l'un des échantillons est soumis à l'essai de rigidité diélectrique du 5.4.9.1, immédiatement après la dernière période à (T_1 ± 2) °C au cours du cycle thermique, excepté que la tension d'essai est multipliée par 1,6; et*
- *les autres échantillons sont soumis à l'essai de rigidité diélectrique approprié du 5.4.9.1 après l'épreuve hygroscopique du 5.4.8, excepté 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 présenter aucun vide apparent, ni trous ou craquelure.

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 déstratification.

5.4.8 Epreuve 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 peuvent être situés les échantillons, est maintenue à ±2 °C près à une valeur T comprise entre 20 °C et 30 °C de manière à éviter la formation de condensation. Au cours de ce conditionnement, 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 porté 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 de l'isolation solide

Sauf spécification contraire dans le présent document, 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 l'essai séparément à l'extérieur de l'équipement, il est porté à la température atteinte par cette partie au cours de l'essai de température décrit en 5.4.1.4 (en le plaçant dans un four, par exemple) avant d'effectuer l'essai de rigidité diélectrique.*

*En variante, le matériau en fines couches d'une **isolation supplémentaire** ou d'une **isolation renforcée** peut être soumis à l'essai à température ambiante.*

*Sauf spécification contraire dans le présent document, la tension d'essai pour évaluer la rigidité diélectrique d'une **isolation principale**, d'une **isolation supplémentaire** ou d'une **isolation renforcée** correspond à la valeur la plus élevée des trois méthodes suivantes:*

- *Méthode 1: Déterminer la tension d'essai conformément au Tableau 25 à l'aide de la **tension de tenue requise** (déterminée à partir des 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 26 en utilisant la valeur de crête de la **tension de service** ou des tensions de crête récurrentes, si cette valeur est plus élevée.*
- *Méthode 3: Déterminer la tension d'essai conformément au Tableau 27 à l'aide de la tension nominale du **réseau d'alimentation** en courant alternatif (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 d'une fréquence de 50 Hz ou 60 Hz; ou*
- *en appliquant une **tension en courant continu** pendant la durée indiquée ci-dessous.*

*La tension appliquée à l'isolation soumise à l'essai est progressivement élevée de zéro à la tension exigée, puis maintenue à cette valeur pendant 60 s (pour les **essais individuels de série**, voir 5.4.9.2).*

Si nécessaire, l'isolation est soumise à l'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 parois isolantes sont soumises à l'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 éléments analogues 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**.*

Si des condensateurs sont montés en parallèle avec l'isolation soumise à l'essai (condensateurs d'antiparasitage, par exemple) et qu'ils peuvent compromettre les résultats d'essai, des tensions d'essai en courant continu doivent être utilisées.

*Il est admis de déconnecter les composants fournissant un chemin en courant continu en parallèle avec l'isolation à soumettre à l'essai, comme les résistances de décharge des condensateurs de filtre et les **dispositifs** de limitation de tension.*

Lorsque l'isolation d'un enroulement de transformateur varie le long de 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 exigée.

Tableau 25 – Tensions d'essai pour les essais de rigidité diélectrique par rapport aux tensions transitoires

Tension de tenue requise inférieure ou égale à	Tension d'essai pour l'isolation principale ou l'isolation supplémentaire	Tension d'essai pour l'isolation renforcée
kV en valeur de crête	kV en valeur de crête ou en courant continu	
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 × U_R [a]
Une interpolation linéaire peut être utilisée entre les deux points les plus proches.		
[a] U_R correspond à une **tension de tenue requise** supérieure à 12 kV.		

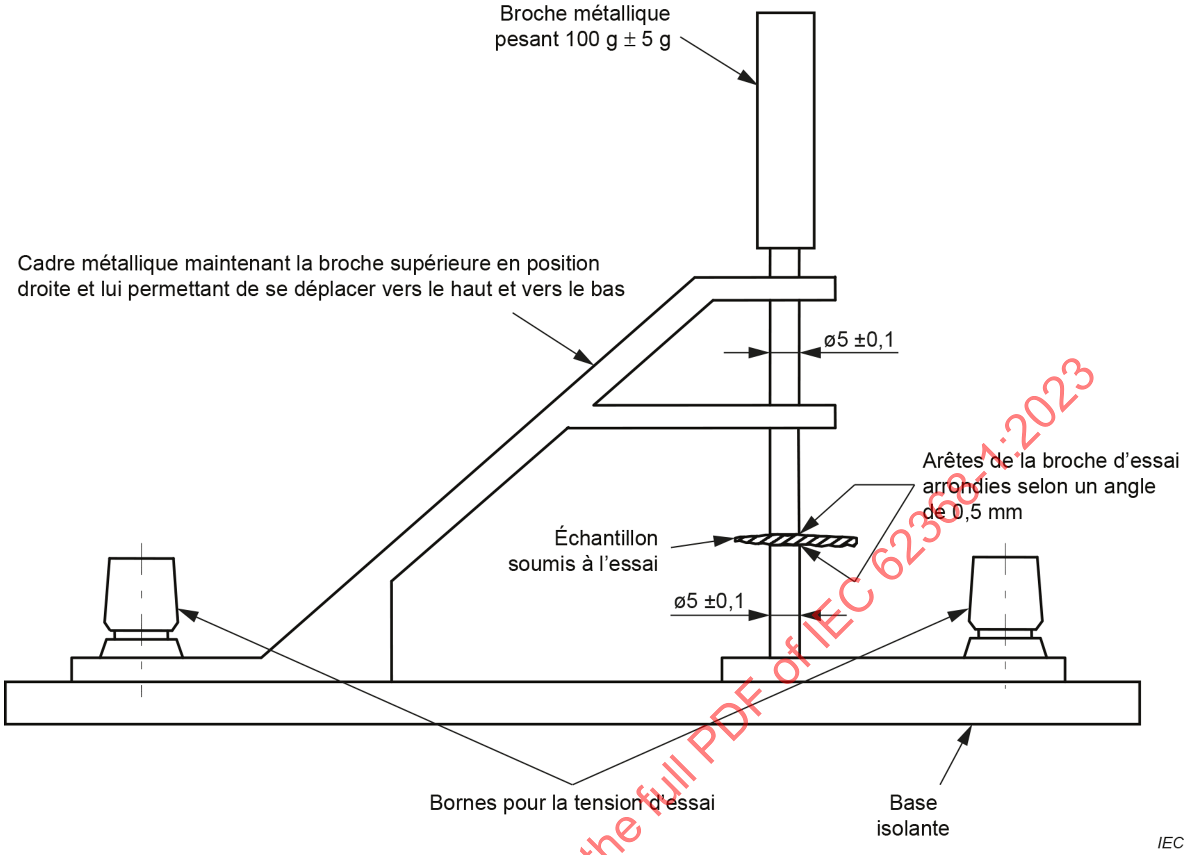
Tableau 26 – Tensions d'essai pour les essais de rigidité diélectrique par rapport aux valeurs de crête des tensions de service et des tensions de crête récurrentes

Tension inférieure ou égale à	Tension d'essai pour l'isolation principale ou l'isolation supplémentaire	Tension d'essai pour l'isolation renforcée
kV en valeur de crête	kV en valeur de crête ou en courant continu	
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 × U_P [a]	1,6 × U_P [a]
Une interpolation linéaire peut être utilisée entre les deux points les plus proches.		
[a] U_P correspond à une tension supérieure à 12 kV.		

Tableau 27 – Tensions d'essai pour les essais de rigidité diélectrique par rapport aux 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	kV en valeur de crête ou en courant continu	
Inférieure ou égale à 250	2	4
Comprise entre 250 et 600	2,5	5

Dimensions en millimètres



NOTE Lors du montage d'essai, vérifier que le diamètre de l'échantillon est suffisant pour empêcher le claquage autour des bords.

Figure 29 – Exemple d'instrument d'essai de rigidité diélectrique pour une isolation solide

NOTE Les isolations en fines couches peuvent être soumises à l'essai en utilisant l'instrument de la Figure 29.

L'isolation ne doit pas subir de claquage pendant l'essai. Il est considéré qu'un claquage de l'isolation s'est produit lorsque le courant qui s'écoule après l'application de la tension d'essai augmente rapidement de manière incontrôlée, c'est-à-dire lorsque l'isolation n'empêche plus le passage du courant. Une décharge en couronne ou un simple contournement momentané n'est pas considéré comme un claquage de l'isolation.

5.4.9.2 Procédure d'essai pour les essais individuels de série

Lorsque cela est exigé, les ***essais individuels de série*** *sont réalisés conformément au 5.4.9.1, excepté pour ce qui suit:*

– *l'essai peut être effectué à température ambiante; et*

– *la durée de l'essai de rigidité diélectrique doit être comprise entre 1 s et 4 s; et*

– *la tension d'essai peut être réduite de 10 %.*

NOTE Les **essais individuels de série** pour l'équipement sont spécifiés dans l'IEC 62911.

L'isolation ne doit pas subir de claquage pendant l'essai. Il est considéré qu'un claquage de l'isolation s'est produit lorsque le courant qui s'écoule après l'application de la tension d'essai augmente rapidement de manière incontrôlée, c'est-à-dire lorsque l'isolation n'empêche plus le passage du courant. Une décharge en couronne ou un simple contournement momentané n'est pas considéré comme un claquage de l'isolation.

5.4.10 Protections contre les tensions transitoires des circuits externes

5.4.10.1 Exigences

Une séparation électrique adéquate doit être assurée entre les circuits destinés à être raccordés à des **circuits externes** avec une tension transitoire comme cela est indiqué dans le Tableau 13, ID 1a, et représenté à la Figure 30, et:

a) les parties non conductrices et les parties conductrices non mises à la terre de l'équipement destinées à être tenues ou maintenues en contact continu avec le corps en utilisation normale (combiné ou casque de téléphone ou surface d'un ordinateur portable sur laquelle s'appuie la paume de la main, par exemple);

b) des parties et des circuits **accessibles**, à l'exception des broches des connecteurs. Cependant, ce type de broche 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 des circuits prévus pour être raccordés à un **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).

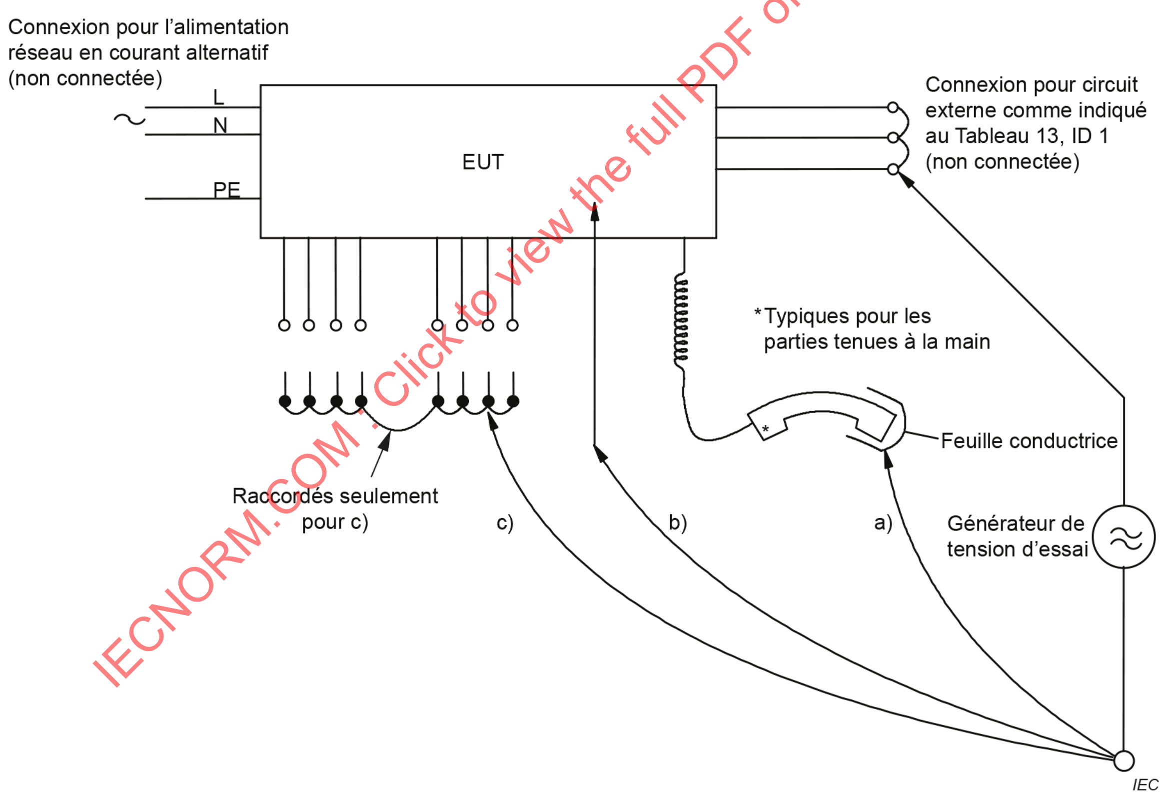


Figure 30 – Points d'application de la tension d'essai

5.4.10.2 Méthodes d'essai

5.4.10.2.1 Généralités

La séparation est vérifiée par l'essai du 5.4.10.2.2 ou du 5.4.10.2.3.

NOTE En Australie, les essais du 5.4.10.2.2 et du 5.4.10.2.3 s'appliquent.

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 28 – – Valeurs pour les essais de rigidité diélectrique

Parties	Essai de choc (voir Annexe D)		Essai en régime établi
	U_c	Générateur d'essai	
Parties indiquées en 5.4.10.1 a) [a]	2,5 kV	circuit 1	1,5 kV
Parties indiquées en 5.4.10.1 b) et c) [b]	1,5 kV	circuit 1 [c]	1,0 kV

[a] Les parasurtenseurs ne doivent pas être retirés.

[b] Les parasurtenseurs peuvent être retirés, sous réserve que ces **dispositifs** réussissent l'essai de choc du 5.4.10.2.2 lorsqu'ils sont soumis à l'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 amorçage se produise dans un TDG.

5.4.10.2.2 Essai de choc

La séparation électrique est soumise à dix impulsions de polarité alternées, comme cela est indiqué dans le Tableau 28. L'intervalle entre les impulsions successives est de 60 s. U_c est la valeur à laquelle le condensateur doit être chargé.

NOTE En Australie, une valeur U_c = 7,0 kV est utilisée pour les téléphones portatifs et pour les casques, la valeur étant de 2,5 kV pour les autres équipements du 5.4.10.1 a). Le choc de 7 kV simule les coups de foudre auxquels sont soumis les réseaux ruraux et semiruraux classiques.

5.4.10.2.3 Essai en régime établi

La séparation électrique est soumise à un essai de rigidité diélectrique selon le 5.4.9.1, avec une valeur de tension conforme au Tableau 28.

NOTE En Australie, la tension d'essai en régime établi est de 3 kV pour 5.4.10.1 a) et de 1,5 kV pour 5.4.10.1 b) et c). Ces valeurs ont été déterminées en tenant compte des tensions induites à basse fréquence provenant du système de distribution d'alimentation électrique.

5.4.10.3 Critères de conformité

Pendant les essais de 5.4.10.2.2 et 5.4.10.2.3:

- *l'isolation ne doit pas subir de claquage; et*
- *à l'exception des indications du Tableau 28, note [c], le parasurtenseur ne doit pas fonctionner et aucun claquage ne doit se produire dans un TDG.*

Pour l'essai de rigidité diélectrique, le claquage de l'isolation est considéré comme s'étant produit 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, le claquage de l'isolation est vérifié selon l'une des deux méthodes suivantes:

- *pendant l'application des impulsions, par observation des oscillogrammes, le fonctionnement du parasurtenseur ou le claquage dans l'isolation est évalué en fonction de la forme d'un oscillogramme;*
- *après l'application de toutes les impulsions, par un essai de résistance d'isolement. Les parasurtenseurs peuvent être déconnectés pendant le mesurage de la résistance d'isolement. La tension d'essai est de 500 V en courant continu ou, si les parasurtenseurs sont laissés en place, la tension d'essai en courant continu est 10 % inférieure à la tension de fonctionnement ou d'amorçage du parasurtenseur. La résistance d'isolement ne doit pas être inférieure 2 MW.*

5.4.11 Séparation entre des circuits externes et la terre

5.4.11.1 Généralités

Ces exigences s'appliquent uniquement à l'équipement avec des **circuits externes** destinés à être raccordés au câblage du bâtiment et dont il est prévu qu'il quitte l'environnement dans lequel il se trouve.

Ces exigences ne s'appliquent à aucun des éléments suivants:

- **équipement relié en permanence**;
- **équipement enfichable de type B**;
- **équipements enfichables de type A stationnaires** qui sont conçus pour être utilisés dans un endroit avec liaison équipotentielle (comme 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 **mise à la terre de protection** du socle de prise de courant par une **personne qualifiée**;
- **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**.

5.4.11.2 Exigences

Une séparation doit être prévue entre les circuits destinés à être connectés aux **circuits externes** mentionnés ci-dessus et les parties ou les circuits qui seront 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 parasurtenseurs en parallèle de la séparation entre les circuits ES1 ou ES2 destinés à être raccordés aux **circuits externes** et la terre doivent présenter une tension de fonctionnement assignée minimale U_{op} (tension de claquage d'un tube à décharge dans un gaz, par exemple) égale à:

$$U_{op} = U_{crête} + \Delta U_{sp} + \Delta U_{sa}$$

où:

$U_{crête}$ est l'une des valeurs suivantes:

– pour l'équipement destiné à être installé dans une zone où la tension nominale du **réseau d'alimentation** en courant alternatif dépasse 130 V: 360 V;

– pour tous les autres équipements: 180 V.

ΔU_{sp} est la tolérance négative sur la tension de fonctionnement assignée due aux variations de production du parasurtenseur, obtenue en soustrayant la tension de fonctionnement assignée minimale de la tension de fonctionnement assignée nominale. Si cela n'est pas spécifié par le fabricant du parasurtenseur, ΔU_{sp} doit être prise égale à 10 % de la tension de fonctionnement assignée du parasurtenseur.

ΔU_{sa} est la variation de la tension de fonctionnement assignée due au vieillissement du parasurtenseur sur la durée de vie prévue de l'équipement, obtenue en soustrayant la tension de fonctionnement minimale après vieillissement de la tension de fonctionnement assignée. Si cela n'est pas spécifié par le fabricant du parasurtenseur, ΔU_{sa} doit être prise égale à 10 % de la tension de fonctionnement assignée du parasurtenseur.

($\Delta U_{sp} + \Delta U_{sa}$) peut être une seule valeur fournie par le fabricant du composant.

5.4.11.3 Méthode d'essai et critères de conformité

*La conformité est vérifiée par examen et par l'essai de rigidité diélectrique du 5.4.9.1 en appliquant une tension d'essai conforme au Tableau 25 pour l'**isolation principale** ou l'**isolation supplémentaire** en fonction de la **tension de tenue requise** pour le **réseau d'alimentation** de l'équipement.*

Les composants, autres que les condensateurs, qui sont en parallèle de la séparation 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 doit être utilisé (230 V pour l'Europe ou 120 V pour l'Amérique du Nord, par exemple).*

Le courant passant dans le circuit d'essai de la Figure 31 ne doit pas dépasser 10 mA.

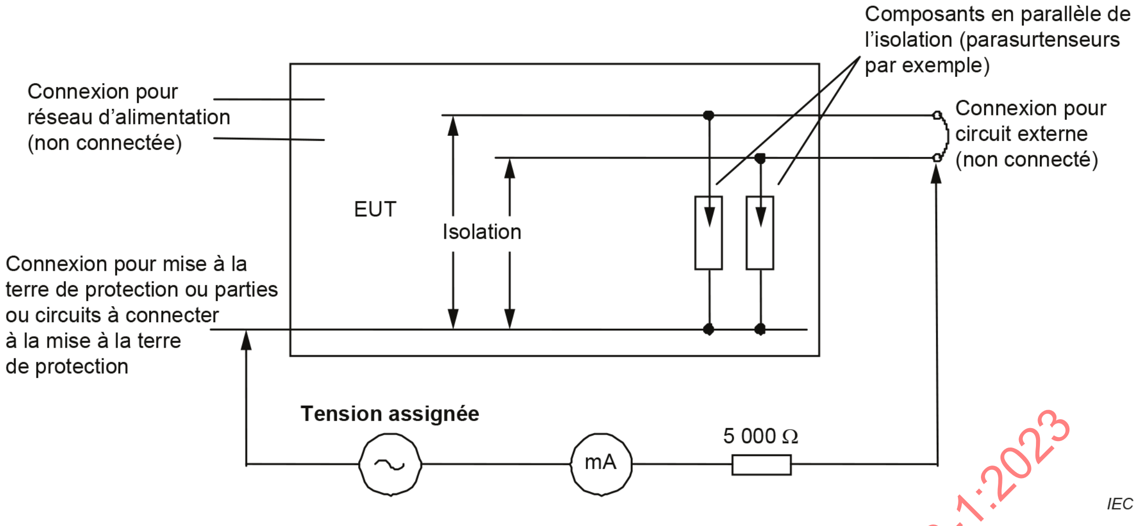


Figure 31 – Essai de séparation entre un circuit externe et la terre

5.4.12 Isolant liquide

5.4.12.1 Exigences générales

Un **isolant liquide** utilisé comme **protection** ne doit pas subir de claquage en raison de surtensions, y compris les transitoires, qui pénètrent dans l'équipement, et de tensions de crête qui peuvent être générées à l'intérieur de l'équipement.

L'**isolant liquide** doit satisfaire au 5.4.12.2 et au 5.4.12.3. Le conteneur de l'**isolant liquide** doit satisfaire au 5.4.12.4.

5.4.12.2 Rigidité diélectrique d'un isolant liquide

La rigidité diélectrique de l'**isolant liquide** doit satisfaire à l'essai de rigidité diélectrique du 5.4.9 avec l'**isolant liquide** dans l'équipement.

5.4.12.3 Compatibilité d'un isolant liquide

L'**isolant liquide** ne doit pas réagir avec les **protections** ni les détériorer, comme:

– l'**isolation solide**; ou
– l'**isolant liquide** lui-même.

*Pour les **isolants liquides** de classification thermique correspondant à la Classe 105 (A) de l'IEC 60085, la conformité est vérifiée en faisant fonctionner l'équipement immergé pendant 60 jours, suivis d'un essai de rigidité diélectrique conforme à 5.4.9. Il ne doit se produire aucun claquage ni dommage ou déformation visible des autres **protections de l'équipement** immergées.*

Pour les classes thermiques supérieures, les exigences du 5.4.1.4.3 s'appliquent.

5.4.12.4 Conteneur de l'isolant liquide

Le conteneur de l'**isolant liquide** doit comporter des moyens de détente de pression, dans le cas d'un récipient fermé.

Le conteneur d'**isolant liquide** doit satisfaire au G.15.2.1 s'il s'agit d'un récipient fermé.

Si un **isolant liquide** est également considéré comme une **substance dangereuse**, le conteneur doit également satisfaire aux exigences du 7.2.

La conformité est vérifiée par les essais correspondants.

5.5 Composants comme protections

5.5.1 Généralités

Un composant est considéré comme une **protection** si la classification de la source d'énergie augmente par suite d'une défaillance du composant.

Un composant utilisé comme **protection** doit:

– satisfaire à l'ensemble des exigences applicables à la **protection** concernée; et
– être utilisé dans les limites de ses caractéristiques assignées.

NOTE Pour la qualification des composants utilisés comme **protection**, consulter l'Annexe G.

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 l'IEC 60384-14. Les cellules RC peuvent être constituées de composants discrets.

Les condensateurs et les 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 à la cellule RC utilisés comme **protection principale** entre chacun des cas suivants:

– une ES3 isolée du **réseau d'alimentation** et la terre de protection;
– une ES2 et la terre de protection;
– une ES2 et une ES1;

conformes à l'essai de rigidité diélectrique du 5.4.9.1, en tenant compte de la **tension de service** totale à travers le ou les condensateurs et cellules RC. Il n'est pas nécessaire de soumettre à l'essai les condensateurs qui sont conformes à l'IEC 60384-14 et au G.11.3.

Dans les **conditions de premier défaut**, si un condensateur ou une cellule RC comprend plusieurs condensateurs, la tension aux bornes de chacun des condensateurs restants ne doit pas dépasser la valeur assignée de chacun des condensateurs concernés.

NOTE En Norvège, en raison du système de distribution d'alimentation IT utilisé, les condensateurs doivent être assignés pour la tension entre phases applicable (230 V).

Les condensateurs de classe X peuvent être utilisés comme **protections principales** dans des circuits isolés du **réseau d'alimentation**, mais ne doivent pas être utilisés comme:

– **protection principale** dans les circuits connectés au **réseau d'alimentation**; ou
– **protection supplémentaire**.

Les condensateurs de classe X ne doivent pas être utilisés comme **protection renforcée**.

5.5.2.2 Décharge du condensateur après déconnexion d'un connecteur

Lorsqu'une tension de condensateur devient **accessible** après la déconnexion d'un connecteur (le connecteur du **réseau d'alimentation**, par exemple), la tension **accessible** mesurée 5 s après la déconnexion du connecteur de l'équipement **enfichable de type B** et 2 s après la déconnexion de tout autre 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**.

Une résistance ou un groupe de résistances utilisé comme **protection** contre une décharge du condensateur n'est pas soumis aux **conditions de premier défaut** simulées si la résistance ou le groupe de résistances satisfait à 5.5.6.

Si un circuit intégré qui comprend une fonction de décharge du condensateur (ICX) est utilisé pour satisfaire aux conditions ci-dessus:

– la tension **accessible** (au niveau du connecteur du **réseau d'alimentation**, par exemple) ne doit pas dépasser les limites indiquées ci-dessus en **condition de premier défaut** d'un ICX ou d'un composant du circuit de décharge du condensateur associé; ou
– l'ICX avec les circuits associés tels qu'ils sont fournis dans l'équipement doit satisfaire aux exigences de l'Article G.16. Tout composant qui atténue les impulsions (comme les varistances et les TDG) est déconnecté; ou
– trois échantillons d'ICX soumis séparément à l'essai doivent satisfaire aux exigences de l'Article G.16.

Le mesurage est réalisé 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 interrupteur (l'interrupteur du **réseau d'alimentation**, par exemple) 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) doit être réalisée lorsque le condensateur d'entrée du **dispositif** à l'essai est chargé à sa valeur de crête.

D'autres méthodes donnant un résultat analogue à celui de la méthode ci-dessus peuvent être utilisées.

5.5.3 Transformateurs

Les transformateurs utilisés comme **protection** doivent être conformes au G.5.3.

5.5.4 Optocoupleurs

L'isolation des optocoupleurs utilisés comme **protection** doit satisfaire aux exigences du 5.4 ou de l'Article G.12.

5.5.5 Relais

L'isolation des relais utilisés comme **protection** doit satisfaire aux exigences du 5.4.

5.5.6 Résistances

Les applications de résistances suivantes doivent satisfaire aux essais correspondants indiqués dans le Tableau 29:

– une seule résistance utilisée comme **protection renforcée** ou en parallèle de l'**isolation renforcée**;
– une résistance ou un groupe de résistances servant de **protection** entre un circuit raccordé au **réseau d'alimentation** et un circuit prévu pour être raccordé au câble coaxial;
– les résistances servant de **protection** contre les décharges du condensateur.

NOTE En Finlande, en Norvège et en Suède, les résistances utilisées comme **protection principale** ou en parallèle de l'**isolation principale** dans des **équipements enfichables de type A de classe I** doivent satisfaire aux exigences de l'Article G.10.

De plus, les résistances qui sont en parallèle de l'**isolation principale**, l'**isolation supplémentaire** ou **l'isolation renforcée** doivent satisfaire à chacune des exigences suivantes:

– une résistance unique ou un groupe de résistances doit satisfaire aux exigences relatives à la **distance d'isolement** du 5.4.2 et à la **ligne de fuite** du 5.4.3, entre ses extrémités et pour la **tension de service** totale aux bornes de l'isolation (voir Figure O.4);
– pour un groupe de résistances utilisé comme **protection renforcée** ou en parallèle de l'**isolation renforcée**, la **distance d'isolement** et la **ligne de fuite** sont évaluées comme si chaque résistance était successivement court-circuitée, sauf si le groupe satisfait aux exigences correspondantes de l'Article G.10.

Tableau 29 – Vue d'ensemble des essais pour les applications utilisant des résistances

Utilisation de la résistance	Conditionnement	Essai de résistance	Essai de tension de choc	Essai de choc	Essai de surcharge
	G.10.2	G.10.3	G.10.4	G.10.5	G.10.6
Protection renforcée ou en parallèle de l'**isolation renforcée**	X	X			
Entre un circuit connecté au **réseau d'alimentation** et un câble coaxial	X		X	X	
Protection contre les décharges du condensateur	X				X

5.5.7 Parasurtenseurs

Si une varistance est utilisée entre un circuit du **réseau d'alimentation** à la tension ES3 et la **mise à la terre de protection**:

– la connexion à la terre doit être conforme au 5.6.7; et
– la varistance doit être conforme à l'Article G.8.

Si une varistance est utilisée entre la phase et le neutre ou entre les phases, elle doit être conforme à l'Article G.8.

Lorsqu'une limitation des surtensions est utilisée entre le **réseau d'alimentation** et la **mise à la terre de protection**, elle doit comprendre une varistance et un TDG connectés en série, avec les exigences suivantes:

– la varistance doit être conforme à l'Article G.8;
– le TDG doit satisfaire:
  • à l'essai de rigidité diélectrique du 5.4.9.1 pour l'**isolation principale** à une tension d'essai conforme au Tableau 26 et au Tableau 27; et
  • aux exigences relatives aux **distances d'isolement** et aux **lignes de fuite** externes de 5.4.2 et 5.4.3 respectivement pour l'**isolation principale**.

NOTE 1 Les MOV, les varistances et les TDG sont des exemples de parasurtenseurs. Une varistance est parfois appelée VDR ou varistance à oxyde métallique (MOV).

NOTE 2 Dans les **matériels de classe II**, les parasurtenseurs sont parfois utilisés entre le **réseau d'alimentation** et un **circuit externe** comme cela est défini dans le Tableau 13, ID 1a, 1b et 1c afin de protéger les circuits internes contre les surtensions provoquées par la foudre. L'Annexe A de l'IEC TR 62368-2:20— fournit des informations relatives à l'utilisation de parasurtenseurs à ces fins.

Les exigences ci-dessus ne s'appliquent pas aux parasurtenseurs reliés à une terre fiable (voir 5.6.7).

NOTE 3 Le présent document n'établit aucune exigence selon laquelle les parasurtenseurs nécessitent d'être conformes à une norme de composant particulière. Cependant, l'attention est attirée sur les séries de normes IEC 61643 et IEC 61051, notamment:

– l'IEC 61051-2 (varistances pour limitations de surtensions transitoires);
– l'IEC 61643-21 (dispositifs de protection contre les surtensions reliés aux réseaux de télécommunication et de signalisation);
– l'IEC 61643-311 (tubes à décharge dans un gaz);
– l'IEC 61643-321 (diodes à avalanche);
– l'IEC 61643-331 (varistances à oxyde métallique);
– l'IEC 61643-341 (parasurtenseurs à thyristor, TSS).

NOTE 4 Les parasurtenseurs placés entre un **circuit externe** et la terre ne sont pas considérés comme une **protection**. Les exigences relatives à ces parasurtenseurs sont traitées en 5.4.11.2.

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 toute résistance en parallèle sur cette isolation, doit être en mesure de 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;
– un équipement connecté à une terre fiable conformément au 5.6.7.

La combinaison de l'isolation et de la résistance est soumise à l'essai après avoir effectué le conditionnement des résistances montées en parallèle de cette isolation, soit séparément soit en combinaison avec l'isolation, conformément au G.10.2 comme suit:

– *pour l'équipement destiné à être raccordé à un câble coaxial connecté à une antenne extérieure, l'essai de surtension du G.10.4; ou*
– *pour l'équipement prévu pour être raccordé à un autre câble coaxial, l'essai de choc du G.10.5; ou*
– *pour l'équipement prévu pour être raccordé à une antenne extérieure et à d'autres connexions coaxiales, l'essai de surtension du G.10.4 et l'essai de choc du G.10.5.*

Lorsque le G.10.5 exige seulement un essai de choc à 4 kV, ce dernier n'est pas exigé si l'isolation satisfait à l'essai de rigidité diélectrique conformément au 5.4.9.1 pour une valeur de crête ou en courant continu de 4 kV au minimum.

La résistance peut être retirée pendant les essais. Après l'essai, l'appareil doit être conforme au 5.4.5.3.

5.5.9 Protection des socles de prises de courant d'un matériel pour installation extérieure

Un **dispositif** à courant différentiel résiduel (DDR) dont le courant différentiel de fonctionnement assigné ne dépasse pas 30 mA doit être utilisé dans le **réseau d'alimentation** pour les socles de prises de courant à usage général.

Le DDR doit faire partie intégrante du **matériel pour installation extérieure** ou de l'installation du bâtiment. Si le DDR ne fait pas partie intégrante du matériel, les instructions doivent indiquer les exigences d'installation du DDR.

La conformité est vérifiée par examen.

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, ni **appareil** limiteur de courant ou **dispositif** de protection contre les surintensités.

Le courant admissible des **conducteurs de protection** doit être approprié 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 fixé à une partie ou à un **sous-ensemble** qui peut être retiré par une personne autre qu'une **personne qualifiée**;

NOTE Les bonnes pratiques appliquent également cette construction lorsqu'il est probable 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 d'un **conducteur de protection**.

L'extrémité d'un **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. Une seule borne peut être utilisée pour connecter plusieurs **conducteurs de liaison de protection.** L'extrémité d'un **conducteur de mise à la terre de protection** ne doit pas servir à sécuriser un composant ou une partie autre que le **conducteur de liaison de protection**.

Une seule borne pour fil électrique (terminaison) de type à vis ou à goujon peut être utilisée pour sécuriser le **conducteur de mise à la terre de protection** et le **conducteur de liaison de protection** de l'équipement équipé d'un **câble d'alimentation fixé à demeure**. Dans ce cas, l'extrémité du fil du **conducteur de mise à la terre de protection** doit être séparée de celle du **conducteur de liaison de protection** au moyen d'un écrou. Le **conducteur de mise à la terre de protection** doit se trouver en bas de la pile, de manière à retirer la connexion en dernier.

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.

Pour les conducteurs de **mise à la terre fonctionnelle**, la combinaison de couleurs vert et jaune ne doit pas être utilisée, sauf pour les composants préassemblés à usages multiples (câbles multiconducteurs ou filtres CEM, par exemple).

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.7.

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 L'IEC 60364-5-54 peut également être utilisée pour déterminer les dimensions minimales du conducteur.

Pour les équipements connectés par un câble alimentés par un **réseau d'alimentation** en courant continu, la connexion de **mise à la terre de protection** peut être fournie par une borne distincte.

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 au G.7.1 et pas plus léger que les câbles renforcés spécifiés à l'Annexe C de l'IEC 62440:2008; ou

– avoir une dimension de conducteur minimale supérieure ou égale à 4 mm^2 s'il n'est pas protégé contre les dommages matériels; ou

– avoir une dimension de conducteur minimale supérieure ou égale à 2,5 mm^2 s'il est protégé contre les dommages matériels; ou

– être protégé par un conduit prévu pour être raccordé à l'équipement et avoir une dimension minimale conforme au Tableau 30.

NOTE 3 Pour les câbles d'alimentation du **réseau d'alimentation**, voir aussi l'Article G.7.

NOTE 4 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 des conducteurs de mise à la terre de protection mm^2
Conduit souple non métallique	4
Conduit souple métallique	2,5
Conduit métallique non souple	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 mesurage des dimensions du ***conducteur de mise à la terre de protection*** *conformément au Tableau 30 ou au Tableau G.7, 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 satisfaire à l'une des conditions suivantes:

– les dimensions minimales des conducteurs indiquées dans le Tableau G.7; ou

– si le **courant assigné** de l'équipement ou la **caractéristique assignée du courant de protection** du circuit dépasse 25 A, les dimensions minimales des conducteurs indiquées dans le Tableau 31; ou

– si à la fois le **courant assigné** de l'équipement et la **caractéristique assignée du courant de protection** du circuit ne dépassent pas 25 A; soit

  • les dimensions minimales des conducteurs indiquées dans le Tableau 31; ou

  • l'essai de court-circuit limité de l'Annexe R; ou

– pour les composants uniquement, les conducteurs ne sont pas de dimensions inférieures aux conducteurs d'alimentation du composant.

Si le **courant assigné** de l'équipement n'est pas déclaré par le fabricant, il est égal à la valeur calculée de la **puissance assignée** divisée par la **tension assignée**.

NOTE La valeur de la **caractéristique assignée du courant de protection** est utilisée dans le Tableau 31 et dans l'essai du 5.6.6.2.

Tableau 31 – Dimensions minimales du conducteur de liaison de protection des conducteurs en cuivre

La valeur la plus faible entre le courant assigné de l'équipement ou la caractéristique assignée du courant de protection du circuit étudié A **inférieure ou égale à**	**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 Gauge et le terme "cmil" fait référence aux mils circulaires pour un mil circulaire égal à (diamètre en mils)^2. Ces termes sont communément utilisés pour désigner les dimensions des câbles en Amérique du Nord.		

5.6.4.2 Détermination de la caractéristique assignée du courant de protection

5.6.4.2.1 Réseau d'alimentation utilisé comme source

Lorsque la source est le **réseau d'alimentation**, la **caractéristique assignée du courant de protection** du circuit est la caractéristique assignée du **dispositif** de protection contre les surintensités fourni dans l'installation du bâtiment ou faisant partie de l'équipement.

Si le **dispositif** de protection contre les surintensités est fourni dans l'installation du bâtiment, alors:

– pour un **équipement enfichable de type A**, la **caractéristique assignée du courant de protection** est la caractéristique assignée d'un **dispositif** de protection contre les surintensités fourni comme élément externe à l'équipement (dans le câblage du bâtiment, dans la fiche de raccordement au **réseau d'alimentation** ou dans un tiroir d'équipement, par exemple), avec un courant minimal de 16 A;

  NOTE 1 Dans la plupart des pays, une intensité de 16 A est considérée comme une valeur appropriée pour la **caractéristique assignée du courant de protection** du circuit alimenté par le **réseau d'alimentation**.

  NOTE 2 Au Canada et aux Etats-Unis, la **caractéristique assignée du courant de protection** du circuit alimenté par le **réseau d'alimentation** est fixée à 20 A.

  NOTE 3 Au Royaume-Uni et en Irlande, la **caractéristique assignée du courant de protection** est prise égale à 13 A. Il s'agit de la caractéristique assignée la plus importante du fusible utilisé dans la fiche de raccordement au **réseau d'alimentation**.

  NOTE 4 En France, dans certains cas, la **caractéristique assignée du courant de protection** du circuit alimenté par le **réseau d'alimentation** est prise égale à 20 A à la place de 16 A.

– pour un **équipement enfichable de type B** et un **équipement relié en permanence,** la **caractéristique assignée du courant de protection** est la caractéristique assignée maximale du **dispositif** de protection contre les surintensités spécifiée dans les instructions d'installation de l'équipement à fournir comme élément externe à l'équipement.

5.6.4.2.2 Source autre que le réseau d'alimentation

Si 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 **caractéristique assignée du courant de protection** du circuit est le courant le plus élevé disponible à partir de cette alimentation sur une charge.

Lorsque le courant maximal de la source d'alimentation externe est limité par des composants électroniques dans la source, la **caractéristique assignée du courant de protection** doit être prise comme le courant de sortie maximal sur une charge résistive, y compris un court-circuit. Si le courant est limité par une impédance, un fusible, un **dispositif** CTP 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 **caractéristique assignée du courant de protection** du circuit est:

– la caractéristique assignée du **dispositif** de protection contre les surintensités si le courant est limité par un **dispositif** de protection contre les surintensités; ou

– le courant de sortie maximal, si le courant est limité par l'impédance de la source de l'alimentation.

Le courant de sortie est mesuré avec une charge résistive, y compris un court-circuit, mesuré 60 s après l'application de la charge, si le courant est limité par une impédance ou que le **dispositif** de limitation du courant est un fusible, un disjoncteur ou un **dispositif** CTP, ou 5 s dans les autres cas.

5.6.4.2.4 Dispositifs de limitation de courant et de protection contre les surintensités

Un **dispositif** de limitation du courant (**dispositif** CTP) ou un **dispositif** de protection contre les surintensités (fusible ou disjoncteur) ne doit pas être connecté en parallèle avec un autre composant susceptible d'être défaillant en situation de faible résistance.

5.6.4.3 Critères de conformité

La conformité est vérifiée par examen et mesurage des dimensions du ***conducteur de liaison de protection*** *conformément au Tableau 31, au Tableau G.7, ou à l'essai de l'Annexe R, selon le cas.*

5.6.5 Bornes des conducteurs de protection

5.6.5.1 Exigences

Les équipements qui doivent avoir une **mise à la terre de protection** doivent comporter une borne de **mise à la terre de protection** principale. Pour les équipements équipés d'un câble d'alimentation non fixé à demeure, la borne de mise à la terre du socle de connecteur est considérée comme la borne de **mise à la terre de protection** principale.

Les bornes de raccordement des **conducteurs de mise à la terre de protection** doivent:

– être conformes aux tailles minimales des bornes du Tableau 32 pour tous les types de bornes (pilier, à tige ou à vis); ou
– être adaptées en tant que connexion **de terre de protection** conformément à la norme IEC applicable à la borne selon 4.1.2, et satisfaire à l'essai du 5.6.6.

Les bornes de connexion des **conducteurs de liaison de protection** doivent satisfaire à l'une des conditions suivantes:

– les tailles minimales des bornes du Tableau 32 pour tous les types de bornes (pilier, à tige ou à vis); ou
– être adaptées en tant que connexion de **terre de protection** conformément à la norme IEC applicable pour la borne concernée selon 4.1.2 et satisfaire à l'essai du 5.6.6; ou
– si le **courant assigné** de l'équipement ou la **caractéristique assignée du courant de protection** du circuit dépasse 25 A, les dimensions de bornes qui ne sont pas inférieures aux valeurs indiquées dans le Tableau 32 de plus d'un pas; ou
– si à la fois le **courant assigné** de l'équipement et la **caractéristique assignée du courant de protection** du circuit ne dépassent pas 25 A; soit
  - les dimensions de bornes qui ne sont pas inférieures aux valeurs indiquées dans le Tableau 32 de plus d'un pas; ou
  - l'essai de court-circuit limité de l'Annexe R;

  ou
– 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 (à partir du Tableau G.7)	Diamètre de filetage nominal minimal mm		Section mm²	
	Type à trou ou type à goujon	Type à vis [a]	Type à trou ou type à goujon	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, le **conducteur de mise à la terre de protection** peut être fixé à des connecteurs spéciaux ou à des moyens de serrage adaptés (par exemple, de type cosse à fourche ou cosse à œillet, de type organe de serrage, de type organe de serrage à plaquettes, de type organe de serrage à capot taraudé, etc.) qui sont fixés par un mécanisme de vis et d'écrou au châssis en métal de l'équipement. La somme des sections de la vis et de l'écrou ne doit pas être inférieure à trois fois la section de la dimension du conducteur du Tableau 31 ou du Tableau G.7, selon le cas. Les bornes doivent être conformes à l'IEC 60998-1 et à l'IEC 60999-1 ou l'IEC 60999-2.

La conformité est vérifiée par examen et mesurage des dimensions des bornes de protection conformément au Tableau 32, à l'évaluation de la conformité par rapport à la norme IEC pertinente sur les bornes selon 4.1.2, à l'essai du 5.6.6 ou de 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 soit inférieure ou égale à 0,6 V.

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

La résistance des **conducteurs de liaison de protection** et leurs extrémités ne doit pas être 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 doit être mise à la terre pour des raisons de sécurité.

Les **conducteurs de liaison de protection** qui respectent, sur toute leur longueur, les dimensions minimales de conducteurs du Tableau G.7 et dont les bornes respecter toutes les dimensions minimales du Tableau 32 sont considérés comme étant 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 multiconducteur 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 prise en compte lors du mesurage.

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 mesurages sont réalisés entre la borne principale de ***mise à la terre de protection*** *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 d'un 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 mesurages de chute de tension sont réalisés uniquement entre la borne principale de* ***mise à la terre de protection*** *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 à l'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* ***caractéristique 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* ***caractéristique assignée du courant de protection*** *appliquée pendant 2 min;*

b) pour les équipements alimentés par le ***réseau d'alimentation*** *en courant alternatif, si la* ***caractéristique assignée du courant de protection*** *du circuit soumis à l'essai dépasse 25 A, le courant d'essai est égal à 200 % la* ***caractéristique assignée du courant de protection*** *ou à 500 A, si cette valeur est plus faible, et la durée de l'essai correspond à la valeur indiquée dans le Tableau 33.*

Tableau 33 – Durée de l'essai, équipements connectés au réseau d'alimentation

Caractéristique assignée du courant de protection du circuit A **inférieure ou égale à**	**Durée de l'essai** min
30	2
60	4
100	6
200	8
supérieur à 200	10

c) une alternative à b) consiste à porter 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'EUT, 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* ***caractéristique assignée du courant de protection****, pour la durée correspondant à 200 % des caractéristiques temps-courant. Si la durée pour 200 % n'est pas indiquée, le point le plus proche des caractéristiques temps-courant peut être utilisé;*

*d) pour les équipements alimentés par un **réseau d'alimentation** en courant continu, si la **caractéristique assignée du courant de protection** du circuit soumis à l'essai dépasse 25 A, le courant et la durée d'essai spécifiés par le fabricant sont utilisés;*

*e) pour les équipements alimentés par un **circuit externe**, le courant d'essai est égal à 1,5 fois le courant maximal disponible à partir du **circuit externe** ou à 2 A, si cette valeur est plus élevée, pendant 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 qui ne dépassent pas un niveau ES2 dans les **conditions de premier défaut**, l'essai est réalisé conformément à la méthode d'essai de a), b), c) ou d), selon la source d'alimentation utilisée.*

5.6.6.3 Critères de conformité

*Si la **caractéristique assignée du courant de protection** ne dépasse pas 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 .*

*Si la **caractéristique assignée du courant de protection** dépasse 25 A, la chute de tension dans le système de protection ne doit pas dépasser 2,5 V.*

5.6.7 Connexion fiable d'un conducteur de mise à la terre de protection

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 également considérée comme fiable pour:

– les **équipements enfichables de type B**; ou
– les **équipements enfichables de type A stationnaires**;
  - qui sont conçus pour être utilisés dans 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 **mise à la 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; et
  - accompagnés d'instructions d'installation de ce conducteur à la terre du bâtiment par une **personne qualifiée**.

Pour les équipements connectés à un **circuit externe**, 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; et
– accompagnés d'instructions d'installation de ce conducteur à la terre du bâtiment par une **personne qualifiée**.

5.6.8 Mise à la terre fonctionnelle

Si un **conducteur de mise à la terre de protection** du câble d'alimentation du **réseau d'alimentation** est utilisé uniquement pour établir la **mise à la terre fonctionnelle**:

– les exigences de dimensions des conducteurs (voir G.7.2) s'appliquent au conducteur de mise à la terre du câble d'alimentation du **réseau d'alimentation**; et
– le marquage du **matériel de classe II** qui assure la **mise à la terre fonctionnelle** doit être apposé, comme cela est indiqué en F.3.6.2; et
– le socle de connecteur, s'il est utilisé, doit satisfaire aux exigences de **distance d'isolement** et de **ligne de fuite** pour la **double isolation** ou l'**isolation renforcée**.

NOTE 1 Certains socles de connecteur de **matériels de classe I** ne présentent pas une isolation suffisante pour servir de **double isolation** ou d'**isolation renforcée** entre les phases et la borne de **mise à la terre de protection**. Les matériels qui utilisent un tel socle ne sont pas considérés comme des **matériels de classe II**.

NOTE 2 En Norvège, les matériels connectés à la fiche de raccordement au **réseau d'alimentation** mise à la terre sont classés parmi les **matériels de classe I**. Voir les exigences de marquage du pays dans la note du 4.1.15. Le symbole IEC 60417-6092 (2013-03) (voir F.3.6.2) est accepté.

5.7 Tension de contact présumée, courant de contact et courant du conducteur de protection

5.7.1 Généralités

Les mesurages de la **tension de contact présumée**, du **courant de contact** et du **courant du conducteur de protection** sont effectués sur l'EUT alimenté à la tension d'alimentation la plus défavorable (voir B.2.3).

5.7.2 Dispositifs de mesure et réseaux

5.7.2.1 Mesurage du courant de contact

Pour les mesurages du **courant de contact**, l'instrument utilisé pour mesurer U_2 et U_3, spécifiées respectivement à la Figure 4 et la Figure 5 de l'IEC 60990:2016, 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 Mesurage de la tension

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, au 5.3 et au 5.4 de l'IEC 60990:2016.

Les équipements équipés d'une connexion à la terre indépendante du **conducteur de mise à la terre de protection** doivent être soumis à l'essai avec cette connexion déconnectée.

Dans un système, les équipements interconnectés, raccordés individuellement au **réseau d'alimentation** doivent être soumis à l'essai séparément.

Les systèmes d'équipements interconnectés avec une seule connexion au **réseau d'alimentation** doivent être soumis à l'essai comme un seul équipement.

NOTE 1 Les systèmes d'équipements interconnectés sont spécifiés plus en détail à l'Annexe A de l'IEC 60990:2016.

L'essai des équipements conçus pour avoir des connexions multiples au **réseau d'alimentation**, où une seule connexion à la fois est exigée, 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 exigée, 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. L'EUT fonctionne normalement pendant cet essai.

5.7.4 Parties accessibles non mises à la terre

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 le 5.1, le 5.4 et le 6.2.1 de l'IEC 60990:2016.

Dans les **conditions de premier défaut** d'une **protection principale** ou d'une **protection supplémentaire** appropriée, y compris 6.2.2.2 de l'IEC 60990:2016, 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 l'IEC 60990:2016.

Pour une partie **accessible** non conductrice, l'essai est réalisé avec une feuille métallique (voir 5.2.1 de l'IEC 60990:2016).

5.7.5 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 l'IEC 60990:2016, à l'exception de 6.2.2.8. Excepté ce qui est admis en 5.7.6, le **courant de contact** ne doit pas dépasser les limites ES2 spécifiées en 5.2.2.2.

Le 6.2.2.3 de l'IEC 60990:2016 ne s'applique pas aux équipements équipés 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**.

5.7.6 Exigences lorsque le courant de contact dépasse les limites de ES2

Lorsque le **courant de contact** dépasse les limites de ES2 (5.2.2.2) dans les conditions de défaut d'alimentation spécifiées en 6.2.2.2 de l'IEC 60990:2016, toutes les conditions ci-dessous s'appliquent:

– le **courant du conducteur de protection** mesuré selon l'Article 8 de l'IEC 60990:2016 ne doit pas dépasser 5 % du courant d'entrée mesuré dans les **conditions normales de fonctionnement**;
– la construction du circuit du **conducteur de mise à la terre de protection** et de ses connexions doivent avoir:
  - un **conducteur de mise à la terre de protection** servant de **protection renforcée** comme cela est spécifié en 5.6.3 ou deux **conducteurs de mise à la terre de protection** indépendants servant de **double protection**; et
  - une connexion fiable à la **mise à la terre de protection**, comme cela est spécifié en 5.6.7;
– le fabricant doit indiquer la valeur du **courant du conducteur de protection** dans les instructions d'installation si le courant dépasse 10 mA;

– une **protection par instructions** doit être fournie conformément à l'Article F.5, excepté que l'élément 3 est facultatif. La **protection par instructions** doit comporter les éléments suivants:

- élément 1a: , IEC 60417-6042 (2010-11); et

  , IEC 60417-6173 (2012-10); et

  , IEC 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.

Les éléments de la **protection par instructions** nécessitant d'être placés sur l'équipement doivent être fixés sur l'équipement à côté de sa connexion d'alimentation.

5.7.7 Tension de contact présumée et courant de contact associés aux circuits externes

5.7.7.1 Courant de contact provenant de câbles coaxiaux

Si l'équipement est raccordé à des **circuits externes** avec un câble coaxial et si un tel raccordement est susceptible d'engendrer un danger, 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 l'IEC 60728-11:2016.

NOTE 1 En Norvège et en Suède, l'écran du réseau de télédistribution n'est en général pas 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 au moyen d'un adaptateur ou d'un câble d'interconnexion à isolation galvanique, qui peut être fourni par exemple par un détaillant.

Le manuel de l'utilisateur doit 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 doit comporter un **dispositif** qui assure l'isolation électrique au-dessous d'une certaine plage de fréquences (isolateur galvanique, voir l'IEC 60728-11)".

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."

NOTE 2 En Norvège, en raison des réglementations applicables aux installations de réseaux de télévision par antenne collective, et en Suède, un isolateur galvanique doit assurer l'isolation électrique au-dessous de 5 MHz. L'isolation doit supporter une rigidité diélectrique de 1,5 kV en valeur efficace, 50 Hz ou 60 Hz, pendant 1 min.

5.7.7.2 Tension de contact présumée et courant de contact associés aux câbles conducteurs à paires

Pour les circuits destinés à être connectés à des **circuits externes** comme ceux décrits en ID 1a, 1b, 1c et 2 du Tableau 13:

– la **tension de contact présumée** doit être conforme à ES2; ou

– le **courant de contact** ne doit pas dépasser 0,25 mA.

Les exigences ci-dessus ne s'appliquent pas si les **circuits externes** correspondants sont reliés à un **conducteur de mise à la terre de protection**.

La conformité est vérifiée par mesurage selon le 5.7.2 et le 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.

NOTE Pour les autres systèmes de distribution d'alimentation, consulter l'IEC 60990:2016.

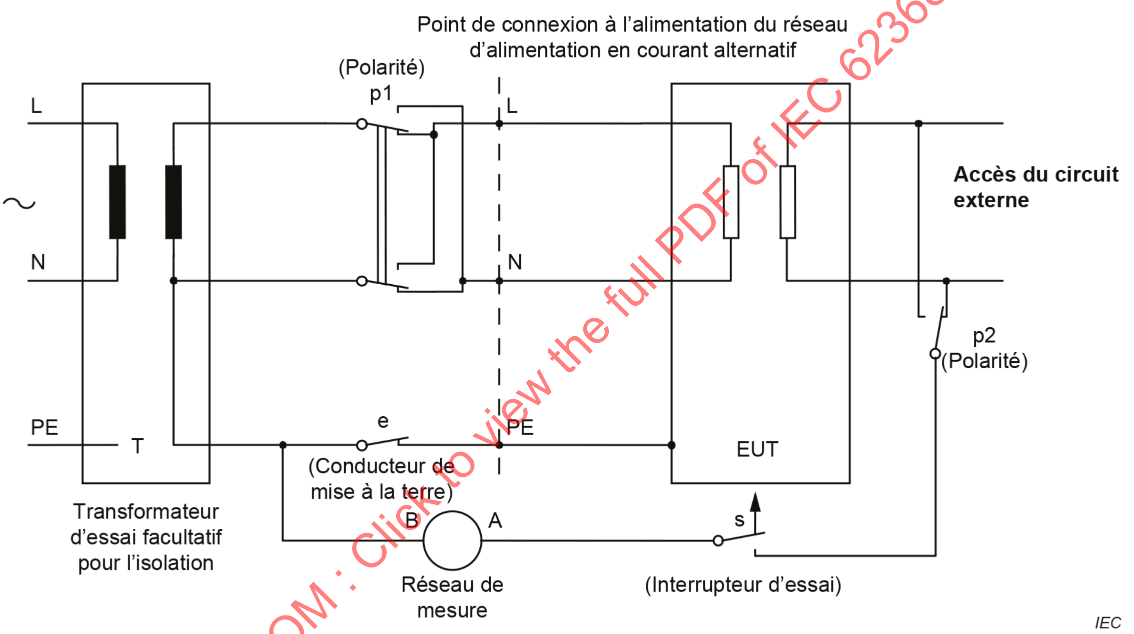


Figure 32 – Circuit d'essai pour le courant de contact des équipements monophasés

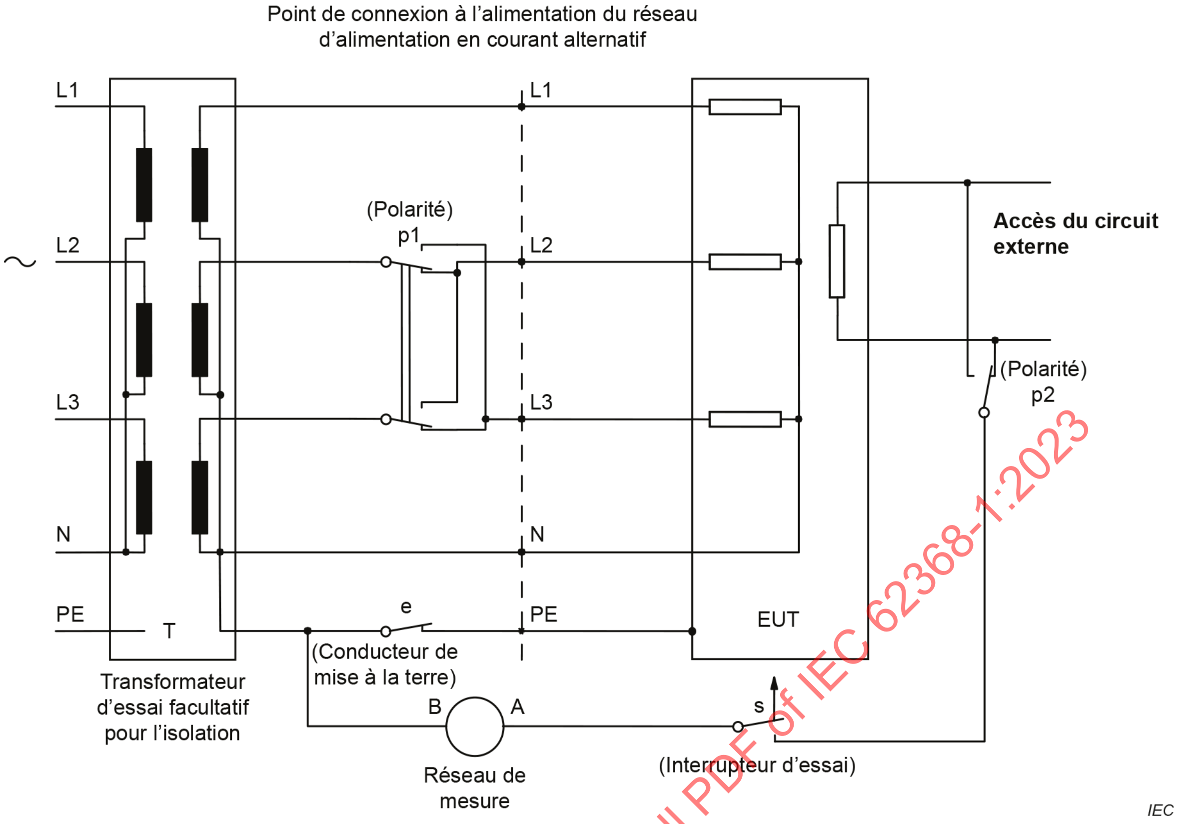


Figure 33 – Circuit d'essai pour le courant de contact des équipements triphasés

5.7.8 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**, en cas d'interruption de la connexion au **réseau d'alimentation**.

Les exigences s'appliquent uniquement aux équipements destinés à être connectés à un **circuit externe**, comme cela est indiqué dans le Tableau 13, ID 1a, 1b, 1c, 2, 3a, 3b et 3c.

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'un autre équipement par un **circuit externe**;
– $S(I_1)$: somme des **courants de contact** reçus de tous les autres équipements par un **circuit externe**;
– I_2: **courant de contact** créé par le **réseau d'alimentation** de l'équipement.

Par hypothèse, chaque circuit de l'équipement connecté à un **circuit externe** doit recevoir un courant d'intensité 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) selon le cas, doivent être respectées:

a) Équipements connectés à un **circuit externe** mis à la terre

Pour les équipements dans lesquels chaque circuit pouvant être connecté à un **circuit externe** est connecté à une borne pour le **conducteur de mise à la terre de protection** de l'équipement, les éléments suivants 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 câble 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 au 5.7.6 et à l'Article F.3.

2) ce type d'équipement doit être conforme au 5.7.6. La valeur de I_2 doit être utilisée pour calculer la limite de 5 % du courant d'entrée par phase spécifiée en 5.7.6.

3) la somme de $S(I_1)$ et I_2 doit satisfaire aux limites ES2 du Tableau 4.

La conformité au 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 l'IEC 60990:2016, à la Figure 5, ou tout autre instrument donnant les mêmes résultats. Une source (source de courant alternatif à couplage capacitif dont la phase et la fréquence de ligne sont identiques au **réseau d'alimentation** en courant alternatif, par exemple) est appliquée à chaque **circuit externe** et ajustée de telle sorte qu'une intensité de 0,25 mA ou que le courant transmis par 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) Équipements connectés à un **circuit externe** non mis à la terre

Si les circuits de l'équipement qui peuvent être connectés à un **circuit externe** n'ont pas de connexion commune, le **courant de contact** de chaque circuit ne doit pas dépasser les limites de ES2 du Tableau 4.

Si tous les circuits de l'équipement qui peuvent être connectés à un **circuit externe** ou à un groupe d'accès ont une connexion commune, le **courant de contact** total provenant de chaque connexion commune ne doit pas dépasser les limites de ES2 du Tableau 4.

La conformité au b) est vérifiée par examen et, s'il existe des points de connexion communs et que la somme de $S(I_1)$ et de I_2 dépasse la limite ES2 du Tableau 4, par l'essai suivant.

Une source de courant alternatif à couplage capacitif dont la phase et la fréquence sont identiques au ***réseau d'alimentation*** en courant alternatif est appliquée à chaque circuit de l'équipement qui peut être connecté à un ***circuit externe*** de telle sorte qu'une intensité de 0,25 mA ou que le courant transmis par un autre équipement d'une valeur connue plus faible, soit disponible pour circuler au sein de ce circuit. Les points de connexion commune sont soumis à l'essai conformément au 5.7.3, que les points soient ***accessibles*** ou non.

5.8 Protection contre le retour de tension en entrée dans les alimentations de secours par batterie

Une alimentation de secours par **batterie** qui fait partie intégrante de l'équipement et qui est capable de générer un retour de tension en entrée doit empêcher une valeur supérieure à ES1 sur les bornes du **réseau d'alimentation** après l'interruption de la puissance du **réseau d'alimentation**.

Il ne doit exister aucun danger au niveau des bornes du **réseau d'alimentation** lorsque le mesurage est effectué 1 s après la mise hors tension du **réseau d'alimentation** pour l'**équipement enfichable de type A**, 5 s pour l'**équipement enfichable de type B** ou 15 s pour les **équipements reliés en permanence**, à l'aide des instruments de mesure décrits en 5.7.2. Si la tension en circuit ouvert mesurée ne dépasse pas les limites de ES1, il n'est pas nécessaire de mesurer le **courant de contact**.

La conformité est vérifiée par examen de l'équipement et du schéma des circuits correspondants, par mesurage et par les ***conditions de premier défaut*** *conformément à l'Article B.4.*

NOTE 1 Pour les normes relatives à l'alimentation de secours par **batterie** ne faisant pas partie intégrante de l'équipement, consulter les normes relatives aux ASI (l'IEC 62040-1, par exemple). Pour les interrupteurs de transfert, voir IEC 62310-1:2005.

NOTE 2 Consulter également les informations explicatives de l'IEC TR 62368-2.

Si un intervalle d'air est utilisé comme **protection contre le retour de tension en entrée**, les exigences du 5.4.2 pour les **distances d'isolement** et du 5.4.3 pour les **lignes de fuite** s'appliquent en plus de celles qui suivent:

– la sortie de l'alimentation de secours par **batterie**, en **mode de fonctionnement en autonomie**, peut être considérée comme un circuit sans transitoire de catégorie de surtension I (à confirmer par le fabricant);
– Les **distances d'isolement** et les **lignes de fuite** doivent satisfaire aux exigences du **degré de pollution** 2, ou à un degré de pollution supérieur si cela est présumé se produire dans l'emplacement d'installation prévu;
– l'**isolation renforcée** doit être appliquée entre l'entrée et la sortie de l'unité si, en **mode de fonctionnement en autonomie**, tous les pôles d'entrée ne sont pas isolés par le **dispositif** de **protection contre le retour de tension en entrée**. Dans tous les autres cas, l'**isolation principale** doit être appliquée.

La conformité est vérifiée par examen.

6 Incendie d'origine électrique

6.1 Généralités

Pour réduire la probabilité de blessures ou de dommages matériels causés par un incendie d'origine électrique dans l'équipement, l'équipement doit être équipé des **protections** spécifiées à l'Article 6.

6.2 Classification des sources de puissance et des sources potentielles d'incendie

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 reposent sur l'énergie disponible pour un circuit.

Dans une source de puissance, une **PIS** peut être créée à la suite 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 en raison 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 exigées, soit pour réduire la probabilité d'inflammation, soit pour réduire la probabilité de propagation du feu en dehors 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 cela est spécifié par le fabricant dans le cas du défaut le plus défavorable dans le 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 de la Figure 34 et de la Figure 35.

6.2.2.2 Mesurage de la puissance pour le cas de défaut le plus défavorable de la charge

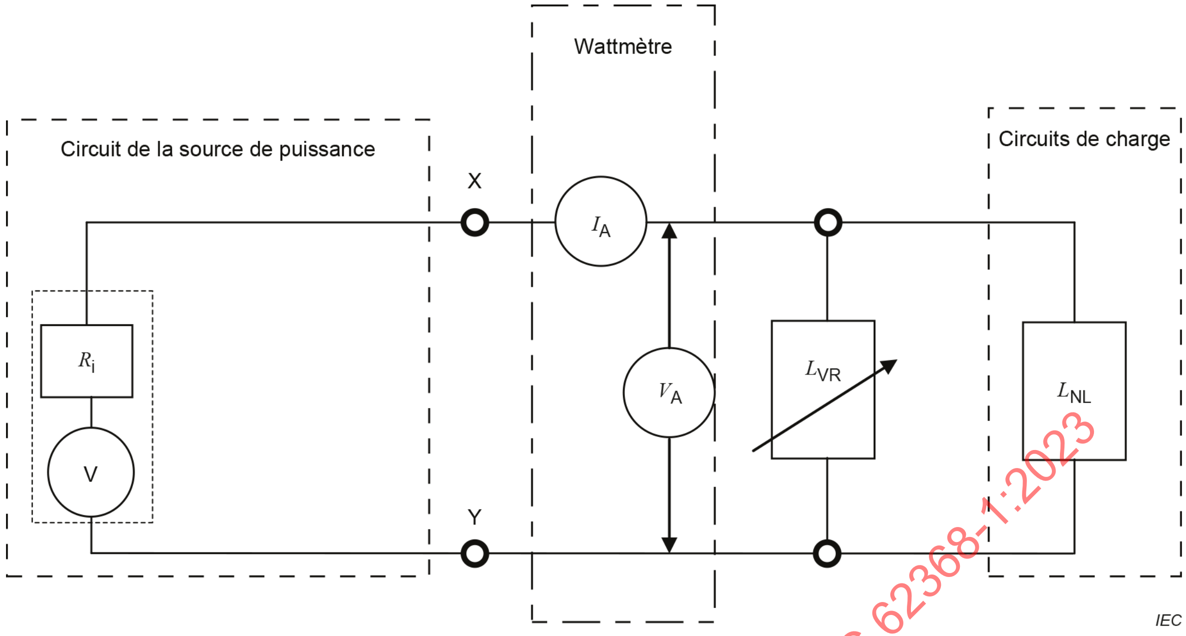
Avec référence à la Figure 34:

– *le mesurage peut être réalisé 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 cela est indiqué;*
– *ajuster la résistance variable, L_{VR}, jusqu'à ce que la source d'alimentation fournisse la puissance maximale en régime établi, et classer la source d'alimentation en conformément au 6.2.2.4, au 6.2.2.5 ou au 6.2.2.6.*

*Si un **dispositif** de protection contre les surintensités fonctionne lors de l'essai, le mesurage doit être répété à 125 % de la valeur assignée du courant du **dispositif** de protection contre les surintensités.*

*Si un **dispositif** ou un circuit de limitation de puissance fonctionne lors de l'essai, le mesurage doit être répété au point situé immédiatement au-dessous du courant auquel fonctionne le **dispositif** ou le circuit de limitation de puissance.*

Lors de l'évaluation des accessoires connectés par les câbles de l'équipement, il convient de prendre en compte l'impédance du câble 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 – Mesurage de la puissance pour le cas de défaut le plus défavorable de la charge

6.2.2.3 Mesurage de la puissance pour 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, V_A et un ampèremètre, I_A);*
- *dans le circuit de la source de puissance, simuler les* ***conditions de premier défaut*** *qui créent la puissance maximale dans le circuit en cours de classification. Tous les composants appropriés dans les circuits de la source de puissance doivent être court-circuités ou déconnectés un par un à chaque mesure;*
- *les équipements qui comportent des* ***amplificateurs audio*** *doivent également être soumis à l'essai dans les* ***conditions anormales de fonctionnement*** *comme cela est spécifié à l'Article E.3.2;*
- *mesurer la puissance maximale comme cela est spécifié et classifier les circuits alimentés par la source de puissance conformément au 6.2.2.4, au 6.2.2.5 ou au 6.2.2.6.*

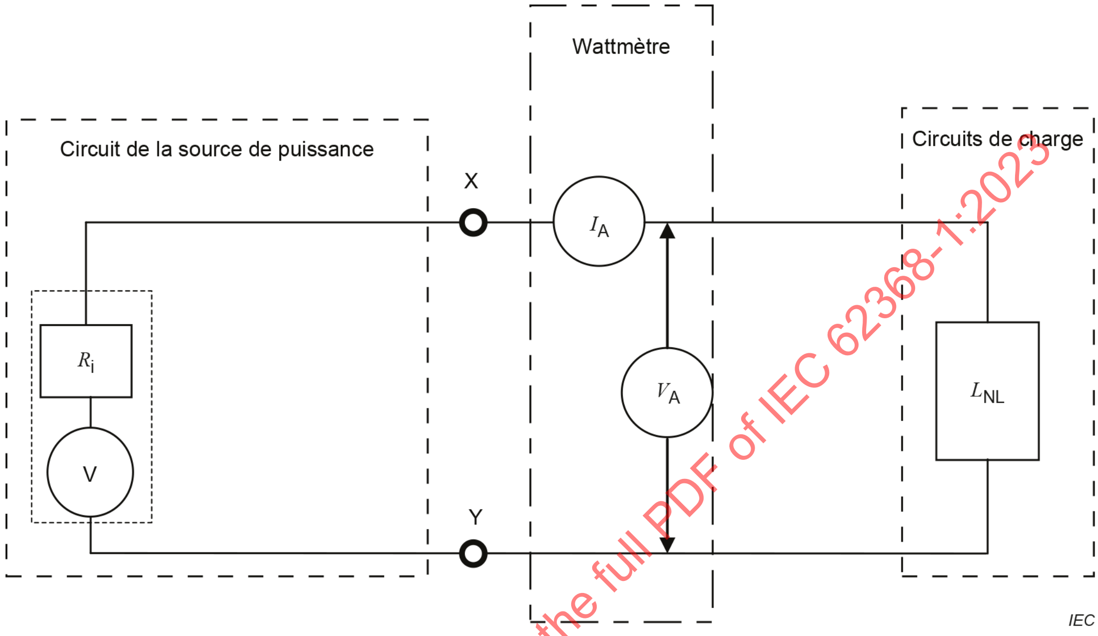
Si un ***dispositif*** *de protection contre les surintensités fonctionne lors de l'essai, le mesurage doit être répété à 125 % de la valeur assignée du courant du* ***dispositif*** *de protection contre les surintensités.*

Si un ***dispositif*** *ou un circuit de limitation de puissance fonctionne lors de l'essai, le mesurage doit être répété au point situé immédiatement au-dessous du courant auquel fonctionne le* ***dispositif*** *ou le circuit de limitation de puissance.*

Lorsque les essais sont répétés, une résistance variable peut être 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 utilisées 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 de puissance est déterminée

L_{NL} charge normale

Figure 35 – Mesurage de la puissance pour 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 Figure 36) mesurée conformément au 6.2.2 ne dépasse pas 15 W mesurée après 3 s.

6.2.2.5 PS2

PS2 est un circuit où la source de puissance (voir Figure 36) mesurée conformément au 6.2.2:

– dépasse les limites de PS1; et
– ne dépasse pas 100 W mesurée après 5 s.

Les circuits qui ont été évalués précédemment et qui sont conformes à l'Annexe Q sont considérés comme n'étant pas supérieurs à PS2. L'ensemble des **protections** et des exigences relatives à PS2 s'appliquent.

NOTE De tels circuits étaient habituellement soumis à l'essai conformément à l'IEC 60950-1.

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 Figure 36).

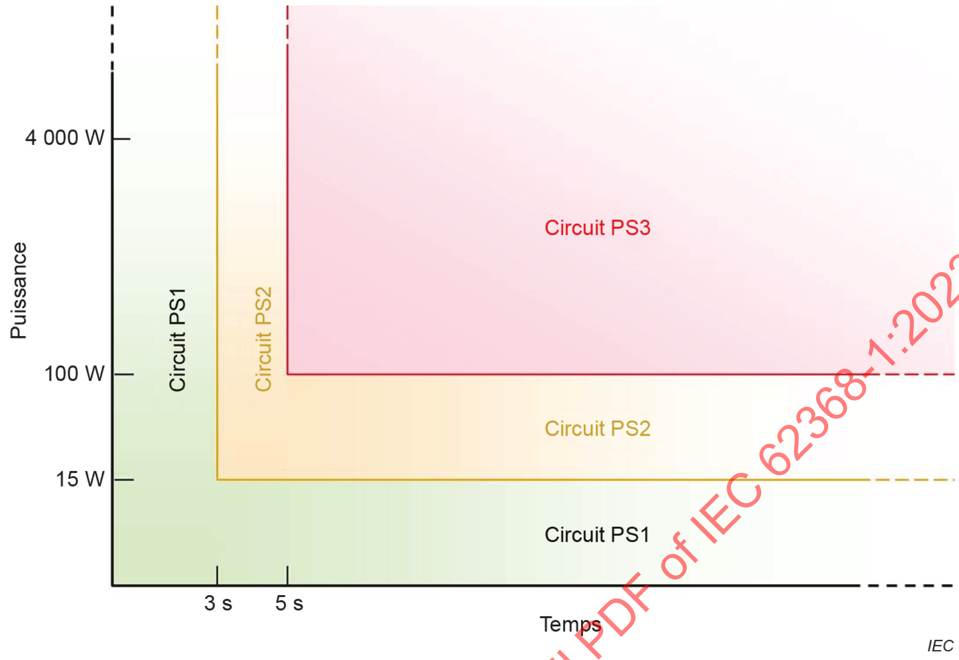


Figure 36 – Représentation de la classification des sources de puissance

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

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}) est supérieur à 15 (soit $V_p \times I_{rms} > 15$) dans chacun des cas suivants:
  - un contact, tel qu'un interrupteur ou un connecteur;
  - une extrémité, telle qu'une extrémité sertie, à ressort ou soudée;
  - l'ouverture d'un conducteur, tel qu'une piste de carte imprimée, causée par une **condition 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 en raison des limites de la source de puissance.

NOTE 1 Un conducteur ouvert dans un circuit électrique comprend les interruptions susceptibles de se produire dans les impressions conductrices de 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 sont composées d'au moins deux connexions en parallèle dans lesquelles, en cas de défaillance de l'une d'elles, les connexions restantes sont toujours en mesure de gérer la pleine puissance.

Les connexions fiables sont les connexions considérées comme non ouvrables.

NOTE 2 Les 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 choisissant des composants dont le coefficient d'expansion thermique est analogue 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.

Cependant, e fabricant peut déclarer un emplacement comme étant une **source potentielle d'incendie causé par la formation d'un arc électrique** sans essai.

6.2.3.2 Source potentielle d'incendie causé par un phénomène résistif

Une **source potentielle d'incendie causé par un phénomène résistif** correspond à une partie d'un circuit PS2 ou PS3 qui, dans les **conditions normales de fonctionnement**, dans les **conditions anormales de fonctionnement** ou dans les **conditions de premier défaut**, dissipe plus de 15 W pendant plus de 30 s.

Concernant la méthode "Maîtrise de la propagation du feu", à l'exception des **batteries d'accumulateurs au lithium**, les composants et les parties parcourues par un courant dans un circuit PS2 sont considérés comme n'étant pas des **sources potentielles d'incendie causé par un phénomène résistif**.

Concernant la méthode "Maîtrise de la propagation du feu", les composants et les parties parcourues par un courant dans un circuit PS3 sont considérés comme des **sources potentielles d'incendie causé par un phénomène résistif**.

Une **source potentielle d'incendie causé par un phénomène résistif** est considérée comme inexistante dans un circuit PS1 en raison des limites de la source de puissance.

Cependant, le fabricant peut déclarer un emplacement comme étant une **source potentielle d'incendie causé par un phénomène résistif** sans essai.

6.3 Protections contre les incendies dans les conditions normales de fonctionnements et les 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 exigées:

– 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, le présent document ne spécifie aucune exigence relative aux poussières ou aux liquides inflammables autres que les **isolants liquides**.

– les **matières combustibles** pour les composants et autres parties (y compris les **enveloppes électriques**, les **enveloppes mécaniques** et les parties décoratives) hors de l'**enveloppe ignifuge** doivent satisfaire:

- au **matériau de classe HB75** si l'épaisseur significative la plus fine de ce matériau est < 3 mm; ou
- au **matériau de classe HB40** si l'épaisseur significative la plus fine de ce matériau est ≥ 3 mm; ou
- au **matériau plastique cellulaire de classe HBF**; ou
- doivent satisfaire à l'essai au fil incandescent à 550 °C selon l'IEC 60695-2-11.

Ces exigences ne s'appliquent à aucun des éléments suivants:

- parties ayant un volume inférieur ou égal à 1 750 mm^3;
- parties d'une masse de **matériau combustible** inférieure à 4 g;
- fournitures, **matériaux consommables**, supports et matériaux d'enregistrement;
- **haut-parleurs** et assemblages de **haut-parleurs**;
- matériau de recouvrement de grille, tissu et mousse réticulée qui sont conformes au S.6;
- parties qui doivent posséder des propriétés particulières pour remplir des fonctions prévues, telles que les rouleaux en caoutchouc synthétique, les tubes d'encre et les matériaux exigeant des caractéristiques optiques;
- 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 éléments analogues.

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 Pour plus d'informations sur l'équilibre thermique, voir B.1.5.

*Les **protections principales** limitant la température qui sont conformes aux exigences applicables du présent document ou de la norme du **dispositif** de sécurité applicable doivent être présentes lors de l'évaluation du circuit.*

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**.

Deux méthodes permettent d'assurer la protection. Toutes deux peuvent être appliquées à différentes parties du même équipement.

– **Réduire la probabilité d'incendie:** L'équipement est conçu de telle sorte que dans les **conditions de premier défaut**, aucune partie ne doit s'être enflammée. Cette méthode peut être utilisée pour un circuit dont la puissance disponible en régime établi ne dépasse pas 4 000 W. Les exigences et essais associés sont décrits en 6.4.2 et en 6.4.3.
  - Pour les **équipements enfichables de type A**, la tension est considérée comme étant inférieure à 4 000 W en régime établi.
  - Pour les **équipements enfichables de type B** et les **équipements reliés en permanence**, la tension est considérée comme étant inférieure à 4 000 W en régime établi si le produit de la tension nominale du **réseau d'alimentation** et de la **caractéristique assignée du courant** du **dispositif** de protection contre les surintensités de l'installation ($V_{\text{réseau d'alimentation}} \times I_{max}$) ne dépasse pas 4 000 W.

– **Maîtriser la propagation du feu:** Choix et application des **protections supplémentaires** pour les composants, le câblage, les matériaux et les mesures de construction qui réduisent la propagation du feu et, si nécessaire, par l'emploi d'une deuxième **protection supplémentaire** comme une **enveloppe ignifuge**. Cette méthode peut être utilisée pour tout type d'équipement. Les exigences adaptées sont détaillées en 6.4.4, 6.4.5 et 6.4.6.

6.4.2 Réduction de la probabilité d'inflammation en conditions de premier défaut dans les circuits PS1

Aucune **protection supplémentaire** n'est exigée pour la protection contre PS1. Un PS1 est considéré comme n'étant pas capable de fournir suffisamment 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 Exigences

La probabilité d'inflammation dans les **conditions de premier défaut** dans les circuits PS2 et PS3 lorsque la puissance disponible ne dépasse pas 4 000 W (voir 6.4.1) doit être réduite à l'aide des **protections supplémentaires** suivantes, selon le cas:

NOTE Pour les circuits PS3, lorsque la puissance disponible dépasse 4 000 W, voir 6.4.6.

– une **source potentielle d'incendie causé par la formation d'un arc électrique** ou une **source potentielle d'incendie causé par un phénomène résistif** doit être séparée, comme cela est spécifié en 6.4.7;

– une **source potentielle d'incendie causé par la formation d'un arc électrique** ou une **source potentielle d'incendie causé par un phénomène résistif** doit être séparée du **matériau combustible** qui est placé sur la surface extérieure **accessible** de l'équipement. S'il existe des ouvertures dans le volume restreint (voir Figure 37), aucune inflammation ne doit se déclarer dans les **conditions de premier défaut**;

– les **dispositifs** de protection faisant office de **protection** doivent satisfaire aux G.3.1 à G.3.4 ou aux normes de composants IEC applicables;

– les moteurs et transformateurs doivent satisfaire au G.5.3, au G.5.4 ou aux normes de composants IEC applicables;

– les varistances doivent satisfaire au G.8.2; et
– les composants associés au **réseau d'alimentation** doivent satisfaire aux normes de composants IEC applicables et aux exigences d'autres parties du présent document.

De plus, les essais de 6.4.3.2 s'appliquent.

EXEMPLES Les composants associés au **réseau d'alimentation** incluent les câbles d'alimentation, les connecteurs, les composants de filtrage CEM, les interrupteurs, etc.

6.4.3.2 Méthode d'essai

Les conditions de l'Article B.4 susceptibles de causer une inflammation sont successivement appliquées. 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 surveillées 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****, ce conducteur ouvert 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 l'obtention d'un régime établi, la température est mesurée immédiatement après l'interruption.*

NOTE 1 Pour plus d'informations sur l'équilibre thermique, voir B.1.5.

NOTE 2 Un échauffement peut être observé après l'interruption du courant, en raison de l'inertie thermique.

Si la température est limitée par un fusible dans une ***condition de premier défaut****:*

– *un fusible conforme à la série IEC 60127 doit s'ouvrir dans un délai de 1 s; ou*
– *un fusible non conforme à la série IEC 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 caractéristique assignée du courant du fusible, les températures sont mesurées après l'obtention d'un régime établi.

Si le courant atteint immédiatement 2,1 fois la caractéristique 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 étudié, le fusible et le court-circuit sont retirés après un temps supplémentaire correspondant au temps maximal de préarc du fusible étudié, et les températures sont mesurées immédiatement après.

Si la résistance du fusible influence la valeur du courant dans le circuit correspondant, la valeur maximale de la résistance du fusible doit être prise en compte lors de la détermination de la valeur du courant.

Les conducteurs des cartes imprimées sont soumis à l'essai en appliquant les ***conditions de premier défaut*** *correspondantes du B.4.4.*

6.4.3.3 Critères de conformité

La conformité est vérifiée par examen, essais et mesures. Voir B.4.8 pour les critères de conformité.

6.4.4 Maîtrise de la propagation du feu dans les circuits PS1

Aucune **protection supplémentaire** n'est exigée pour la protection contre PS1. Par hypothèse, un PS1 ne peut pas fournir suffisamment d'énergie pour que les matériaux atteignent les températures d'inflammation.

6.4.5 Maîtrise de la propagation du feu dans les circuits PS2

6.4.5.1 Généralités

Le présent 6.4.5 définit les méthodes de **protection** qui peuvent être utilisées pour contrôler la propagation du feu.

6.4.5.2 Exigences

La propagation du feu dans les circuits PS2 doit être contrôlée en appliquant les **protections supplémentaires** suivantes.

Les conducteurs, **dispositifs**, composants, parties et matériaux doivent respecter les exigences suivantes:

– les cartes imprimées doivent être constituées de **matériaux de classe V-1** ou de **matériaux de classe VTM-1**; et
– l'isolation et le gainage des fils doivent être conformes au 6.5.1; et
– les moteurs doivent satisfaire au G.5.4; et
– les transformateurs doivent satisfaire au G.5.3; et
– les fournitures, matériaux consommables, supports et matériaux d'enregistrement, ainsi que les parties qui doivent posséder des propriétés particulières pour remplir leurs fonctions prévues, comme les rouleaux en caoutchouc synthétique, les tubes d'encre et les matériaux exigeant des caractéristiques optiques doivent respecter l'une des exigences suivantes:
  - être constitués d'un **matériau de classe HB**; ou
  - ne doivent pas s'enflammer dans les **conditions de premier défaut** dans un circuit PS2; ou
  - se situer à une distance minimale de 13 mm d'un circuit PS2.

NOTE Un circuit PS2 peut être constitué de composants, de pistes de circuits imprimés, de fils ou éléments analogues.

Tous les autres composants d'un circuit PS2, excepté pour les **haut-parleurs** et assemblages de **haut-parleurs**, doivent satisfaire à l'une des conditions suivantes:

– être montés sur des **matériaux de classe V-1** ou des **matériaux de classe VTM-1**;
– être constitués d'un **matériau de classe V-2**, d'un **matériau de classe VTM-2** ou d'un **matériau plastique cellulaire de classe HF-2**;
– satisfaire aux exigences de l'Article S.1;
– avoir un volume inférieur ou égal à 1 750 mm^3;
– avoir une masse de **matériau combustible** inférieure à 4 g;
– satisfaire aux exigences d'inflammabilité de la norme de composant IEC applicable;
– être dans une **enveloppe** étanche de 0,06 m^3 ou moins, composée entièrement de **matériaux non combustibles** et sans ouvertures de ventilation.

6.4.5.3 Critères de conformité

La conformité est vérifiée par des essais ou par examen des fiches techniques de l'équipement et des matériaux.

6.4.6 Maîtrise de la propagation du feu dans les circuits 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 du 6.4.5;

– les **dispositifs** sensibles à la formation d'arcs ou à une variation de la résistance de contact (connecteurs enfichables, par exemple) doivent être conformes à l'une des exigences suivantes:

  • être constitués d'un **matériau de classe V-1**;

  • satisfaire aux exigences d'inflammabilité de la norme de composant IEC applicable;

  • satisfaire aux exigences de l'Article S.1;

  • être montés sur des **matériaux de classe V-1** ou des **matériaux de classe VTM-1** et présenter un volume ne dépassant pas 1 750 mm^3 ou une masse de **matières combustibles** inférieure à 4 g;

– en fournissant une **enveloppe ignifuge** conforme au 6.4.8;

– les varistances situées à moins de 13 mm d'une **enveloppe** et constituées d'un **matériau combustible** doivent satisfaire au G.8.2.

A l'intérieur des **enveloppes ignifuges**, les **matériaux combustibles** qui ne satisfont pas aux exigences d'inflammabilité pour les circuits PS2 et PS3 doivent être conformes à l'essai d'inflammabilité de l'Article S.1 ou doivent être composés de **matériaux de classe V2**, de **matériaux de classe VTM-2** ou de **matériaux plastiques cellulaires de classe HF-2**. Ces exigences ne s'appliquent à aucun des éléments suivants:

– parties ayant un volume inférieur ou égal à 1 750 mm^3;

– parties d'une masse de **matériau combustible** inférieure à 4 g;

– fournitures, **matériaux consommables**, supports et matériaux d'enregistrement;

– parties qui doivent posséder des propriétés particulières pour remplir des fonctions prévues, telles que les rouleaux en caoutchouc synthétique, les tubes d'encre et les matériaux exigeant des caractéristiques optiques;

– 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 éléments analogues;

– tubes pour systèmes pour air ou pour fluide, conteneurs pour poudres ou liquides et parties en 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 en **matériau plastique cellulaire de classe HBF**, ou qu'ils aient satisfait à l'essai au fil incandescent à 550 °C conformément à l'IEC 60695-2-11.

Une **enveloppe ignifuge** n'est nécessaire pour aucun des composants et matériaux suivants:

– l'isolation et le gainage des fils conformes au 6.5.1;

– les composants, y compris les connecteurs, conformes aux exigences de 6.4.8.2.1 qui remplissent une ouverture dans une **enveloppe ignifuge**;

– les fiches et connecteurs qui font partie intégrante d'un câble d'alimentation ou d'un câble d'interconnexion, conformes au 6.5, à l'Article G.4 et à l'Article G.7;

– les **haut-parleurs** et les assemblages de **haut-parleurs**;

– les moteurs conformes au G.5.4;

– les transformateurs conformes au G.5.3.

La conformité est vérifiée par examen des fiches techniques des matériaux et/ou par un essai.

6.4.7 Séparation des matériaux combustibles d'une PIS

6.4.7.1 Généralités

Lorsque cela est exigé, 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 respectées soit par une séparation par la distance (voir 6.4.7.2), soit par une séparation à l'aide d'une barrière contre le feu (voir 6.4.7.3).

Des exigences supplémentaires sont spécifiées en 6.4.8.4 pour les **enveloppes ignifuges** ou les barrières contre le feu en **matériau combustible** situées à moins de 13 mm d'une **source potentielle d'incendie causé par la formation d'un arc électrique** ou de 5 mm d'une **source potentielle d'incendie causé par un phénomène résistif**.

Ces exigences ne s'appliquent pas aux **haut-parleurs** et assemblages de **haut-parleurs**.

6.4.7.2 Séparation par la distance

Les **matériaux combustibles**, à l'exception des matériaux sur lesquels se situe la **source potentielle d'incendie**, doivent être séparés d'une **source potentielle d'incendie causé par la formation d'un arc électrique** ou une d'une **source potentielle d'incendie causé par un phénomène résistif** conformément à la Figure 37 et à la Figure 38.

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 plastiques cellulaires de classe HF-1**.

Dimensions en millimètres

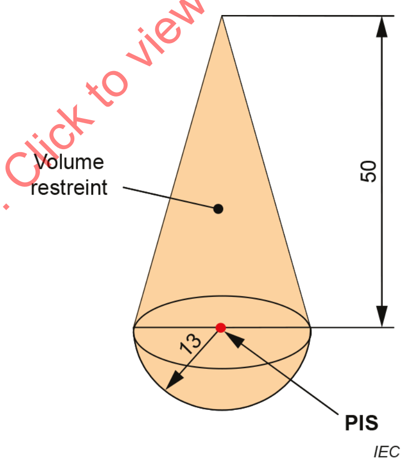
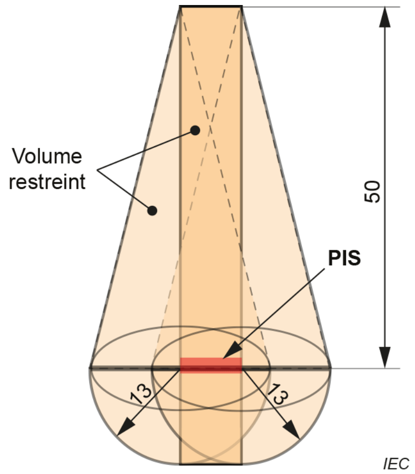


Figure 37 – Exigences minimales de séparation d'une source potentielle d'incendie (PIS)

Dimensions en millimètres



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 mesurages sont réalisés 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 facilement la partie dissipant de l'énergie, alors la surface extérieure du composant est utilisée.

Figure 38 – Exigences étendues de séparation d'une source potentielle d'incendie (PIS)

Si la distance entre une **source potentielle d'incendie** et des **matériaux combustibles** est inférieure à la distance spécifiée à la Figure 37 et à la Figure 38 suivant les cas, les **matériaux combustibles** doivent:

– avoir un volume inférieur ou égal à 1 750 mm^3; ou
– avoir une masse de **matériau combustible** inférieure à 4 g; ou
– satisfaire:
  • aux exigences d'inflammabilité de la norme de composant IEC applicable; ou
  • être constitués de **matériaux de classe V-1**, de **matériaux de classe VTM-1** ou de **matériaux plastiques cellulaires de classe HF-1** ou être conformes à l'IEC 60695-11-5. Les durées d'application de la flamme sont identifiées à 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 en 6.4.8.2.1 (voir Figure 39).

Les cartes imprimées ne sont pas considérées comme des barrières 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 des barrières contre le feu pour une **source potentielle d'incendie causé par un phénomène résistif** sous réserve 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 constituée d'un **matériau de classe V-1**, d'un **matériau de classe VTM-1** ou d'un **matériau plastique cellulaire de classe HF-1**;

– dans un volume restreint, les composants doivent satisfaire aux exigences d'inflammabilité de la norme de composant applicable et aucun autre matériau de classe assignée inférieure à la **classe V-1** ne doit être monté sur la même face de la carte imprimée que la **source potentielle d'incendie causé par un phénomène résistif**; et

– dans le volume restreint, la carte imprimée ne doit pas comporter de conducteurs PS2 ou PS3 (à l'exception des conducteurs qui alimentent le circuit étudié). Cela s'applique aussi bien à chacune des faces de la carte imprimée qu'à ses couches internes.

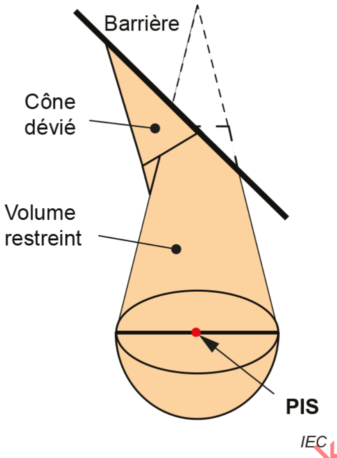


Figure 39a – Représentation d'une barrière oblique

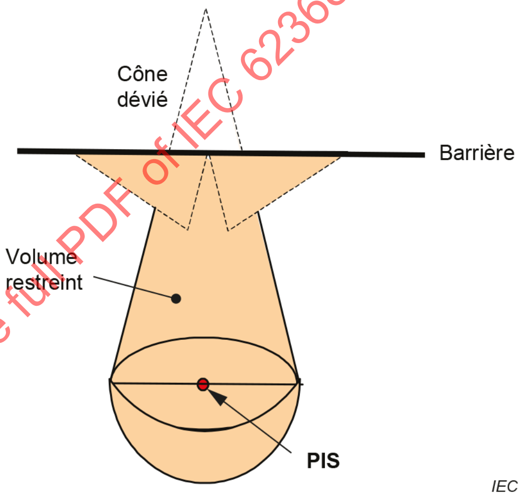


Figure 39b – Représentation d'une barrière horizontale

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, excepté ce qui est indiqué en 6.4.8.4, la distance entre la barrière et la **source potentielle d'incendie** n'est pas importante.

Figure 39 – 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 et/ou par mesurage.

6.4.8 Enveloppes ignifuges et barrières contre le feu

6.4.8.1 Généralités

La fonction de **protection** de l'**enveloppe ignifuge** et de la barrière contre le feu consiste à freiner la propagation du feu à travers l'**enveloppe** ou la barrière.

L'**enveloppe ignifuge** peut être une **enveloppe** générale ou peut être à l'intérieur de l'**enveloppe** générale. L'**enveloppe ignifuge** peut ne pas intégrer de fonction exclusive, mais peut fournir d'autres fonctions en plus de celles d'une **enveloppe ignifuge**.

6.4.8.2 Propriétés du matériau des enveloppes ignifuges et des barrières contre le feu

6.4.8.2.1 Exigences pour les barrières contre le feu

Une barrière contre le feu doit être conforme aux exigences de l'Article S.1, sauf si le matériau est:

– constitué d'un **matériau non combustible** (par exemple, métal, verre, céramique, etc.); ou
– constitué d'un **matériau de classe V-1** ou d'un **matériau de classe VTM-1**.

6.4.8.2.2 Exigences pour une enveloppe ignifuge

Pour les circuits dont la puissance disponible ne dépasse pas 4 000 W (voir 6.4.1), l'**enveloppe ignifuge** doit:

– satisfaire aux exigences de l'Article S.1; ou
– être constituée d'un **matériau non combustible** (par exemple, métal, verre, céramique, etc.); ou
– être constituée d'un **matériau de classe V-1**.

Pour les circuits dont la puissance disponible dépasse 4 000 W, une **enveloppe ignifuge** doit:

– satisfaire aux exigences de l'Article S.5; ou
– être constituée d'un **matériau non combustible** (par exemple, métal, verre, céramique, etc.); ou
– être constituée d'un **matériau de classe 5VA** ou d'un **matériau de classe 5VB**.

Les matériaux des composants qui remplissent une ouverture dans une **enveloppe ignifuge** ou à monter dans une telle ouverture doivent:

– satisfaire aux exigences d'inflammabilité de la norme de composant IEC applicable; 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 appropriées ou par un 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 et une barrière contre le feu

6.4.8.3.1 Ouvertures dans les enveloppes ignifuges et les barrières contre le feu

Les dimensions des ouvertures dans une **enveloppe ignifuge** 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 présentés à la Figure 41 et à la Figure 42.

Quelle que soit l'orientation de l'équipement, l'orientation de la flamme de la **source potentielle d'incendie** est toujours verticale. Si l'équipement a au moins deux orientations dans les **conditions normales de fonctionnement**, les propriétés d'ouverture s'appliquent pour chaque orientation possible.

Les ouvertures sur le dessus, latérales et dans le fond doivent être déterminées selon la Figure 40, en tenant compte de toutes les orientations d'utilisation possible (voir également 4.1.6).

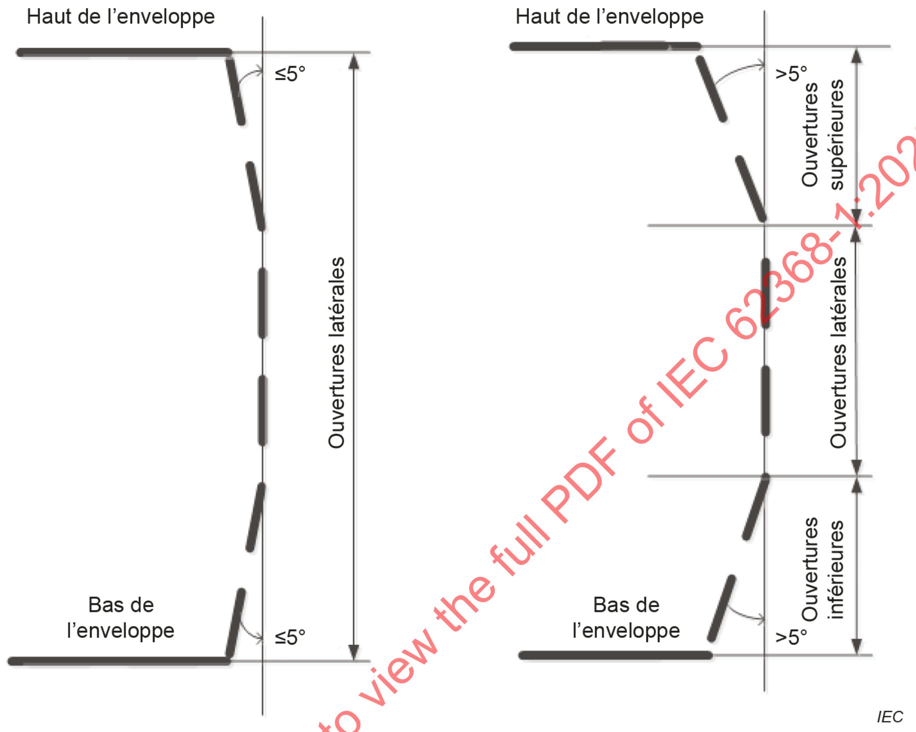


Figure 40 – Détermination des ouvertures sur le dessus, dans le fond et latérales

6.4.8.3.2 Dimensions d'une barrière contre le feu

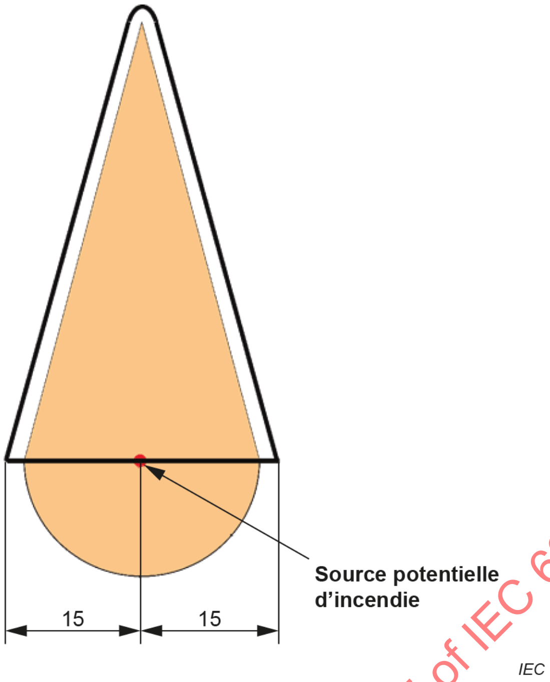
Les bords des barrières contre le feu doivent dépasser le volume restreint (voir Figure 39).

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** doivent s'appliquer aux ouvertures sur une surface horizontale ou sur toute surface qui présente une inclinaison de plus de 5° par rapport à la verticale (voir Figure 40) au-dessus d'une **source potentielle d'incendie** située dans un circuit PS3, comme cela est représenté à la Figure 41. Les propriétés des ouvertures sur le dessus d'une barrière contre le feu doivent s'appliquer aux ouvertures au-dessus d'une **source potentielle d'incendie** située dans un circuit PS3, comme cela est représenté à la Figure 41.

Les ouvertures qui aboutissent dans le volume du cône de feu avec un espace de 2 mm en plus comme cela est représenté à la Figure 41 doivent être conformes à l'Article S.2.

Dimensions en millimètres



NOTE Les dimensions du cône de feu sont identiques à celles de la Figure 37 et de la Figure 38.

Figure 41 – Ouvertures sur le dessus

Aucun essai n'est exigé à condition que les ouvertures ne dépassent pas:

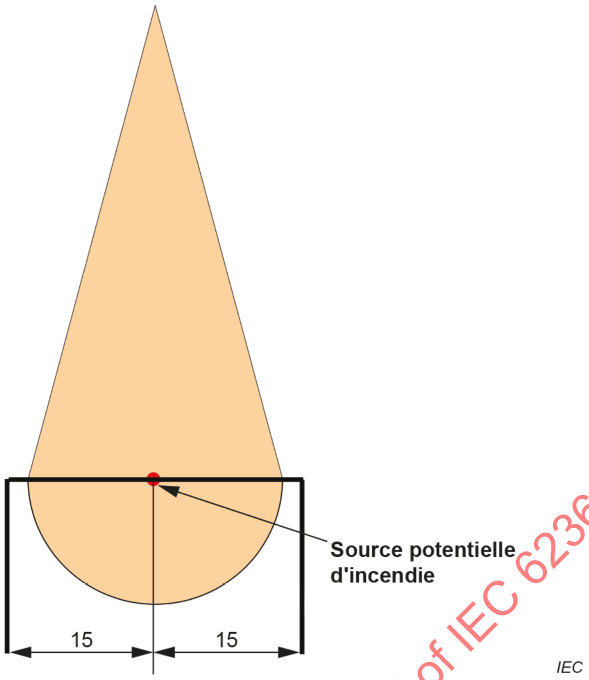
– *5 mm dans toutes les dimensions; ou*
– *1 mm de largeur, quelle que soit la longueur.*

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** et d'une barrière contre le feu doivent s'appliquer aux ouvertures sur une surface horizontale ou sur toute surface qui présente une inclinaison de plus de 5° par rapport à la verticale (voir Figure 40) au-dessous d'une **source potentielle d'incendie** située dans un circuit PS3, comme cela est représenté à la Figure 42. Les ouvertures sur les autres surfaces sous une **source potentielle d'incendie** située dans un circuit PS3 doivent être considérées comme des sources latérales, et le 6.4.8.3.5 s'applique.

Les ouvertures dans le fond sont les ouvertures situées au-dessous d'une **source potentielle d'incendie** située dans un circuit PS3 et comprises dans un cylindre de 30 mm de diamètre qui s'étend indéfiniment au-dessous de la **source potentielle d'incendie**. Concernant la **source potentielle d'incendie**, les ouvertures dans le fond correspondent à toute ouverture dans le volume du cône de feu avec un espace de 2 mm en plus.

Dimensions en millimètres



NOTE Les dimensions du cône de feu 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, sous réserve 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) au-dessous des composants et parties conformes aux exigences relatives aux **matériaux de classe V-1** ou aux **matériaux plastiques cellulaires de classe HF-1** ou au-dessous des composants conformes à l'essai au brûleur-aiguille de l'IEC 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) la construction avec plaque-écran est conforme, comme cela est représenté à la Figure 43.

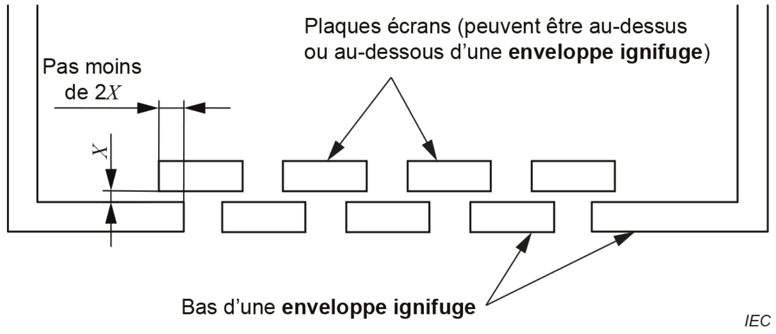


Figure 43 – Construction avec plaque-écran

Concernant les **équipements professionnels** prévus pour être utilisés dans des environnements dans lesquels il est peu probable que des **matériaux combustibles** se trouvent à proximité du produit (centres de traitement des données et salles de serveurs, par exemple), les surfaces du fond étendues sont considérés comme une **enveloppe ignifuge** adaptée, comme cela est représenté à la Figure 44, si ces surfaces sont conformes au 6.4.8.3.4.

Dimensions en millimètres

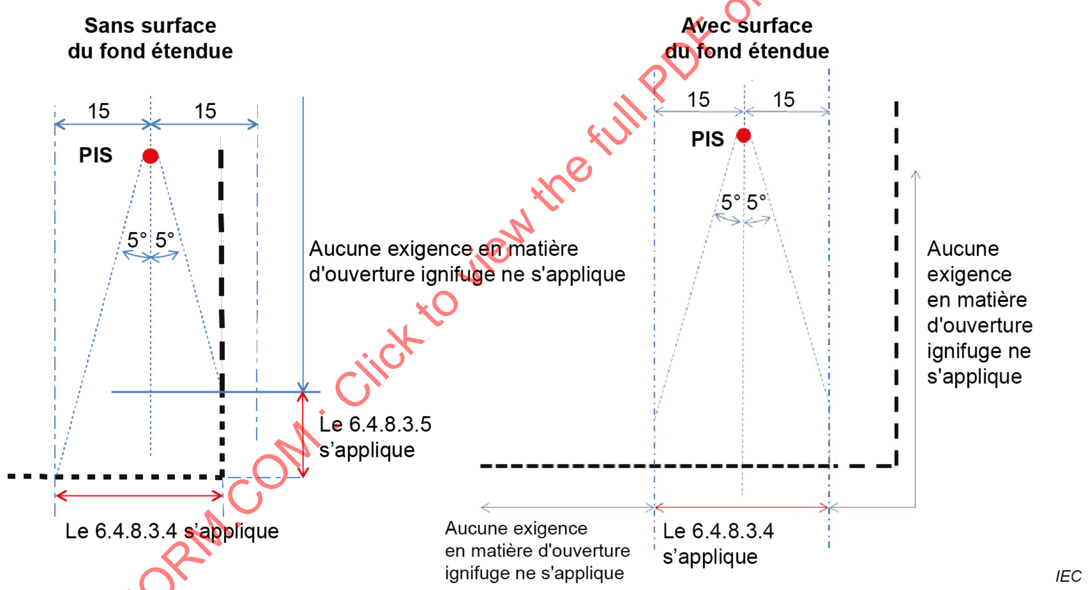


Figure 44 – Application des exigences relatives aux ouvertures dans le fond

Les **équipements fixes** destinés à être posés au sol sur une surface non combustible n'exigent pas d'**enveloppe ignifuge** au fond. Ces équipements doivent être marqués conformément à l'Article F.5, sauf que l'élément 3 est facultatif.

La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: non disponible
– élément 2: "RISQUE D'INCENDIE" ou texte équivalent
– élément 3: facultatif
– élément 4: "Installer seulement sur du béton ou tout autre sol en matériau non combustible" ou texte équivalent

6.4.8.3.5 Ouvertures latérales et propriétés des ouvertures latérales

Les propriétés des ouvertures latérales d'une **enveloppe ignifuge** et d'une barrière contre le feu doivent s'appliquer aux ouvertures situées sur une surface latérale verticale (±5°).

Si une partie latérale d'une **enveloppe ignifuge** se trouve dans les limites de la zone formée par l'angle de 5° (Figure 46), les limitations de 6.4.8.3.4 sur les dimensions des ouvertures dans le fond des **enveloppes ignifuges** s'appliquent également sur cette partie latérale.

Les ouvertures latérales conformes aux dimensions maximales représentées à la Figure 45 sont considérées comme respectant les exigences du présent paragraphe sans étude supplémentaire.

NOTE Dans ce cas, l'épaisseur de l'ouverture latérale de l'**enveloppe** fait office de fond d'**enveloppe** et est suffisante pour empêcher que des débris d'incendie (métal fondu ou matériau brûlant) ne s'échappent.

Épaisseur des matériaux à étudier pour l'application de la règle des 5°

- y = dimension verticale maximale de l'ouverture latérale
- t = épaisseur du matériau de l'enveloppe latérale
- d = dimension maximale de l'ouverture dans le fond selon le 6.4.8.3.4

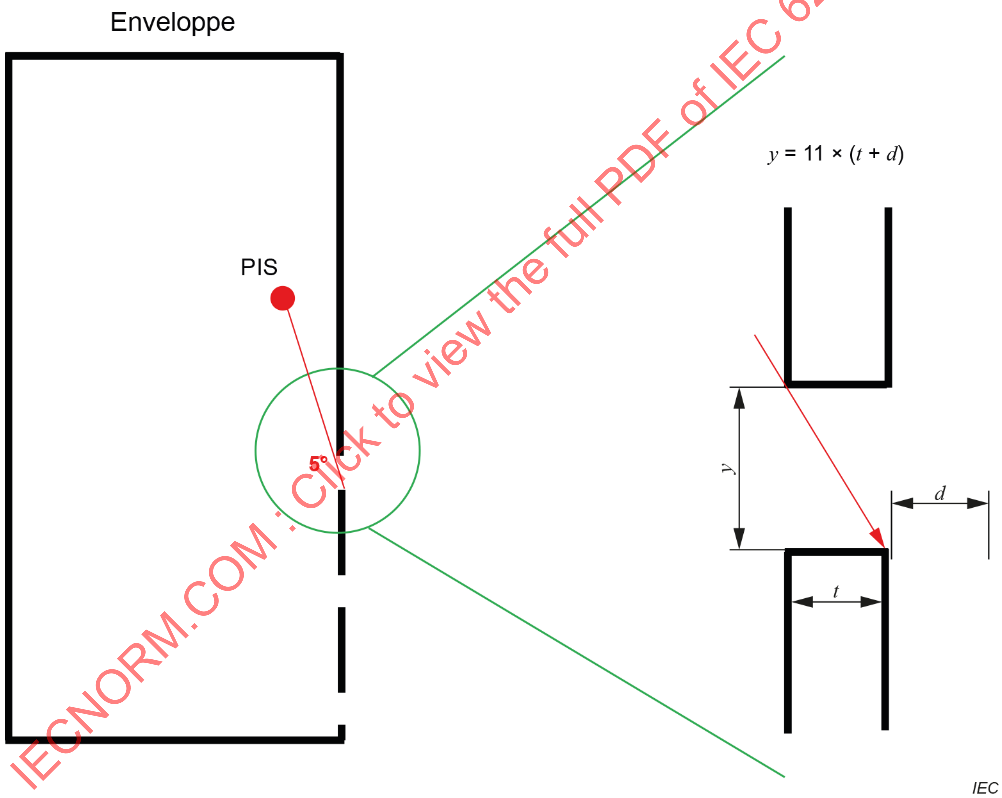
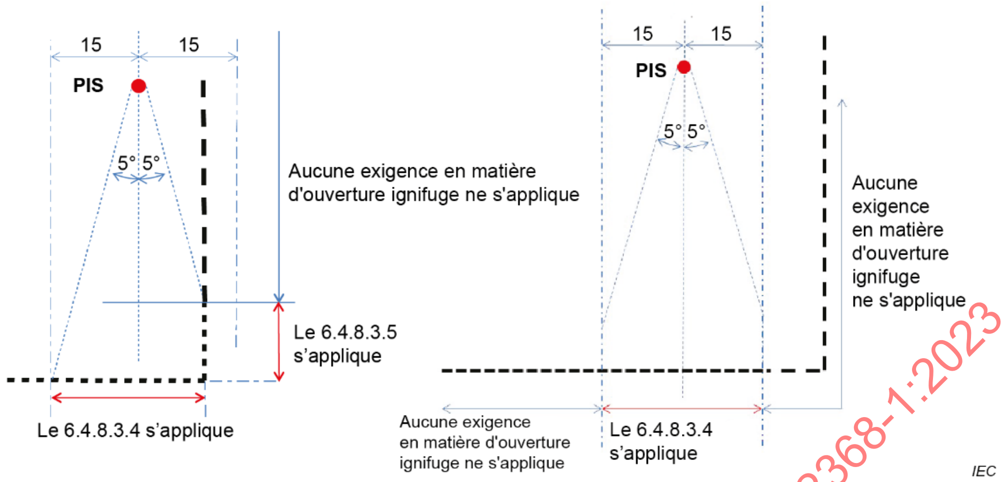


Figure 45 – Application des propriétés des ouvertures dans le fond par rapport à l'épaisseur du matériau de l'enveloppe latérale

La conformité est vérifiée par examen et par mesurage. Sauf si cette partie latérale d'une ***enveloppe ignifuge*** *est soumise aux exigences du 6.4.8.3.5 (voir alinéas ci-dessus), ces ouvertures latérales ne sont pas prises en compte davantage.*

NOTE Les limitations en matière de taille des ouvertures latérales sont décrites dans d'autres articles du présent document.

Dimensions en millimètres



La **source potentielle d'incendie** peut être soit un point, un composant ou une piste sur une carte imprimée.

Figure 46 – Trajectoire vers le bas de la source potentielle d'incendie

6.4.8.3.6 Intégrité d'une enveloppe ignifuge

Si une partie d'une **enveloppe ignifuge** se compose d'une porte ou d'un couvercle qui peut être ouvert par une **personne ordinaire**, la porte ou le couvercle doit satisfaire aux exigences a), b) ou c):

a) la porte ou le couvercle doit être verrouillé et satisfaire aux exigences relatives au **verrouillage de sécurité** de l'Annexe K;

b) une porte ou un couvercle, destiné à être régulièrement ouvert par une **personne ordinaire**, doit satisfaire aux deux conditions suivantes:

   – il ne doit pas être séparable des autres parties de l'**enveloppe ignifuge** par la **personne ordinaire**; et

   – il doit être équipé d'un moyen pour le garder 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, peuvent être amovibles à condition que des instructions de dépose et de réinstallation correctes soient fournies dans conformément à l'Article F.4.

6.4.8.3.7 Critères de conformité

La conformité est vérifiée par examen des fiches techniques appropriées et, le cas échéant, par un essai.

6.4.8.4 Distances de séparation entre une source potentielle d'incendie et une enveloppe ignifuge ou une barrière contre le feu

Une **enveloppe ignifuge** 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**.

Des distances inférieures sont admises sous réserve que la partie de l'**enveloppe ignifuge** ou de la barrière contre le feu située à la distance de séparation exigée respecte l'une des exigences suivantes:

– l'**enveloppe ignifuge** ou la barrière contre le feu satisfait à l'essai au brûleur aiguille selon l'IEC 60695-11-5. Les conditions sont identifiées à l'Article S.2. Après l'essai, le matériau de l'**enveloppe ignifuge** ou de la barrière contre le feu ne doit présenter aucun trou dont la dimension est supérieure à celle admise en 6.4.8.3.3 ou en 6.4.8.3.4 selon le cas; ou

– l'**enveloppe ignifuge** est composée d'un **matériau de classe V-0**; ou

– la barrière contre le feu est composée d'un **matériau de classe V-0** ou d'un **matériau de classe VTM-0**.

6.4.9 Inflammabilité d'un isolant liquide

Un **isolant liquide**:

– doit présenter une température d'autoinflammation supérieure ou égale à 300 °C conformément à l'ISO 871 ou une à norme nationale analogue (ASTM E659-84, par exemple); et

– ne doit pas s'amorcer ou doit présenter un point d'éclair supérieur à 135 °C conformément à l'ISO 2719 déterminé selon la méthode en vase clos de Pensky-Martens (ou une norme nationale comme l'ASTM D93, par exemple), ou par la méthode en vase clos à petite échelle conformément à l'ISO 3679 (ou des normes nationales comme l'ASTM D3828 et l'ASTM D3278).

La température des composants en contact avec l'**isolant liquide** ne doit pas dépasser le point d'éclair de l'**isolant liquide**.

La conformité est vérifiée par consultation des données disponibles ou par examen et par des essais, selon le cas.

6.5 Câblage interne et externe

6.5.1 Exigences générales

Dans les circuits PS2 ou PS3, l'isolation sur les câblages internes ou externes doit satisfaire aux méthodes d'essai décrites ci-dessous ou méthodes équivalentes.

Pour les conducteurs dont la section est supérieure ou égale à 0,5 mm^2, les méthodes d'essai de l'IEC 60332-1-2 et de l'IEC 60332-1-3 doivent être appliquées.

Pour les conducteurs dont la section est inférieure à 0,5 mm^2, les méthodes d'essai de l'IEC 60332-2-2 doivent être appliquées.

Concernant les câblages internes et externes, la méthode d'essai décrite dans l'IEC TS 60695-11-21 peut se substituer aux méthodes d'essai décrites dans l'IEC 60332-1-2, l'IEC 60332-1-3 ou l'IEC 60332-2-2.

NOTE Les fils conformes à l'UL 2556 VW-1 sont considérés comme étant conformes à ces exigences.

Le conducteur ou le câble isolé doit être acceptable s'il satisfait aux exigences de performance recommandées des normes applicables de la série IEC 60332 ou aux exigences de l'IEC TS 60695-11-21.

6.5.2 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 normales de fonctionnement** ou 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 indépendamment de l'installation de l'équipement.

Les circuits PS2 ou PS3 qui alimentent des **circuits externes** doivent limiter leur puissance en sortie à des valeurs qui réduisent la possibilité d'incendie dans le câblage du bâtiment dans les **conditions normales de fonctionnement** et les conditions de défaut externes.

Des **circuits externes** comme ceux qui sont décrits dans le Tableau 13, ID 1a, 1b, 1c et 2 doivent présenter un courant limité à 1,3 A en valeur efficace ou en courant continu lorsqu'ils sont destinés à fournir de la puissance par le biais d'un câble conducteur à paires ayant un diamètre de fil minimal de 0,4 mm.

EXEMPLE Les caractéristiques temps-courant des fusibles de types gD et gN spécifiés dans l'IEC 60269-2 respectent la limite ci-dessus. Les fusibles de type gD ou gN assignés à 1 A satisfont à la limite de courant de 1,3 A.

La conformité est vérifiée par essai, par examen et selon les exigences de l'Annexe Q.

6.5.3 Câblage interne des socles de prises de courant

La section nominale du câblage interne des socles de prises de courant ou des socles femelles de connecteurs qui alimentent les autres équipements avec la puissance du **réseau d'alimentation** doit être au moins celle spécifiée dans le Tableau G.7, y compris la condition de la note de bas de tableau [a].

La conformité est vérifiée par examen.

6.6 Protections contre les incendies dus à la connexion des équipements supplémentaires

La puissance délivrée par les accès de communication aux équipements ou accessoires connectés doit être limitée à PS2, sauf s'ils sont également susceptibles d'être conformes au 6.3, au 6.4 et au 6.5.

Cette exigence ne s'applique pas à la sortie audio des **amplificateurs audio**.

La conformité est vérifiée par examen ou par mesurage.

7 Blessures dues à des substances dangereuses

7.1 Généralités

Pour réduire la probabilité de blessures causées par une exposition à des **substances dangereuses**, l'équipement doit être équipé des **protections** spécifiées à l'Article 7.

NOTE 1 Ces **protections** ne sont pas destinées à être les seuls moyens pour réduire la probabilité de telles blessures.

NOTE 2 La classification des autres **substances dangereuses** possibles ne figurant pas à l'Article 7 n'est pas couverte par le présent document. Dans de nombreuses régions, différentes législations s'appliquent telles que les directives RoHS (Restriction of Hazardous Substances Directive) et REACH (Registration, Evaluation, Autorisation and Restriction of Chemicals).

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 que les substances chimiques ont sur le matériau du conteneur; et*

– *les essais appropriés éventuels de l'Annexe T selon 4.4.3, 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 La limite d'exposition à long terme type pour l'ozone est par hypothèse de 0,1 × 10−6 (0,2 mg/m^3), calculée comme une concentration moyenne pondérée dans le temps sur 8 h. La moyenne pondérée dans le temps est le niveau moyen d'exposition sur une période 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**, comme le confinement d'une substance chimique, ne s'appliquent pas d'un point de vue pratique, une **protection individuelle** doit être spécifiée dans les instructions fournies avec l'équipement.

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, les **protections par instructions** spécifiées dans l'ISO 7010 et des instructions doivent être apposées sur l'équipement conformément à l'Article F.5.

La conformité est vérifiée par examen des instructions ou des documents d'accompagnement.

8 Blessures dues à un choc mécanique

8.1 Généralités

Pour réduire la probabilité de blessures causées par une exposition à des dangers mécaniques, l'équipement doit être équipé 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 à 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 34.

Tableau 34 – Classification des différentes catégories de sources d'énergie mécanique

Ligne	Catégorie	MS1	MS2	MS3
1	Arêtes vives et angles vifs	Ne provoque pas de douleurs ni de blessures [b]	Ne provoque pas de blessures [b], mais peut être douloureux	Peut provoquer des blessures [c]
2	Parties mobiles	Ne provoque pas de douleurs ni de blessures [b]	Ne provoque pas de blessures [b], mais peut être douloureux	Peut provoquer des blessures [c]
3a	Pales en plastique de ventilateur [a] Voir Figure 48	$\frac{N}{15\,000} + \frac{K}{2\,400} \le 1$	$\frac{N}{44\,000} + \frac{K}{7\,200} \le 1$	> MS2
3b	Autres pales de ventilateurs [a] Voir Figure 47	$\frac{N}{15\,000} + \frac{K}{2\,400} \le 1$	$\frac{N}{22\,000} + \frac{K}{3\,600} \le 1$	> MS2
4	Desserrage, explosion ou implosion de parties	NA	NA	Voir [d]
5	Masse de l'équipement [f]	≤ 7 kg	≤ 25 kg	> 25 kg
6	Montage au mur/plafond ou sur une autre structure [f]	Masse de l'équipement ≤ 1 kg monté ≤ 2 m [e]	Masse de l'équipement > 1 kg monté ≤ 2 m [e]	Tous les équipements montés > 2 m

[a] Le facteur K est déterminé à l'aide 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, en fonction de l'expérience et/ou des normes de sécurité fondamentales, l'intervention d'un médecin ou d'une urgence hospitalière n'est pas nécessaire.

[c] L'expression "Peut provoquer des blessures" signifie que, en fonction de l'expérience et/ou des normes de sécurité fondamentales, l'intervention d'un médecin ou d'une urgence hospitalière peut être nécessaire.

[d] Les équipements ayant les conceptions suivantes sont des exemples considérés comme des équipements 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.

[f] La masse des fournitures, des **matériaux consommables**, des supports ou des éléments analogues qui peuvent être contenus dans l'équipement doit être inclus dans le calcul de la masse de l'équipement. La masse supplémentaire de ces éléments est déterminée par le fabricant.

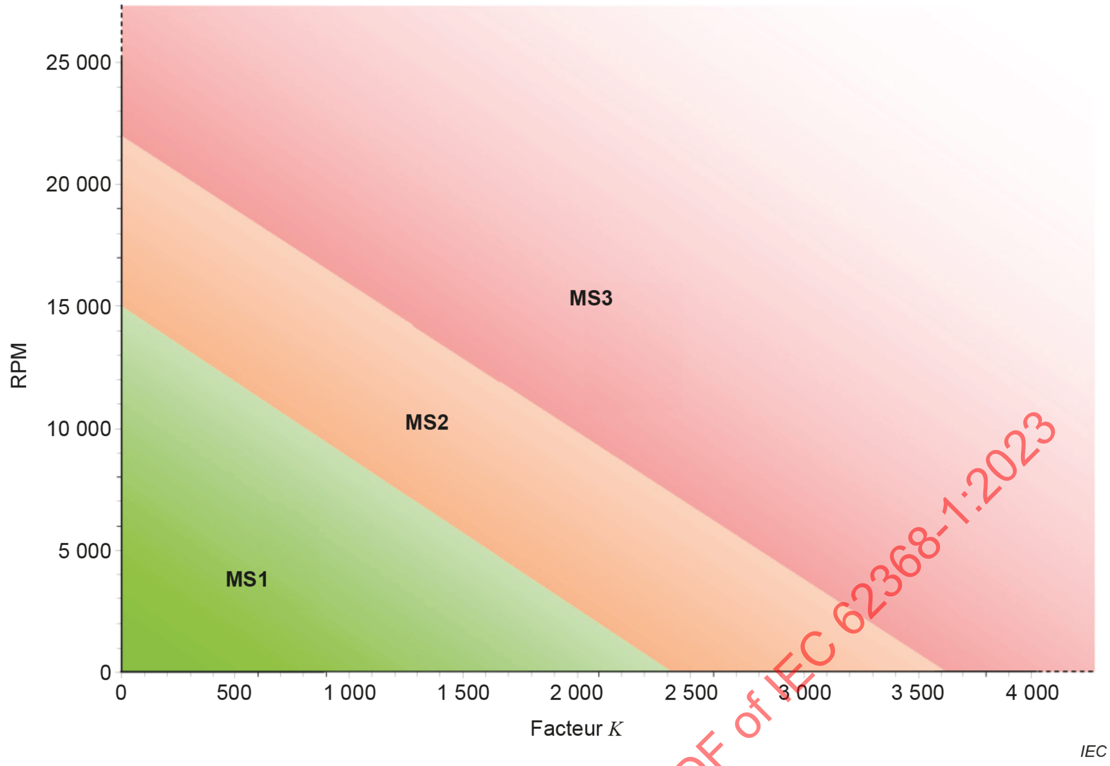


Figure 47 – Limites pour les pales mobiles de ventilateurs en matériaux autres que le plastique

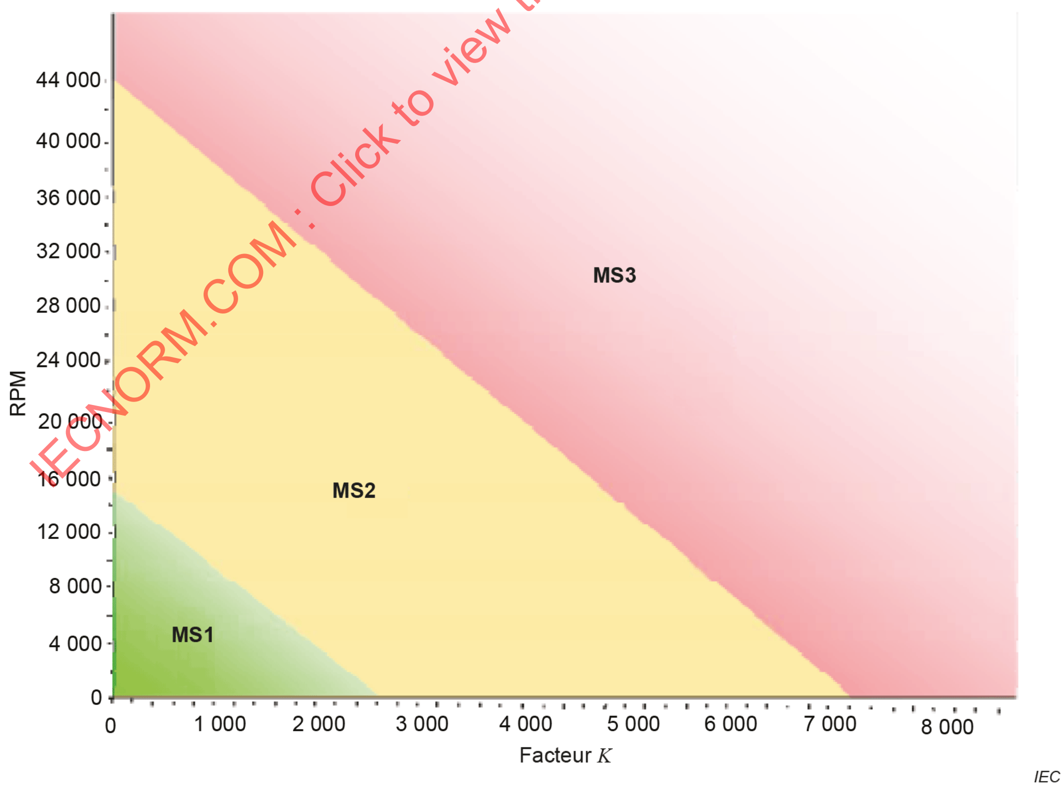


Figure 48 – Limites pour les pales mobiles de ventilateurs en matériaux plastiques

8.2.2 MS1

MS1 est une source d'énergie mécanique de classe 1 avec des niveaux ne dépassant pas les limites de MS1 dans les **conditions normales de fonctionnement** et dans les **conditions anormales de fonctionnement** et ne dépassant pas MS2 dans les **conditions de premier défaut**.

8.2.3 MS2

MS2 est une source d'énergie mécanique de classe 2 avec des niveaux ne dépassant 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 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**, dans les **conditions anormales de fonctionnement** ou dans les **conditions de premier défaut**, ou toute source d'énergie mécanique déclarée comme étant traitée comme MS3 par le fabricant.

8.3 Protection contre les sources d'énergie mécanique

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.

Une **protection par instructions** qui n'est pas évidente pour une **personne avertie** doit être prévue pour MS2. Une **protection par instructions** qui n'est pas évidente pour une **personne qualifiée** doit être prévue pour MS3.

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 34.

Si une arête ou un angle vif classifié MS2 ou MS3 doit être **accessible** 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, excepté que l'élément 3 est facultatif.

La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: , IEC 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

*Si une arête ou un angle vif doit être **accessible** pour le fonctionnement de l'équipement, la conformité est vérifiée par examen.*

*Si une arête ou un angle vif ne doit pas 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 (points de pincement, engrenages et parties qui peuvent commencer à bouger par suite d'un réenclenchement accidentel d'un **dispositif** de commande, par exemple) sont spécifiées ci-dessous.

Les pales de ventilateurs en plastique sont classées conformément au Tableau 34, ligne 3a. Les autres pales de ventilateurs sont classées conformément à la ligne 3b du Tableau 34. Les autres parties mobiles sont classées conformément à la ligne 2 du Tableau 34.

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 le présent document 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 un **verrouillage de sécurité** est utilisé comme **protection**, l'énergie de la partie mobile doit être réduite à la classe MS1 avant que la partie ne soit **accessible**.

Sauf spécification contraire dans le présent document, s'il existe une probabilité que des doigts, bijoux, vêtements, cheveux, etc. puissent entrer en contact avec des parties mobiles MS2 ou MS3, une **protection de l'équipement** doit être fournie afin d'éviter la pénétration ou le coincement de parties du corps.

Si une partie mobile MS2 doit être **accessible** pour permettre à une **personne ordinaire** de faire fonctionner l'équipement, la partie mobile doit être protégée dans toute la mesure du possible, et une **protection par instructions** (voir 8.5.2) doit être utilisée.

Si une partie MS3 mobile doit être **accessible**, pour le fonctionnement de l'équipement, à une **personne ordinaire** ou une **personne avertie**:

– une 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** (voir 8.5.2) doit être utilisée; et
– un **dispositif** d'arrêt à commande manuelle doit être facilement visible et mis en évidence à environ 750 mm de la partie MS3.

  Les composants du **dispositif** d'arrêt à commande manuelle doivent être électromécaniques. Un **dispositif** d'arrêt à commande manuelle peut être composé:

  • d'un interrupteur conforme à l'IEC 61058-1 et qui respecte les exigences de l'Annexe K et équipé d'un mécanisme d'accrochage conforme aux exigences de l'IEC 60947-5-5; ou
  • d'un **dispositif** d'arrêt d'urgence conforme à l'IEC 60947-5-5.

Le redémarrage du système mécanique ne doit être possible qu'en engageant une procédure de commande de démarrage après le réarmement manuel du **dispositif** d'arrêt à commande manuelle.

Les parties mobiles MS3:

– uniquement **accessibles** à une **personne qualifiée**; et
– dont la partie mobile MS3 n'est pas évidente (**dispositif** à mouvement intermittent; par exemple);

doivent comporter une **protection par instructions** comme cela est indiqué 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 fournie pour réduire la probabilité d'un contact involontaire avec une partie mobile conformément à l'Article F.5, excepté que l'élément 3 est facultatif.

La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: , IEC 60417-6056 (2011-05) pour les pales mobiles de ventilateurs; ou
  , IEC 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", "Se tenir à l'écart des pales de ventilateurs" 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 mettre en échec 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'alimentation avant la mise en échec ou le contournement de la **protection de l'équipement**; et
– rétablir la **protection de l'équipement** avant de rétablir l'alimentation.

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 contenant des parties mobiles

8.5.4.1 Généralités

L'Article 8.5.4 s'applique aux équipements autonomes de grandes dimensions qui sont installés dans des **zones à accès limité** (centre de traitement des données, par exemple), dont les dimensions permettent généralement à une personne de pouvoir y entrer complètement ou de pouvoir entrer un membre entier ou la tête dans des zones contenant des parties mobiles dangereuses, et où une personne est présumée entrer dans la zone afin de procéder à l'entretien ou à l'exploitation de l'équipement.

Les équipements couverts par le présent alinéa sont des systèmes automatisés de stockage et d'extraction d'informations de grande capacité qui utilisent des parties mobiles dangereuses entières pour manipuler les supports enregistrés (par exemple, cartouches, des cassettes, des disques optiques, etc.) et fonctions analogues, ainsi que de grandes imprimantes.

8.5.4.2 Equipements contenant des cellules de travail avec des parties MS3

8.5.4.2.1 Protection des personnes dans la cellule de travail

Dans les **conditions normales de fonctionnement**, aucune partie mobile MS3 ne doit être **accessible** au niveau de l'**enveloppe** extérieure d'une **cellule de travail.**

L'équipement doit être équipé de **protections** afin de réduire le risque de blessures dues aux parties mobiles MS3 dans la **cellule de travail**. Les autres sources d'énergie de classe 3 à l'intérieur d'une cellule de travail ne doivent pas être **accessibles** dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut**.

EXEMPLES Les **protections** incluent les verrouillages, les barrières et les signaux d'avertissement, accompagnés de procédures et d'une formation.

NOTE 1 Certaines autorités peuvent exiger l'installation de systèmes de détection d'incendie et de systèmes d'extinction dans les **cellules de travail**.

L'accès à une **cellule de travail** ou l'un de ses compartiments doit être protégé par l'une des méthodes suivantes:

– Méthode 1 – Méthode par **verrouillage de sécurité**. Aucune clé ni aucun **outil** ne sont nécessaires pour entrer dans la **cellule de travail**. Des **verrouillages de sécurité** conformes aux exigences de l'Annexe K doivent être prévus pour empêcher l'accès à la **cellule de travail** lorsque les parties mobiles MS3 de ce compartiment sont sous tension. L'alimentation des parties mobiles MS3 ne doit pas être rétablie tant que les portes ne sont pas fermées et verrouillées. L'ouverture de la porte d'accès verrouillée d'un compartiment d'une **cellule de travail** contenant des parties mobiles MS3, ou celle d'une porte d'accès entre un compartiment contenant des parties mobiles MS3 et une partie désactivée, doit automatiquement déclencher la coupure d'alimentation de ces parties, et passer à une source d'énergie de classe 2 dans les 2 s qui suivent pour une **personne avertie** ou une **personne qualifiée**. Si la réduction de la classe de la source d'énergie dure plus de 2 s, une **protection par instructions** doit être fournie conformément à l'Article F.5.
– Méthode 2 – Méthode par clé ou **outil**. Une clé ou un **outil** doit être exigée pour accéder et contrôler l'accès à la **cellule de travail.** Cet accès doit être empêché lorsque les parties mobiles MS3 de cette **cellule de travail** sont sous tension. Les instructions de fonctionnement et d'entretien, selon le cas, doivent spécifier que la clé ou l'**outil** doit être porté par la personne lorsque celle-ci se trouve dans la **cellule de travail**. Lorsqu'il est possible d'entrer complètement dans la **cellule de travail**, la fermeture complète de la porte sans clé ni **outil** ne doit pas provoquer un redémarrage automatique de l'équipement.

  NOTE 2 La clé ou l'**outil** peut être utilisé pour couper l'alimentation avant d'accéder à la **cellule de travail** ou au compartiment.

Excepté ce qui est admis en 8.5.4.2.2, il ne doit pas être possible de démarrer ou redémarrer le système tant que toutes les portes d'accès concernées n'ont pas été fermées et verrouillées.

S'il est possible d'entrer complètement dans une **cellule de travail**, un verrouillage mécanique automatique doit être prévu pour que la porte ne puisse pas se fermer par inadvertance si cette fermeture permettrait à l'équipement de redémarrer. Il doit être possible d'ouvrir une porte depuis l'intérieur de la **cellule de travail** sans l'aide d'une clé ou d'un **outil**. Les moyens d'ouverture de la porte depuis l'intérieur de la **cellule de travail** doivent être aisément identifiables et visibles, que la porte soit ouverte ou fermée et quel que soit l'état de fonctionnement de l'équipement.

La conformité est vérifiée par examen.

Pendant l'entretien de l'équipement, il peut s'avérer nécessaire de le mettre sous tension pour permettre l'alignement, etc. Dans ce cas, dans les **conditions de premier défaut** ou les **conditions anormales de fonctionnement**, des moyens appropriés doivent être prévus pour limiter le mouvement des parties et éviter qu'elles n'entrent dans la classe MS3 (par une course étendue ou si des parties se détachent et sont éjectées de l'assemblage mobile, par exemple). Ces moyens doivent permettre de limiter ces parties mobiles dans une classe inférieure à MS3 dans les conditions de charge assignée, de vitesse maximale et d'extension maximale.

*La conformité est vérifiée par examen et, si nécessaire, par les essais de l'Article B.3 et de l'Article B.4. L'**enveloppe** ou les barrières de séparation de compartiment doivent contenir une partie qui peut se détacher pendant l'essai.*

8.5.4.2.2 Réenclenchement forcé de la protection d'accès

8.5.4.2.2.1 Généralités

S'il est nécessaire pour une **personne qualifiée** de procéder au réenclenchement forcé d'un mécanisme de protection (un **verrouillage de sécurité**, par exemple) pour accéder à une **cellule de travail** ou un compartiment, un système de réenclenchement forcé conforme à l'Article K.4 doit être prévu. De plus, si un système de réenclenchement forcé est utilisé, un système d'arrêt d'urgence doit être prévu selon 8.5.4.2.3 et doit satisfaire aux exigences d'endurance opérationnelles de 8.5.4.2.4.

La conformité est vérifiée par examen.

8.5.4.2.2.2 Indicateur visuel

Un ensemble d'au moins deux voyants clignotants conformes à l'IEC 60073 doit fonctionner dans les conditions suivantes:

a) dans le cas d'une **cellule de travail** ou d'un compartiment dans laquelle/lequel il est possible d'entrer complètement, pour indiquer que le fonctionnement normal de l'équipement est en cours de rétablissement et qu'un mouvement est imminent; ou
b) pour n'importe quel équipement, lorsque le verrouillage est forcé et que la puissance de transmission est disponible sur les parties mobiles MS3.

Les voyants doivent être aisément visibles en tout point à l'intérieur de la **cellule de travail** ou du compartiment correspondant, et à l'entrée. Pour la condition a), les voyants doivent fonctionner pendant au moins 10 s avant le déplacement d'une partie mobile MS3 le long de l'axe le plus important. Si la condition a) peut se produire pendant le déroulement de la condition b), la séquence lumineuse doit changer, de manière à rendre évident le changement d'état pour les personnes à l'intérieur ou à l'entrée de la **cellule de travail**.

NOTE L'axe le plus important est celui dont la distance de déplacement est la plus longue. Il s'agit en général de l'axe horizontal (X).

La conformité est vérifiée par examen et par essai.

8.5.4.2.3 Système d'arrêt d'urgence

Le présent paragraphe s'applique uniquement si un réenclenchement forcé du **verrouillage de sécurité** est prévu comme cela est spécifié en 8.5.4.2.2.

Un système d'arrêt d'urgence doit neutraliser toutes les autres commandes, couper la puissance de transmission des parties mobiles MS3 et procéder au freinage automatique, si nécessaire, afin d'arrêter l'ensemble des parties mobiles dans un délai raisonnable, de manière à ne pas pouvoir atteindre un danger de niveau 3.

Les composants du système d'arrêt d'urgence doivent être électromécaniques. Une commande d'arrêt d'urgence peut être composée:

– d'un interrupteur conforme à l'IEC 61058-1 et qui respecte les exigences de l'Annexe K et d'un mécanisme d'accrochage conforme aux exigences de l'IEC 60947-5-5, ou d'un dispositif équivalent; ou
– d'un **dispositif** d'arrêt d'urgence conforme à l'IEC 60947-5-5.

NOTE Au Royaume-Uni, un système d'arrêt d'urgence conforme aux exigences de l'IEC 60204-1 et de l'ISO 13850 s'applique en cas de risque de blessures corporelles.

En variante, la fonction de sécurité du système d'arrêt d'urgence doit présenter un niveau d'intégrité de sécurité (SIL, *Safety Integrity Level*) conforme à l'IEC 62061 ou un niveau de performance (PL, *Performance Level*) conforme à l'ISO 13849-1 en cohérence avec les résultats de l'appréciation du risque de la **cellule de travail**.

Le redémarrage du système mécanique doit uniquement être possible en lançant une procédure de commande de démarrage après le réarmement manuel de la commande d'arrêt d'urgence.

Pour les équipements dans lesquels une personne peut entrer complètement dans la **cellule de travail**, le système d'arrêt d'urgence doit inclure au moins deux commandes d'arrêt d'urgence, l'une à l'extérieur de la **cellule de travail** et l'autre à l'intérieur de la **cellule de travail**. La procédure de démarrage du système doit inclure une méthode non dangereuse visant à s'assurer que personne n'est présent dans la **cellule de travail**. S'il peut être démontré, après l'application des essais de premier défaut spécifiés en 8.5.4.2.4 aux circuits de commande du mouvement ou d'autres moyens de détection, que ces essais ne contournent pas la procédure de démarrage non dangereux, l'essai de distance d'arrêt d'urgence du présent paragraphe n'est pas exigé.

Pour les équipements dans lesquels une personne ne peut pas entrer complètement dans une **cellule de travail** ou un compartiment, au moins une commande d'arrêt d'urgence doit être prévue à l'extérieur de la **cellule de travail**. Le système d'arrêt d'urgence doit être opérable par une personne qui souhaite accéder à la **cellule de travail**.

Une commande d'arrêt d'urgence prévue à l'extérieur de la **cellule de travail** doit être aisément visible et placée sur l'équipement de sorte que la personne qui l'actionne puisse voir si la **cellule de travail** est occupée. Les instructions d'installation doivent exiger de prévoir un espace autour de la commande permettant à une **personne avertie** ou une **personne qualifiée** de pouvoir aisément l'atteindre et l'activer.

Une commande d'arrêt d'urgence prévue à l'intérieur de la **cellule de travail** doit être aisément accessible à partir de n'importe quel endroit à l'intérieur de la **cellule de travail** et doit être équipée d'un éclairage permettant de l'identifier sans difficulté. Elle doit être composée d'un bouton coup de poing, d'un bouton champignon ou de dispositions indirectes (un câble de sécurité rouge aisément identifiable, par exemple) qui activent le système d'arrêt d'urgence.

La conformité est vérifiée par examen et, si nécessaire, par l'essai suivant:

Lorsque le système mécanique fonctionne à son énergie cinétique maximale (en transmettant la capacité de charge maximale à la vitesse maximale), le système d'arrêt d'urgence doit être activé et la distance d'arrêt doit alors être mesurée. Les mesures de distance doivent montrer que, après l'activation du système d'arrêt d'urgence, tous les mouvements subséquents dans toutes les directions n'ont aucune de chance de présenter un risque de blessure.

La distance d'arrêt maximale à partir du point d'activation, le long de l'axe le plus important, doit être de 1 m ou moins. De plus, en présence d'un point limite le long de l'axe le plus important au-dessus duquel la partie mobile MS3 ne fonctionne pas, un espace libre d'au moins 150 mm doit être prévu entre ce point limite et la partie mécanique fixe la plus proche, ce qui procure un espace suffisant pour éviter à une personne de se blesser. Les exigences de B.3.8 s'appliquent.

8.5.4.2.4 Exigences d'endurance

Outre les éléments de 8.5.4.2.3, le présent paragraphe s'applique uniquement si un réenclenchement forcé du **verrouillage de sécurité** est prévu (voir 8.5.4.2.2) ou si un câble accessible par une **personne avertie** ou une **personne qualifiée** contient des tensions ES3.

Les faisceaux de câbles mobiles sont soumis à l'essai afin de s'assurer que ne se produit aucun dommage mécanique qui pourrait:

– donner lieu à un dysfonctionnement du système de **verrouillage de sécurité**;
– compromettre les barrières de séparation de compartiment ou les **enveloppes mécaniques**;
– exposer une personne à d'autres dangers.

Si la tension dans ces câbles et le circuit de commande du mouvement sont classés ES3, les essais d'endurance mécanique doivent être appliqués afin de vérifier l'absence de tout danger de choc électrique.

Pour les câbles dont les tensions satisfont aux exigences de ES1, et s'il peut être démontré que les essais de premier défaut en circuit ouvert ou en court-circuit de ces câbles et du circuit de commande du mouvement ne présentent aucun danger, ils sont dispensés des essais d'endurance mécanique.

La conformité est vérifiée par examen et, le cas échéant, par les essais d'endurance mécanique suivants:

Le système mécanique, y compris les moyens (des interrupteurs de fin de course, par exemple) permettant de limiter le mouvement pendant le fonctionnement normal, sont soumis à 100 000 cycles de fonctionnement à la charge assignée et à la vitesse maximale sur toute la longueur ou rotation maximale de course admise par la conception.

Après le cycle thermique:

– *un contrôle des fonctions mécaniques (parties mobiles MS3 pour actionner les interrupteurs électromécaniques, la butée mécanique de fin de course, etc.) et un examen visuel sont réalisés. Les butées mécaniques et les interrupteurs électromécaniques doivent fonctionner comme cela est prévu. Il ne doit y avoir aucun signe de perte d'intégrité mécanique. Toutes les fonctions liées à la sécurité (y compris les systèmes d'arrêt d'urgence et dispositifs analogues, selon le cas) doivent fonctionner normalement; et*
– *les câbles d'assemblage qui commandent les parties mobiles MS3, autres que ceux contenant uniquement des circuits ES1, sont examinés pour détecter les éventuels dommages qui exposent les conducteurs transportant un circuit supérieur à ES1. Aucun conducteur ne doit être cassé, et aucun brin ne doit pénétrer dans l'isolation. Si les dommages ne peuvent pas être évalués par examen, l'assemblage de câble doit être soumis à un essai diélectrique de 1 000 V (voir 5.4) appliqués entre les conducteurs transportant un circuit supérieur à ES1 et une feuille enroulée autour du corps du câble.*

8.5.4.3 Equipements comportant un dispositif électromécanique pour la destruction de supports

8.5.4.3.1 Exigences générales

Les **protections d'équipement** pour la protection des personnes, y compris les enfants, pour 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.

EXEMPLES Les équipements qui incluent les déchiqueteuses de documents à usage de bureau personnel et à usage domestique et les **dispositifs** analogues de destruction de supports, selon la nature de leur source de puissance.

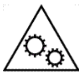
A l'exception des équipements industriels ou des équipements destinés à une utilisation dans une **zone à accès limité**, les autres équipements destinés à une utilisation dans des locaux non susceptibles de recevoir des enfants doivent disposer d'un énoncé conforme à l'Article F.4.

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 relatives aux **verrouillages de sécurité** sont conformes au 4.4.5, excepté 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.

8.5.4.3.2 Protections par instructions contre les parties mobiles

Pour les équipements installés dans des emplacements où des enfants peuvent être présents, une **protection par instructions** doit être fournie conformément à l'Article F.5, excepté que l'élément 3 est facultatif.

La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: , IEC 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 "Eviter 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

8.5.4.3.3 Déconnexion de l'alimentation électrique

Un interrupteur de sectionnement conforme à l'Annexe L doit être prévu pour couper l'alimentation électrique des parties mobiles MS3. Un interrupteur avec une position "OFF" (arrêt), qui coupe l'alimentation 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 au F.3.5.2.

Pour un interrupteur à plusieurs positions, la position "OFF" (arrêt) doit être marquée conformément au F.3.5.2 et les autres positions doivent être marquées avec les libellés ou les symboles appropriés.

8.5.4.3.4 Méthode d'essai

*Les **dispositifs** de destruction de supports sont soumis à l'essai en appliquant la sonde en coin de la Figure V.4 dans une direction quelconque par rapport à l'orifice:*

– *en appliquant une force maximale de 45 N pour un **dispositif** du type coupe en bande; et*
– *en appliquant 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 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 en 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) en utilisant généralement un moteur plus puissant et un mécanisme de déchiquetage plus complexe.

*Une **enveloppe** ou une garde qui peut être enlevée ou ouverte par une **personne ordinaire** ou une **personne avertie** doit être enlevée ou ouverte avant l'application des sondes.*

8.5.4.3.5 Critères de conformité

La conformité est vérifiée conformément au V.1.2 et au V.1.5. La sonde en coin ne doit pas entrer contact avec des parties mobiles.

*Lorsque l'équipement dispose d'un **verrouillage de sécurité**, la conformité est vérifiée conformément au 4.4.5, excepté 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 34 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** en 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 soumis 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, normalement installées dans l'équipement, ou les deux.*

*L'**explosion** d'une lampe est simulée par impact mécanique, par un générateur d'impulsions électroniques ou par une méthode analogue. 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, l'équipement ou le module de lampes est placé sur une surface horizontale et un tapis adhésif sombre (ou toute autre méthode adéquate) de taille appropriée pour capturer les particules est placé près de l'orifice de sortie de l'équipement. L'ouverture de l'équipement doit être orientée de façon à évaluer le mieux possible la quantité de particules éjectées horizontalement en provenance du produit vers le tapis adhésif sombre. Après la rupture, les particules de verres générées sont mesurées à l'aide d'une loupe d'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 adhésif est de couleur bleu foncé.

Un exemple représentant 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 du 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 tapis 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 à plus 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**, la valeur de 0,8 mm peut être remplacée 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 conformément au Tableau 34, 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 afin d'être déplacées, 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 l'essai conformément à 8.6.2.2.

Les équipements doivent satisfaire aux exigences et essais spécifiés en 8.6.2, en 8.6.3, en 8.6.4 et en 8.6.5 conformément au Tableau 35. Où "x" signifie que l'essai s'applique.

Tableau 35 – Présentation des exigences et essais

Type d'équipement		Type d'essai				
		Stabilité statique	**Force dirigée vers le bas**	**Relocalisation**	**Essai de lame de verre** [b]	**Force horizontale**
		8.6.2.2	**8.6.2.3**	**8.6.3**	**8.6.4**	**8.6.5**
MS1	Tous les équipements	Aucune exigence de stabilité				
MS2	Posé au sol			x		
	Non posé au sol	x				
	Commandes ou affichage [a]	x			x	
	Equipement fixe	Aucune exigence de stabilité				
MS3	Posé au sol	x	x	x		
	Non posé au sol	x				
	Commandes ou affichage [a]	x			x	x
	Equipement fixe	Aucune exigence de stabilité				

[a] Equipements dont les commandes d'utilisateur **accessibles** sont montées à l'avant et qui comportent 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] L'essai de lame de verre ne s'applique pas aux équipements posés au sol, même s'ils peuvent comporter des commandes ou un écran.

Si des matériaux thermoplastiques ont un impact sur la stabilité de l'équipement, 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 comporter une **protection par instructions** conformément à l'Article F.5, excepté que la **protection par instructions** peut être fournie dans les instructions d'installation ou dans un document d'accompagnement équivalent de l'équipement.

La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: non disponible
– élément 2: "Danger d'instabilité" ou texte 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

Un téléviseur peut tomber et 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: – TOUJOURS utiliser les coffres, les supports ou les méthodes de montage recommandés par le fabricant du téléviseur. – TOUJOURS utiliser uniquement les meubles qui peuvent soutenir le téléviseur de manière sécurisée. – TOUJOURS s'assurer que le téléviseur ne dépasse pas du bord du meuble qui le soutient. – TOUJOURS enseigner aux enfants les dangers de monter sur les meubles pour atteindre le téléviseur ou ses commandes. – TOUJOURS faire cheminer les cordons et les câbles reliés à votre téléviseur de manière à ce qu'ils ne puissent pas être piétinés, tirés ou arrachés. – Ne JAMAIS placer un téléviseur dans un endroit instable. – Ne JAMAIS 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 JAMAIS placer le téléviseur sur un tissu ou d'autres matériaux qui peuvent se trouver entre le téléviseur et le meuble qui le soutient. – Ne JAMAIS placer d'objets qui pourraient inciter les enfants à monter sur le téléviseur ou le meuble sur lequel il est placé (un jouet ou la télécommande, par exemple). 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 éventuels doivent contenir la quantité de substance selon leur capacité assignée, qui correspond aux conditions les plus défavorables.

*L'ensemble des portes, tiroirs, roulettes, pieds réglables et autres accessoires qui sont **accessibles** à une **personne ordinaire**, sont disposés dans n'importe quelle combinaison qui donne la stabilité la plus défavorable. Les équipements dont les caractéristiques permettent plusieurs positions doivent être soumis à l'essai dans la position la plus défavorable admise par la construction de l'équipement. Cependant, si les roulettes sont uniquement conçues pour transporter l'équipement et si les instructions d'installation exigent 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 prévue, les portes, tiroirs, etc. ou tout autre moyen d'ajustement ***accessible*** *à une* ***personne avertie*** *ou une* ***personne qualifiée*** *doit être disposé selon la combinaison spécifiée dans les instructions d'entretien qui donnent la stabilité la plus défavorable.*

Les essais du 8.6.2.2 et du 8.6.2.3 doivent être effectués comme cela est indiqué dans le Tableau 35.

8.6.2.2 Essai de stabilité statique

L'équipement doit être soumis à l'un des essais suivants:

– *l'équipement est incliné dans toutes les directions, de sorte que sa base présente un angle d'inclinaison jusqu'à 10° inclus; ou*
– *l'équipement est placé sur un plan selon un angle de 10° par rapport à l'horizontale, puis pivoté lentement à 360° par rapport à son axe vertical normal; ou*
– *l'équipement est placé sur une surface horizontale antidérapante et soumis à une force égale à:*
  - *50 % du poids de l'unité en position verticale vers le bas, mais pas plus de 100 N. Si la surface de support empêche l'équipement de se renverser pendant l'essai, l'essai doit être répété sans la surface de support; et*
  - *13 % du poids dans toutes les directions horizontales, mais pas plus de 250 N,*

  appliquée dans les positions les plus défavorables sur l'équipement au moyen d'un appareillage d'essai adapté dont la surface plane mesure environ 125 mm x 200 mm, 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.

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 avec une surface plane d'environ 125 mm x 200 mm. La force dirigée vers le bas est appliquée en mettant la totalité de la surface plane de l'outil d'essai en contact avec l'équipement. Cependant, l'outil d'essai peut ne pas être en contact total avec des surfaces irrégulières (surfaces ondulées ou courbes, par exemple).

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.

EXEMPLE 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 Stabilité en mouvement

8.6.3.1 Exigences

L'équipement doit être stable lorsqu'il est déplacé. L'équipement doit:

– être équipé de roues d'au moins 100 mm de diamètre; ou
– satisfaire aux essais du 8.6.3.2.

8.6.3.2 Méthode d'essai et critères de conformité

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 avant d'être 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 destinés à 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 n'importe quelle combinaison qui donne la stabilité la plus défavorable.

Les portes, tiroirs, etc. des équipements destinés à être déplacés par une ***personne avertie*** *ou une* ***personne qualifiée****, doivent être positionnés conformément aux instructions du fabricant.*

Un équipement dont les caractéristiques permettent plusieurs positions doit être soumis à l'essai dans la position la plus défavorable admise par la construction de l'équipement.

L'équipement ne doit pas se renverser pendant l'essai.

8.6.4 Essai de lame de verre

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 doit être placé sur une surface horizontale antidérapante en disposant l'ensemble des portes, tiroirs, roulettes, pieds réglables et autres parties mobiles selon toute combinaison qui donne la condition la moins stable. 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 20 % du poids de l'équipement ou à 250 N, si cette valeur est plus faible, est appliquée en un point de l'équipement qui donne la stabilité la plus défavorable. 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 un 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 pendant l'essai.

8.7 Equipements montés au mur, au plafond ou sur une autre structure

8.7.1 Exigences

La classification des équipements pour les besoins de l'évaluation des moyens de montage au mur, au plafond ou sur une autre structure fixe (pylône ou tour, par exemple) est réalisée selon le Tableau 34, ligne 6.

Pour les équipements MS2 ou MS3:

– si le fabricant définit un moyen de montage particulier, la combinaison des moyens de montage et de l'équipement doit être conforme à 8.7.2, Essai 1. Le matériel utilisé pour fixer le moyen de 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 définit pas de moyen de montage particulier, mais que l'équipement est livré avec des éléments (un crochet ou une ouverture filetée, par exemple) facilitant la fixation de ce moyen de montage à l'équipement, ces éléments doivent satisfaire au 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 moyen de montage, les pièces filetées sans le moyen de montage doivent de plus être conformes à 8.7.2, Essai 3.

NOTE Les essais consistent à vérifier la fixation du moyen de montage à l'équipement et non la fixation au mur, au plafond ou sur une autre structure.

8.7.2 Méthodes d'essai

Si la construction comporte des matériaux thermoplastiques ayant un impact sur la résistance du système de montage, 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 conformément aux 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 1 min. 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,*

si cette valeur est plus faible.

Ensuite, pour les équipements montés au mur ou sur une autre structure, une force horizontale de 50 N est appliquée latéralement pendant 1 min.

<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 représentatif du système de montage doit être soumis séparément aux six forces d'essai suivantes:

– *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°;*
– *une force de poussée dirigée vers l'intérieur appliquée parallèlement à son axe central pendant 1 min;*
– *une force de traction dirigée vers l'extérieur appliquée parallèlement à son axe central pendant 1 min.*

Essai 3

Si la conception du système de montage repose sur des parties filetées, chaque partie doit être soumise à l'essai suivant séparément.

La vis est serrée selon le couple indiqué dans le Tableau 36, puis desserrée (5 fois au total). Le couple doit être appliqué progressivement.

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 est recommandé dans les instructions d'utilisation, toute vis de même diamètre doit être utilisée pour l'essai.

Tableau 36 – Couple à appliquer aux vis

Diamètre nominal de la vis mm	Couple Nm
jusqu'à 2,8 inclus	0,4
entre 2,8 et 3,0 inclus	0,5
entre 3,0 et 3,2 inclus	0,6
entre 3,2 et 3,6 inclus	0,8
entre 3,6 et 4,1 inclus	1,2
entre 4,1 et 4,7 inclus	1,8
entre 4,7 et 5,3 inclus	2,0
entre 5,3 et 6,0 inclus	2,5

8.7.3 Critères de conformité

La conformité est vérifiée par examen et par les essais du 8.7.2, selon le cas. L'équipement ou ses moyens de montage associés ne doivent pas se détacher, et doivent rester mécaniquement intacts et sécurisés pendant l'essai. Les parties filetées doivent rester intactes d'un point de vue mécanique.

8.8 Rigidité des poignées

8.8.1 Généralités

Une partie de l'équipement utilisée pour soulever ou transporter l'équipement est considérée comme étant une poignée, indépendamment de sa forme, de son emplacement ou s'il s'agit d'une pièce destinée aux opérations de levage ou de transport manuel ou par des moyens mécaniques. Elle doit par ailleurs présenter une résistance adéquate.

L'équipement est classifié conformément au Tableau 34, 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 qui peut être transporté.

*La conformité est vérifiée par examen, par consultation des données disponibles ou, si nécessaire, par l'essai du 8.8.2. Après 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 ni se détacher de l'équipement.*

8.8.2 Méthode d'essai

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 poids supplémentaire, comme cela est spécifié ci-dessous:

– *pour les équipements MS1, avec deux poignées ou plus, un poids qui exerce une force égale à trois fois le poids de l'équipement;*

  NOTE Aucun essai ne s'applique aux équipements MS1 équipés d'une seule poignée.

– *pour les équipements MS2, un poids qui exerce une force égale à trois fois le poids de l'équipement;*
– *pour les équipements MS3 d'une masse inférieure ou égale à 50 kg, un poids qui exerce une force égale à deux fois le poids de l'équipement ou à 75 kg, si ce poids est plus élevé; et*
– *pour les équipements MS3 d'une masse supérieure à 50 kg, un poids qui exerce une force égale au poids de l'équipement ou à 100 kg, si ce poids est plus élevé.*

Le poids supplémentaire doit commencer à zéro et augmenter progressivement afin d'atteindre la valeur d'essai dans un délai compris entre 5 s et 10 s et de la maintenir 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 peut être considéré comme capable d'être porté par une seule poignée, chaque poignée doit être capable de soutenir la force totale.

8.9 Exigences relatives aux attaches des roues ou des roulettes

8.9.1 Généralités

L'équipement est classifié conformément au Tableau 34, ligne 5. Si l'équipement est destiné à être utilisé avec des chariots, supports et éléments de supports analogues équipés de roues ou de roulettes, la classification est appliquée en utilisant la masse combinée.

La probabilité que des équipements MS3, y compris des chariots, des supports ou des éléments de support analogues de l'équipement ne se renversent lorsqu'ils sont en mouvement doit être réduite.

8.9.2 Méthode d'essai

Les roues ou roulettes des équipements MS3 ou leur chariot, support ou élément de support analogue, prévus pour être déplacés en ***conditions normales de fonctionnement****, doivent être capables de supporter une traction de 20 N. La force de traction doit être appliquée par un poids ou une traction régulière à la roue ou roulette pendant 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 analogues

8.10.1 Généralités

L'équipement doit être stable par rapport au chariot, support ou élément de support analogue. Les classifications du Tableau 34, 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 analogues 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 analogues, qui ne sont pas déplacés en **conditions normales de fonctionnement**, doivent être conformes à l'essai de force horizontale du 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 comporte des roues ou roulettes qui lui permettent de se déplacer uniquement dans des directions limitées, l'essai n'est réalisé que dans ces directions-là (tableau blanc électronique, par exemple).

8.10.2 Marquage et instructions

Un chariot, support ou élément de support analogue 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.

La **protection par instructions** doit comporter les éléments suivants:

- 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 dans un 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 analogue 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 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 dans un document d'accompagnement équivalent de l'équipement.

8.10.3 Essai de chargement du chariot, du support ou de l'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 doit être appliquée à un tiroir d'étagère ou à un support à cheville ou à une partie équivalente située à moins de 750 mm du sol et qui supporte tout ou partie du poids d'un enfant. La force doit être appliquée pendant 1 min avec le chariot ou support à 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 destinée à supporter un affichage à images mobiles; ou*
– *quatre fois la charge prévue par le fabricant ou 100 N, si cette valeur est plus élevée, mais inférieure ou égale à 440 N, est appliquée à l'ensemble des surfaces appropriées.*

Une zone de stockage dédiée prévue pour contenir des accessoires spécifiques tels que les cassettes, les disques, etc. doit être complètement remplie au niveau de la charge assignée.

Le poids doit être appliqué pendant 1 min sur chaque surface d'appui, avec les autres surfaces non chargées.

8.10.4 Essai de choc sur chariot, support ou élément de support

Lorsqu'ils sont soumis à l'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 doit être appliqué à une partie du chariot ou du support conformément à la méthode d'essai décrite à l'Article T.6. Cependant, un chariot, support ou élément de support en verre doit être soumis à l'essai conformément à 4.4.3.6.

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 du 8.6.3 et du 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 abaissant la force à 13 % du poids de l'équipement seul ou à 100 N, si cette valeur est plus faible.

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 retrait, 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 rails (SRME)

8.11.1 Généralités

Le présent paragraphe spécifie les exigences relatives aux rails montés horizontalement afin de réduire la probabilité de blessures en immobilisant le SRME dans une position stable et en évitant le gondolage des rails, la rupture des moyens de fixation ou le glissement du SRME à l'extrémité des rails.

Les exigences ci-dessous s'appliquent aux moyens de montage des SRME de classes MS2 et MS3:

– installés dans une baie et qui peuvent glisser sur les rails afin d'être sortis de la baie à des fins d'installation, de fonctionnement ou d'entretien; et
– SRME qui s'étend sur toute la largeur de la baie; 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 à aucun des éléments suivants:

– **sous-ensembles** d'équipements;
– autres équipements fixes en place dans la baie;
– équipements non destinés à être entretenus lorsqu'ils sont étendus sur les rails.

Les moyens de montage mécaniques du SRME sont appelés des rails. 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 incluent les glissières de support, les glissières de frottement ou tout autre moyen de montage équivalent.

NOTE 2 Les **sous-ensembles** du produit fini (modules amovibles, tiroirs de composants, bacs d'alimentation à extraction des photocopieurs/imprimantes, par exemple) ne sont pas considérés comme des SRME.

8.11.2 Exigences

La classification des produits dans le but d'évaluer la stabilité de l'équipement doit être effectuée conformément au Tableau 34, ligne 5.

NOTE Pour l'évaluation de la stabilité de l'équipement, voir 8.6.

Les rails doivent maintenir le SRME en place et être équipés de butées d'extrémité qui empêchent le SRME de glisser accidentellement à l'extrémité des moyens de montage.

Les rails doivent être installés dans une baie représentative avec le SRME ou dans un dispositif équivalent, conformément aux instructions du fabricant.

Les rails avec une seule position étendue doivent satisfaire à l'essai de force vers le bas du 8.11.3.1 en position étendue.

Les rails avec une position d'entretien et une position d'installation doivent satisfaire à l'essai de force vers le bas du 8.11.3.1 en position d'entretien.

Tous les rails doivent satisfaire aux essais du 8.11.3.2 et du 8.11.3.3 en position d'entretien et en position d'installation.

A l'issue de chaque essai, les rails et le SRME peuvent être remplacés avant de réaliser l'essai suivant.

Un rail à positions multiple ne doit pas s'étendre automatiquement dans l'une de ses positions étendues. Le SRME doit uniquement être en mesure de prendre sa position d'entretien lorsqu'il est tiré. Un verrou ou d'autres moyens doivent être prévus afin d'immobiliser le SRME en position d'entretien. Toutes les positions d'entretien et positions d'installation doivent être expliquées. Une **protection par instructions** doit être fournie pour l'installateur. La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: non disponible
– élément 2: Danger d'instabilité
– élément 3: "La baie peut basculer et provoquer des blessures corporelles graves"
– élément 4: le texte ci-dessous ou texte équivalent

Avant d'étendre la baie en position d'installation, lire les instructions d'installation. Ne pas charger l'équipement monté sur rails en position d'installation. Ne pas laisser l'équipement monté sur rails en position d'installation.

8.11.3 Essai de résistance mécanique

8.11.3.1 Essai de force vers le bas

Avec les SRME montés en position étendue, une force en plus du poids du SRME doit être appliquée vers le bas au centre de gravité pendant 1 min.

La force supplémentaire appliquée au SRME doit être égale à la valeur la plus élevée des deux valeurs suivantes, avec une valeur maximale de 800 N:

– *50 % du poids du SRME plus une force de 330 N; ou*
– *50 % du poids du SRME, plus un poids supplémentaire égal au poids du SRME ou à une force de 530 N, si cette valeur est plus faible.*

NOTE Cette force supplémentaire est présumé prendre en compte les autres objets ou **dispositifs** pouvant être empilés au sommet du SRME en position étendue lors de l'installation d'un autre SRME.

Dans le cas d'étagères montées sur rails, l'étagère doit être soumise à l'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 afin d'indiquer le poids maximal qui peut être placé dessus.

8.11.3.2 Essai de force de poussée latérale

Une force statique de 250 N est appliquée latéralement, dans les deux directions au niveau ou à proximité de l'extrémité du SRME équipé des rails dans leur position (d'entretien) entièrement étendue pendant 1 min. Le poids appliqué ne doit pas nécessairement être en contact total avec des surfaces irrégulières (surfaces ondulées ou courbes, par exemple), mais doit être appliqué à 30 mm de l'extrémité du SRME.

8.11.3.3 Intégrité des butées d'extrémité des rails

Pour soumettre à l'essai l'intégrité des butées d'extrémité, une force de poussée statique de 250 N est appliquée sur la face avant du rail entièrement étendu du SRME pendant 1 min afin de tenter de faire sortir le SRME du rail. Le SRME est ensuite replacé en position d'utilisation (installée), puis de nouveau placé en position entièrement étendue. L'essai est réalisé 10 fois.

8.11.4 Critères de conformité

La conformité est vérifiée par examen et par consultation des données disponibles du fabricant. Si les données ne sont pas disponibles, les essais conformes à 8.11.3 sont alors effectués.

A l'issue de chaque essai, le SRME et ses rails associés doivent rester fixés pendant un cycle complet de déplacement sur les rails. 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 du SRME, et ce, afin de rentrer entièrement le SRME dans la baie.

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 le SRME dans une position sécurisée et ne doivent pas lui permettre de glisser à l'extrémité des rails.

8.12 Antennes télescopiques ou fouets

Une antenne télescopique ou fouet susceptible de se trouver dans des lieux où des enfants peuvent être présents doit comporter un dispositif qui réduit le risque de blessures avec un point saillant ou une arête vive à l'extrémité.

Les éléments suivants sont considérés comme étant conformes:

– *si l'extrémité ne présente aucune arrête vive ni point saillant; ou*
– *si l'extrémité comporte un bouton ou une boule de 6,0 mm de diamètre au minimum.*

La pièce d'extrémité d'une antenne et les sections d'une antenne télescopique doivent être sécurisées de manière à éviter tout retrait.

La conformité est vérifiée par examen et par l'essai de l'Article T.11.

9 Brûlure thermique

9.1 Généralités

Pour réduire la probabilité de douleurs et de brûlures de la peau, les parties **accessibles** doivent être classifiées et, si nécessaire, être équipées des **protections** spécifiées à l'Article 9.

NOTE Les brûlures thermiques dues à des sources d'énergie de radiofréquence (RF) constituent un cas spécial dans le présent document. 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] du Tableau 4.

9.2 Classifications des sources d'énergie thermique

9.2.1 TS1

TS1 est une source d'énergie thermique de classe 1 où le niveau de température:

– ne dépasse pas les limites de TS1 dans les **conditions normales de fonctionnement**; et
– ne dépasse pas les limites de TS2 dans:
  - les **conditions anormales de fonctionnement**; et
  - les **conditions de premier défaut**.

9.2.2 TS2

TS2 est une source d'énergie thermique de classe 2 où le niveau de température:

– dépasse les limites de TS1; et
– ne dépasse pas les limites de TS2 dans:
  - les **conditions normales de fonctionnement**;
  - les **conditions anormales de fonctionnement**; et
  - les **conditions de premier défaut**.

Aucune limite ne s'applique, sauf pour les dispositifs portés sur le corps en contact direct avec la peau, où le dysfonctionnement de l'équipement est évident.

9.2.3 TS3

TS3 est une source d'énergie thermique de classe 3 avec des niveaux dépassant les limites de TS2 appropriées du Tableau 37 dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** ou les **conditions de premier défaut**.

9.3 Limites de température de contact

9.3.1 Exigences

A l'exception de ce qui est indiqué ci-dessous, les températures de contact des parties **accessibles** doivent être conformes à celles du Tableau 37.

Une partie **accessible** qui, lorsqu'elle entre en contact avec le corps, est susceptible de chuter en température au moment du contact peut être évaluée dans les limites de l'Annexe A du Guide 117:2010 de l'IEC. Une méthode d'essai appropriée et reproductible est déterminée par le fabricant en tenant compte de la méthode d'essai du Guide 117 de l'IEC.

9.3.2 Méthode d'essai et critères de conformité

Les essais de température sont réalisés dans les conditions ambiantes définies en B.1.5, excepté que la température ambiante doit être de 25 °C ± 5 °C.

Si l'essai est réalisé à une température comprise entre 20 °C et 25 °C, les résultats sont ajustés pour refléter une valeur de 25 °C.

NOTE 1 Pour connaître les raisons pour lesquelles l'essai est réalisé à 25 °C sans ajustage des résultats pour des températures plus élevées, consulter l'IEC TR 62368-2.

*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 2 Il est possible que cela ne corresponde pas aux conditions de courant d'entrée maximal ou de puissance d'entrée maximale, mais aux conditions qui fournissent le plus niveau thermique le plus élevé à la partie concernée.

*La conformité est vérifiée en mesurant la température en régime établi des surfaces **accessibles**.*

Tableau 37 – Limites de température de contact pour les parties accessibles

	Parties accessibles [b]	Température maximale (T_{max}) °C			
		Métal [d]	Verre, porcelaine et matériau vitreux	Plastique et caoutchouc	Bois
TS1	**Dispositifs** portés sur le corps (en contact direct avec la peau) en utilisation normale (> 8 h) [e]	43 à 48	43 à 48	43 à 48	43 à 48
	Poignées, boutons, prises, etc., et surfaces tenus ou touchés en utilisation normale (> 1 min et < 8 h) [a]	48	48	48	48
	Poignées, boutons, prises, etc., et surfaces tenus pendant de courtes périodes ou touchés occasionnellement (> 10 s et 1 min)	51	56	60	60
	Poignées, boutons, prises, etc., et surfaces touchés occasionnellement pendant de très courtes périodes (> 1 s et < 10 s) [ff]	60	71	77	107
	Surfaces qui n'ont pas à être touchées pour le fonctionnement de l'équipement (< 1 s)	70	85	94	140
TS2	**Dispositifs** portés sur le corps (en contact direct avec la peau) en utilisation normale (> 8 h) [e]	43 à 48	43 à 48	43 à 48	43 à 48
	Poignées, boutons, prises, etc., et surfaces tenus en utilisation normale (> 1 min) [a]	58	58	58	58
	Poignées, boutons, prises, etc., et surfaces tenus pendant de courtes périodes ou touchés occasionnellement (> 10 s et < 1 min)	61	66	70	70
	Poignées, boutons, prises, etc., et surfaces touchés occasionnellement pendant de très courtes périodes (> 1 s et < 10 s) [f]	70	81	87	117
	Surfaces qui n'ont pas à être touchées pour le fonctionnement de l'équipement (< 1 s)	80 (100) [c]	95 (100) [c]	104	150
TS3	Supérieur aux limites de TS2				

[a] Des exemples de ces surfaces sont un combiné de téléphone, un téléphone portable ou tout autre **dispositif** portatif, ainsi que la surface d'un ordinateur portable sur laquelle s'appuie la paume de la main. Les limites > 1 s et < 10 s peuvent être utilisées pour les points chauds locaux dont le contact peut être aisément évité en portant le **dispositif** autrement.

[b] Le cas échéant, la durée de contact doit être déterminée par le fabricant et doit être cohérente avec l'utilisation prévue conformément aux instructions de l'équipement.

[c] Les valeurs entre parenthèses peuvent être utilisées pour les zones et les surfaces suivantes:

– une zone sur la surface 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 radiateurs et parties métalliques qui recouvrent directement ces derniers, à l'exception de ceux disposés sur des surfaces comportant des interrupteurs ou des organes de commande manipulés en utilisation normale.

Pour ces zones et parties, une **protection par instructions** conforme à l'Article 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 de l'équipement, une **protection principale de l'équipement** est exigée.

[d] Pour les parties métalliques recouvertes de matériau plastique ou de caoutchouc d'au moins 0,3 mm d'épaisseur, le revêtement est considéré comme étant adapté à utilisation comme **protection**, et la limite de température du plastique ou du caoutchouc est admise.

[e] Exemples: **dispositifs** portables légers comme les montres, casques, lecteurs de musique individuels et équipements de sport. Pour les **dispositifs** plus volumineux ou les **dispositifs** en contact direct avec des zones vitales du visage (voies respiratoires, par exemple), des limites inférieures peuvent s'appliquer. Pour une durée de contact inférieure à 8 h selon son utilisation normale prévue, appliquer des limites comprises entre 48 °C/1 min et 43 °C/8 h. Les calculs doivent être arrondis au nombre entier inférieur. Il s'agit par exemple d'un casque avec une charge de **batterie** limitée à 2 h.

[f] Les exemples comprennent les surfaces qui n'ont pas à être touchées pour la déconnexion.

9.4 Protection contre les sources d'énergie thermique

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.

Pour la protection d'une **personne ordinaire** contre TS2, une **protection par instructions** conforme à 9.5.2 peut faire office de **protection principale**.

Les parties **accessibles** (internes et externes) classées TS3 qui exigent de la chaleur pour la fonction prévue (contre-colleuse, tête d'impression thermique, four de fixage, etc.) doivent satisfaire à l'ensemble des exigences suivantes:

– il n'est pas nécessaire de toucher la partie pour faire fonctionner l'équipement (une partie servant également de poignée, de bouton ou de prise, par exemple);
– il est peu probable qu'une **personne ordinaire** touche volontairement la partie dans les **conditions normales de fonctionnement**;
– un contact involontaire avec la partie par une **personne ordinaire** est peu probable pendant la maintenance n'impliquant pas la partie;
– la partie est équipée d'une **protection par instructions** sur ou à proximité de la partie (voir 9.5.2); et
– il est peu probable que des enfants touchent la partie.

Pour la protection d'une **personne qualifiée**, 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 Figure 19).

9.5 Exigences pour les protections

9.5.1 Protection de l'équipement

Une **protection de l'équipement** doit limiter le transfert d'énergie thermique (température source) dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut** ou limiter l'accessibilité à une source d'énergie thermique à une température de contact, comme cela est spécifié dans la classification du Tableau 37.

Les limites de température sont appliquées uniquement à celles des **conditions anormales de fonctionnement** ou des **conditions de premier défaut** dans lesquelles l'équipement continue de fonctionner comme cela est prévu, la **condition anormale de fonctionnement** ou la **condition de premier défaut** n'étant donc pas évidentes. En cas de dysfonctionnement évident, les limites ne s'appliquent pas.

9.5.2 Protection par instructions

Une **protection par instructions** doit être fournie conformément à l'Article F.5, excepté que l'élément 3 est facultatif.

La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: , IEC 60417-5041 (2002-10)
– élément 2: "ATTENTION" et "Surface chaude" ou texte équivalent
– élément 3: facultatif
– élément 4: "Ne pas toucher" ou texte équivalent

9.6 Exigences relatives aux émetteurs de puissance sans fil

9.6.1 Généralités

Les **émetteurs de puissance sans fil** pour le transfert de puissance sans fil de champ proche peuvent chauffer des objets métalliques étrangers qui peuvent être placés à proximité ou sur ces émetteurs. Pour éviter les brûlures dues aux températures élevées des objets métalliques étrangers, l'émetteur est soumis à l'essai comme cela est spécifié en 9.6.3. Cette exigence s'applique aux **dispositifs** émetteurs de puissance sans fil dont la surface est essentiellement plane, ce qui assure ainsi un contact suffisant avec l'objet étranger et le récepteur afin d'induire une induction magnétique en champ proche depuis la bobine primaire vers la bobine secondaire qui fait partie du **dispositif** de réception de puissance.

9.6.2 Spécification des objets étrangers

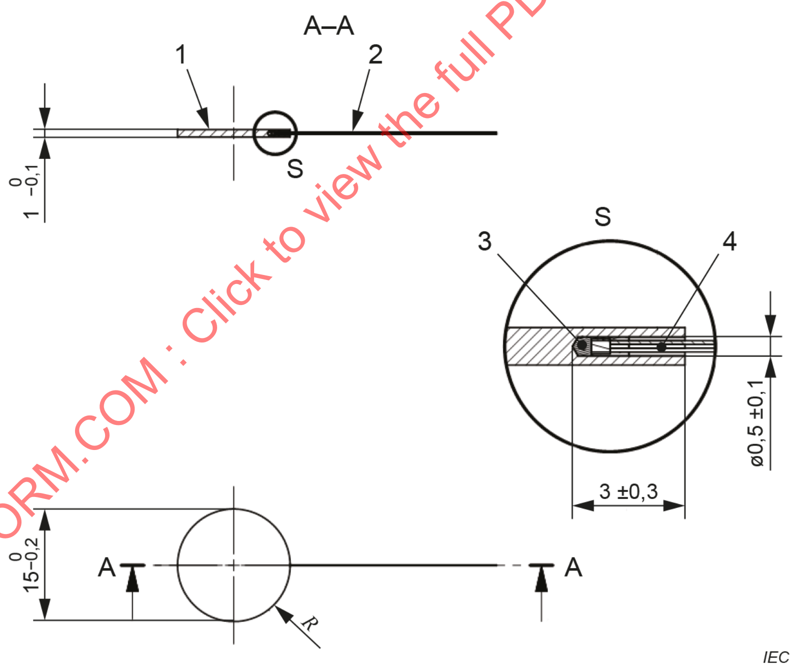
Les objets étrangers suivants sont utilisés:

– un disque en acier (voir Figure 49);

– une bague en aluminium (voir Figure 50); et

– une feuille d'aluminium (voir Figure 51).

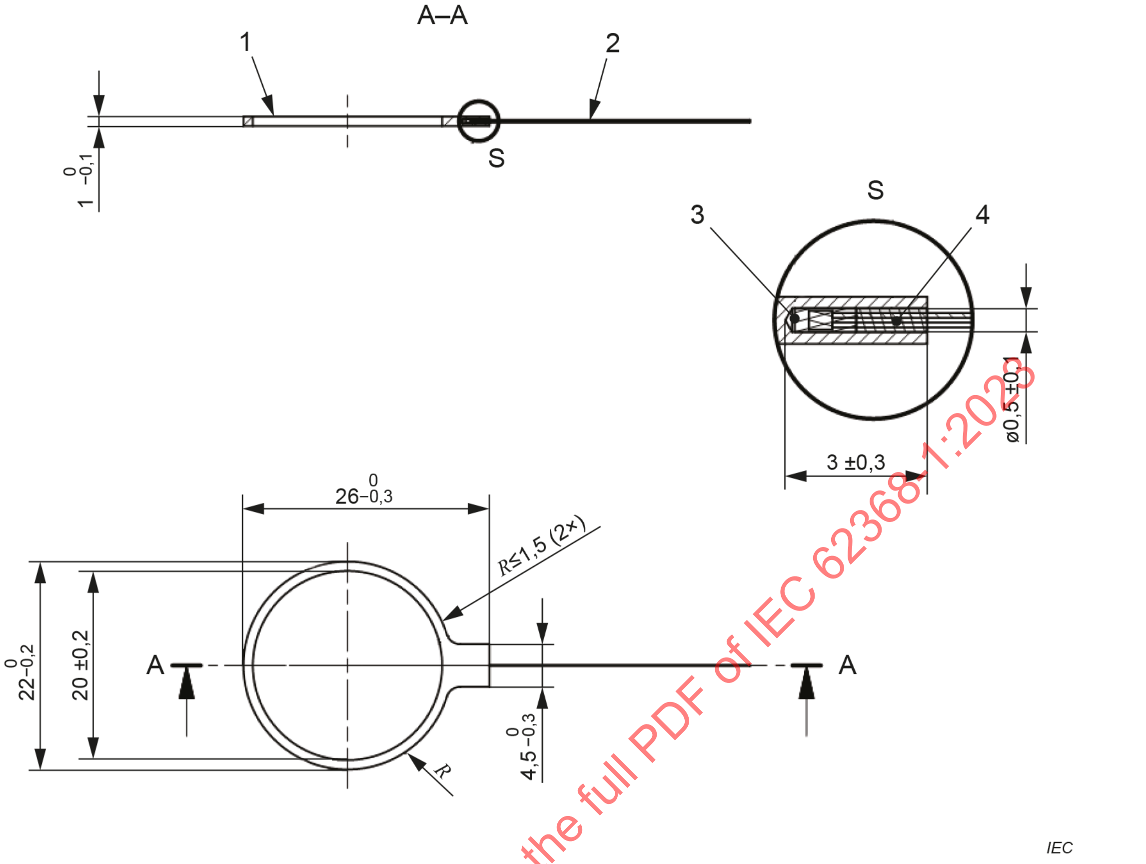
Dimensions en millimètres



N°	Nom	Remarques
1	Disque	Acier 1,1011/ RFe 160
2	Thermocouple	Tout type approprié
3	Composé dissipateur thermique	Transfert de chaleur
4	Tuyau en silicone	Relâchement des contraintes

Figure 49 – Disque en acier

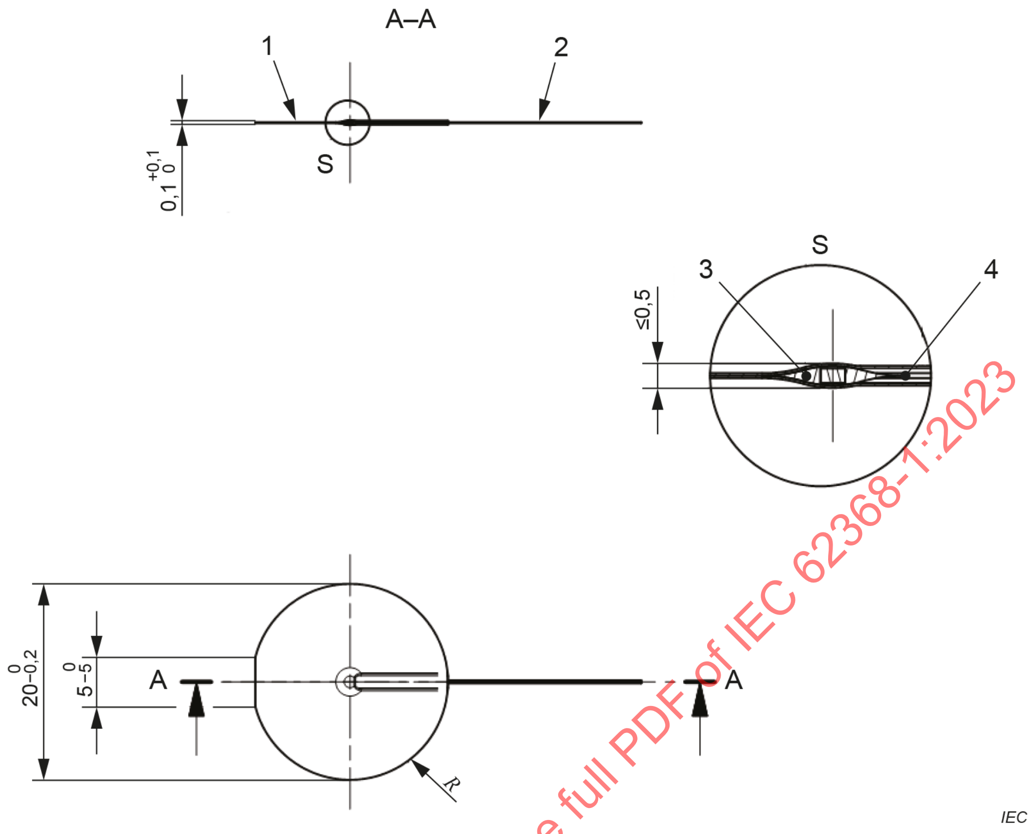
Dimensions en millimètres



N°	Nom	Remarques
1	Bague	Aluminium (AlSiIMg1Mn 100 Hv, par exemple)
2	Thermocouple	Tout type approprié
3	Composé dissipateur thermique	Transfert de chaleur
4	Tuyau en silicone	Relâchement des contraintes

Figure 50 – Bague en aluminium

Dimensions en millimètres



N°	Nom	Remarques
1	Feuille	Al 99,5 %
2	Thermocouple	Tout type approprié
3	Composé dissipateur thermique	Transfert de chaleur
4	Tuyau en silicone	Relâchement des contraintes (ou utilisation d'une couche de colle sur la feuille)

Figure 51 – Feuille d'aluminium

9.6.3 Méthode d'essai et critères de conformité

*L'**émetteur de puissance sans fil** est placé dans une pièce aux conditions de température spécifiées en 9.3.2.*

L'essai est divisé en deux parties (partie A et partie B). Pendant chaque partie, le centre de la bobine de réception doit être aligné sur le centre de la bobine de transmission. Les essais effectués à distance nécessitent normalement l'emploi d'entretoises d'une épaisseur de (2,0 ± 0,5) mm et de (5,0 ± 0,5) mm. Le cadre (le cas échéant) et l'entretoise peuvent être intégrés.

L'émetteur est mis en fonctionnement pour émettre à sa puissance maximale. Une méthode fiable doit être utilisée pour faciliter la sécurisation des objets étrangers, de l'émetteur et du récepteur. Les méthodes suivantes peuvent être considérées comme des méthodes fiables:

– *un cadre avec:*
  - *un matériau thermorésistant, par exemple le polyétheréthercétone (PEEK);*
  - *des dimensions extérieures assurant le maintien de l'émetteur et du récepteur; et*
  - *une découpe destinée à recevoir un objet étranger et le thermocouple associé; ou*

– *un ruban capable d'assurer l'adhérence pendant toute la durée de l'essai; ou*

– *un autre moyen d'assurer l'alignement tout au long de l'essai; ou*

– *une combinaison des éléments ci-dessus.*

Pendant chaque cycle, l'objet étranger doit être déplacé sur l'émetteur afin de déterminer la température la plus élevée.

Partie A: L'essai est réalisé en mettant l'émetteur sous tension, puis en plaçant chacun des objets étrangers spécifiés en 9.6.2 en contact direct avec l'émetteur. Cette partie comprend quatre cycles:

– *l'un sans présence d'un récepteur et avec l'objet étranger en contact direct avec l'émetteur; et*

– *l'un avec un récepteur placé en contact direct avec l'objet étranger; et*

– *l'un avec un récepteur placé à 2 mm à la verticale de l'objet étranger; et*

– *l'un avec un récepteur placé à 5 mm à la verticale de l'objet étranger.*

Partie B: L'essai est répété en plaçant d'abord chacun des objets étrangers spécifiés en 9.6.2 en contact direct avec l'émetteur, puis en mettant l'émetteur sous tension. Les quatre cycles de la Partie A sont ensuite répétés.

Pendant les essais des Parties A et B:

– *la température de l'objet étranger ne doit pas dépasser 85 °C pour le disque en acier, 120 °C pour l'anneau d'aluminium et 155 °C pour la feuille d'aluminium; et*

– *la température de l'émetteur ne doit pas dépasser les limites TS2 spécifiées dans le Tableau 37.*

10 Rayonnements

10.1 Généralités

Pour réduire la probabilité de douleurs et de blessures causées par l'énergie optique (rayons visibles, IR, UV), les rayons X et l'énergie acoustique, l'équipement doit être équipé 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 38.

Tableau 38 – Classifications des sources d'énergie de rayonnement

Source		RS1	RS2	RS3
Lasers	systèmes de télécommunication par fibres optiques (STFO)	Conformément à l'IEC 60825-2		
	systèmes de communications optiques en espace libre utilisés pour la transmission d'informations	Conformément à l'IEC 60825-12		
	Autres lasers, sauf ceux utilisés dans les projecteurs d'images	Conformément à l'IEC 60825-1:2014 [a]		
Lampes et systèmes de lampes (y compris les LED), sauf ceux utilisés dans les projecteurs d'images		Conformément à l'IEC 62471:2006 [b]		
Projecteurs d'images (vidéoprojecteurs)	Projecteurs d'images avec lasers	Conformément à l'IEC 60825-1:2014 [a] ou à l'IEC 62471-5:2015 si applicable		
	Projecteurs d'images avec des lampes ou des LED	Conformément à l'IEC 62471-5:2015		
Rayons X		≤ 36 pA/kg à 50 mm [c]	≤ 185 pA/kg à 100 mm [d]	> RS2
Pression acoustique maximale d'un PMP [e]	sortie acoustique	≤ 85 dB(A)	≤ 100 dB(A)	> RS2
	sortie analogique	≤ 27 mV	≤ 150 mV	> RS2
	sortie numérique	≤ –25 **dBFS**	≤ –10 **dBFS**	> RS2
Exposition à la dose acoustique maximale d'un PMP [e]	sortie acoustique	100 % de la CSD = ≤ 80 dB(A) / 40 h	≤ 100 dB(A)	> RS2
	sortie analogique	≤ 15 mV	≤ 150 mV	> RS2
	sortie numérique	≤ –30 **dBFS**	≤ –10 **dBFS**	> RS2

[a] Des considérations supplémentaires relatives aux produits laser conçus pour fonctionner comme des lampes conventionnelles (projecteur d'images laser, par exemple) sont indiquées à la Note 2 de 10.3.

NOTE 1 Par exemple, dans l'IEC 60825-1:2014, les Classe 1, Classe 1C, Classe 1M, Classe 2, Classe 2M, Classe 3R, Classe 3B et Classe 4 sont définies. Il ne s'agit pas de classifications de la source d'énergie de rayonnement elle-même.

[b] Pour classifier le groupe de risque, les **conditions anormales de fonctionnement** et les **conditions de premier défaut** doivent être prises en compte.

En général, le rayonnement des applications à faible puissance d'une lampe appartient au groupe sans risque. De même, la classification selon l'IEC 62471 (toutes les parties) n'est pas exigée pour:

– les voyants de signalisation;

– les **dispositifs** à infrarouge tels que ceux utilisés dans les **dispositifs** (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;

– les rayonnements UV des lampes fluorescentes et incandescentes universelles, avec des enveloppes en verre ordinaire; et

– les autres **dispositifs** analogues à faible puissance.

NOTE 2 Si le rayonnement optique est un rayonnement IR-A visible à large bande et que 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 l'IEC 62471:2006 (voir 4.1 de l'IEC 62471:2006).

Pour les limites UV-C (longueurs d'onde comprises entre 180 nm et 200 nm), la valeur donnée dans l'IEC 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 protection radiologique (ICRP, *International Commission on Radiation Protection*).

d 185 pA/kg est égal à 25 µSv/h ou 2,5 mR/h.

Le mesurage est effectué, toute partie du coffret, du boîtier et du châssis étant retirée selon les instructions d'entretien (tube cathodique exposé), à la tension d'essai maximale applicable et dans les conditions spécifiées ci-dessous.

NOTE 3 Dans les pays membres du CENELEC, le taux de rayonnements ionisants est réglementé par la directive européenne 2013/59/Euratom.

NOTE 4 Aux Etats-Unis, les conditions de mesure données dans la partie 1020 du titre 21 du code des règlements fédéraux des Etats-Unis sont les suivantes (pour les exigences complètes, voir les règlements ci-dessus).

Les mesurages sont effectués avec l'EUT connecté à la source d'alimentation suivante:

– 130 V si la **tension assignée** est comprise entre 110 V et 120 V; ou
– 110 % de la **tension assignée** si la **tension assignée** n'est pas comprise entre 110 V et 120 V.

Pendant les mesurages:

– 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 tout composant ou le mauvais fonctionnement d'un circuit qui entraîne une augmentation des émissions à rayonnement X doivent être simulés.

NOTE 5 Au Canada, les conditions de mesure données dans la partie c.1370 de la Codification des règlements du Canada sont les suivantes (pour les exigences complètes, voir les règlements ci-dessus).

Les mesurages sont effectués avec l'EUT connecté à la source d'alimentation suivante:

– 127 V si la **tension assignée** est comprise entre 110 V et 120 V; ou
– 110 % de la **tension assignée** si la **tension assignée** n'est pas comprise entre 110 V et 120 V.

Pendant les mesurages, toutes les commandes utilisateur et de service **accessibles** sont réglées en fonction des combinaisons qui produisent des émissions à rayonnement X maximales.

e Les mesures dans les **conditions de premier défaut** ne sont pas exigées pour les **dispositifs** d'écoute et les lecteurs de musique individuels.

10.2.2 RS1

Pour les sources de rayonnement X, RS1 est une source d'énergie de rayonnement de classe 1 qui ne dépasse pas les limites de RS1 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**.

Pour les sources de rayonnement acoustique, RS1 est une source d'énergie de rayonnement de classe 1 qui ne dépasse pas les limites de RS1 dans:

– les **conditions normales de fonctionnement**; et
– les **conditions anormales de fonctionnement**.

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
– les **conditions anormales de fonctionnement**; et
– les **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
– les **conditions anormales de fonctionnement**; ou
– les **conditions de premier défaut**.

10.3 Protections contre le rayonnement laser

Les équipements contenant des lasers doivent satisfaire aux exigences indiquées dans le Tableau 38.

Lors de l'application de la série IEC 60825, les exigences du présent document doivent être prises en compte, en particulier celles concernant:

– la robustesse d'une **protection** (voir 4.4.3);
– les conditions de fonctionnement (voir Annexe B); et
– les **verrouillages de sécurité** (voir Annexe K).

Les équipements laser destinés à être utilisés par une **personne ordinaire** ou une **personne avertie** ne doivent pas être de Classe 3B ni de Classe 4.

NOTE 1 La législation nationale et régionale en matière de santé et de sécurité au travail, et de grand public (produits de grande consommation, par exemple) peut contenir des exigences supplémentaires ou différentes.

NOTE 2 Pour les produits laser conçus pour fonctionner comme des lampes conventionnelles (projecteur d'images laser, par exemple), voir 4.4 de l'IEC 60825-1:2014. Pour des considérations supplémentaires relatives à ce type d'équipement, voir 10.4.

La conformité est vérifiée par évaluation des fiches techniques disponibles, par examen et, si nécessaire, par des mesurages.

NOTE 3 Pour obtenir des recommandations concernant les techniques de mesure, consulter la série IEC 60825.

10.4 Protection contre les rayonnements optiques des lampes et systèmes de lampes (y compris à LED)

10.4.1 Exigences générales

Les équipements émettant des rayonnements optiques doivent satisfaire aux exigences indiquées dans le Tableau 38.

Les exigences du 10.4 ne s'appliquent pas aux équipements pour jeux de lumière électroniques. Cependant, des instructions d'installation adaptées doivent être fournies.

Pour les lampes utilisées dans d'autres équipements, ce qui suit s'applique:

Les rayonnements qui n'ont pas besoin d'être **accessibles** pour le bon fonctionnement de l'équipement ne doivent pas dépasser le niveau indiqué dans le Tableau 39. S'il est nécessaire que le niveau de rayonnement **accessible** pour le bon fonctionnement de l'équipement dépasse les niveaux indiqués dans le Tableau 39, l'équipement doit être équipé d'une **protection par instructions** conformément au 10.4.3.

NOTE La législation nationale en matière de santé et de sécurité au travail peut établir des exigences supplémentaires ou différentes.

Tableau 39 – Niveau de rayonnement admis conformément à l'IEC 62471 pour chaque type de danger

Type de danger	Longueur d'onde	Niveau de rayonnement admis
Danger lié aux ultraviolets	200 nm à 400 nm	Groupe sans risque
Danger de lumière bleue pour la rétine	300 nm à 700 nm	Groupe sans risque ou Groupe de risque 1
Danger thermique rétinien	380 nm à 1 400 nm	Groupe sans risque ou Groupe de risque 1
Danger infrarouge pour la cornée et le cristallin	780 nm à 3 000 nm	Groupe sans risque
Danger thermique rétinien, stimulus visuel faible	780 nm à 1 400 nm	Groupe sans risque

Les lampes et systèmes de lampes destinés à être utilisés par une **personne ordinaire** ou une **personne avertie** ne doivent pas émettre d'énergie du Groupe de risque 3.

Le groupe de risque, qui repose sur la classification de la série IEC 62471, doit être marqué sur l'équipement. Si la taille ou la conception du produit ne permet pas d'apposer correctement le marquage, ce dernier doit être apposé sur l'emballage et inclus dans les instructions utilisateur. Si le niveau de rayonnement **accessible** ne dépasse pas le niveau spécifié dans le Tableau 39, le marquage n'est pas exigé.

Si un **verrouillage de sécurité** est utilisé pour réduire le niveau de rayonnement, il doit réduire le rayonnement aux niveaux admis spécifiés dans le Tableau 39.

Si l'équipement émet des rayonnements optiques correspondant à plusieurs types de dangers, voir également 10.4.3.

Il convient que le manuel de l'utilisateur fournisse les informations suivantes pour le bon fonctionnement et la bonne installation. Ces informations doivent également être fournies pour le fonctionnement en toute sécurité par une **personne qualifiée** qui peut être exposée à des niveaux d'énergie du Groupe de risque 3:

– des instructions adéquates pour le montage correct, l'installation, la maintenance et l'utilisation en toute sécurité, y compris des mises en garde claires concernant les précautions à prendre pour éviter une éventuelle exposition à des rayonnements optiques dangereux; et
– des conseils sur les procédures pour un fonctionnement en toute sécurité, et des mises en garde relatives à un **mauvais usage raisonnablement prévisible**, aux dysfonctionnements et aux modes de défaillance dangereux. Si les procédures d'entretien et de maintenance sont détaillées, il convient dans la mesure du possible qu'elles incluent des instructions explicites sur les procédures de sécurité à suivre; et
– il convient de reproduire le marquage sur l'équipement dans le manuel de l'utilisateur. Un fond jaune n'est pas exigé dans le manuel de l'utilisateur.

10.4.2 Exigences pour les protections d'équipements

L'**enveloppe** de protection contre les rayonnements optiques qui n'a pas besoin d'être **accessible** pour le bon fonctionnement de l'équipement et qui dépasse le niveau spécifié dans le Tableau 39 doit satisfaire au 4.4.3 et est considérée comme une **protection renforcée**.

Les matériaux qui constituent 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. Les matériaux en métal, en verre et en céramique sont considérés comme étant résistant à la dégradation.

10.4.3 Protection par instructions

Pour les projecteurs d'images, la **protection par instructions** doit satisfaire aux exigences de 6.5.4 et 6.5.5 de l'IEC 62471-5:2015 pour le Groupe de risque 2 et le Groupe de risque 3, respectivement.

Pour les projecteurs d'images avec des lampes, la mise en garde de l'IEC 62471-5:2015 doit être utilisée comme une **protection par instructions**.

Pour tous les autres équipements avec des lampes, une **protection par instructions** conforme à l'Article F.5 doit être utilisée. La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: le symbole de rayonnement UV 

, IEC 60417-6040:2010-08 pour les dangers liés aux ultraviolets; ou

le symbole de rayonnements visibles , IEC 60417-6041:2010-08 pour les dangers liés à la lumière bleue pour la rétine et les dangers thermiques rétiniens; ou

le symbole de rayonnements IR 

, IEC 60417-6151:2012-02 pour les dangers infrarouges pour la cornée et le cristallin et les dangers thermiques rétiniens, stimuli visuels faibles

– élément 2: Selon le Tableau 40 ou texte équivalent

– élément 3 et élément 4: Selon le Tableau 41 ou texte équivalent

L'élément 1a et l'élément 2 doivent être noirs sur fond jaune.

Tableau 40 – Marquage de l'équipement en fonction du groupe de risque lié au danger

Danger	Groupe sans risque	Groupe de risque 1	Groupe de risque 2	Groupe de risque 3
Danger lié aux ultraviolets 200 nm à 400 nm	Non exigé	AVIS Ultraviolets émis par ce produit	ATTENTION Ultraviolets émis par ce produit.	MISE EN GARDE Ultraviolets émis par ce produit.
Danger de lumière bleue pour la rétine 300 nm à 700 nm	Non exigé	Non exigé	ATTENTION Rayonnements optiques potentiellement dangereux émis par ce produit	MISE EN GARDE Rayonnements optiques potentiellement dangereux émis par ce produit
Danger thermique rétinien 380 nm à 1 400 nm	Non exigé	Non exigé	ATTENTION Rayonnements optiques potentiellement dangereux émis par ce produit	MISE EN GARDE Rayonnements optiques potentiellement dangereux émis par ce produit
Danger infrarouge pour la cornée et le cristallin 780 nm à 3 000 nm	Non exigé	AVIS Infrarouges émis par ce produit	ATTENTION Infrarouges émis par ce produit	MISE EN GARDE Infrarouges émis par ce produit.
Danger thermique rétinien, stimulus visuel faible 780 nm à 1 400 nm	Non exigé	MISE EN GARDE Infrarouges émis par ce produit	MISE EN GARDE Infrarouges émis par ce produit.	MISE EN GARDE Infrarouges émis par ce produit.

Tableau 41 – Explication des informations de marquage et recommandations concernant les mesures de contrôle

Danger	Groupe sans risque	Groupe de risque 1	Groupe de risque 2	Groupe de risque 3
Danger lié aux ultraviolets 200 nm à 400 nm	Non exigé	Limiter le plus possible l'exposition des yeux et de la peau. Utiliser une protection appropriée.	Une exposition peut provoquer des irritations des yeux et de la peau. Utiliser une protection appropriée.	Eviter d'exposer les yeux ou la peau à un produit non protégé.
Danger de lumière bleue pour la rétine 300 nm à 700 nm	Non exigé	Non exigé	Ne pas regarder fixement la lampe en fonctionnement. Peut être nocif pour les yeux.	Ne pas regarder la lampe en fonctionnement. Des blessures oculaires peuvent en résulter.
Danger thermique rétinien 380 nm à 1 400 nm	Non exigé	Non exigé	Ne pas regarder fixement la lampe en fonctionnement. Peut être nocif pour les yeux.	Ne pas regarder la lampe en fonctionnement. Des blessures oculaires peuvent en résulter.
Danger infrarouge pour la cornée et le cristallin 780 nm à 3 000 nm	Non exigé	Utiliser un écran approprié ou une protection oculaire appropriée.	Eviter d'exposer les yeux. Utiliser un écran approprié ou une protection oculaire appropriée.	Eviter d'exposer les yeux. Utiliser un écran approprié ou une protection oculaire appropriée.
Danger thermique rétinien, stimulus visuel faible 780 nm à 1 400 nm	Non exigé	Ne pas regarder fixement la lampe en fonctionnement.	Ne pas regarder fixement la lampe en fonctionnement.	Ne pas regarder la lampe en fonctionnement.

Si l'équipement émet des rayonnements optiques dans plusieurs zones dangereuses du spectre, il doit être classé pour le cas le plus restrictif. Si les rayonnements optiques dans une zone du spectre exigent la présence d'un marquage conforme au Tableau 40 ou au Tableau 41, toutes les mises en garde pertinentes doivent être incluses. Par exemple, pour une lampe relevant du Groupe de risque 3 pour un danger IR rétinien et émettant des ultraviolets au niveau du Groupe de risque 2, le marquage doit indiquer le Groupe de risque 3, avec le texte de "Mise en garde" approprié, et présenter le texte "Attention" correspondant au Groupe de risque 2 pour les UV, mais ne doit pas mentionner explicitement le Groupe de risque 2 (voir Figure 52).

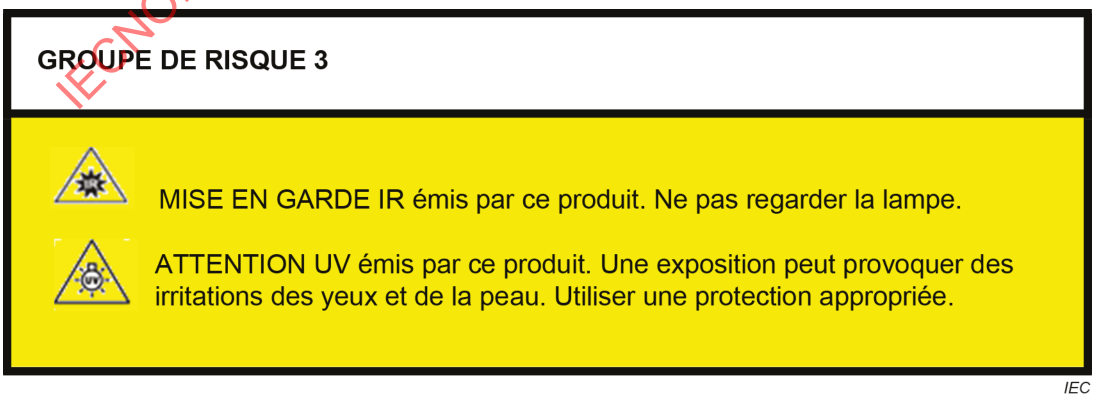


Figure 52 – Exemple d'étiquette de mise en garde pour une lampe avec plusieurs zones dangereuses du spectre

10.4.4 Critères de conformité

La conformité est vérifiée par évaluation des fiches techniques disponibles, par examen et, si nécessaire, par des mesurages.

NOTE Pour obtenir des recommandations concernant les techniques de mesure, consulter les parties applicables de la série IEC 62471.

La conformité par rapport aux détériorations des matériaux dues aux rayonnements 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 du 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 avec une surface effective de 1 000 mm^2 ou au moyen d'équipements de mesure d'autres types qui donnent des résultats équivalents.

*Les mesurages sont réalisés 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'époxy ou de matériaux analogues sont considérés comme des moyens de blocage sûrs.

*De plus, le mesurage doit être effectué 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 le mesurage est effectué et moyenné sur 5 min.*

Pendant les mesurages, 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 contournements sur une période de 1 h; et*
– *une résolution horizontale correspondant au moins à 1,5 MHz au centre, avec une dégradation verticale analogue.*

NOTE 2 Aux Etats-Unis et au Canada, une image intelligible est en synchronisation avec une couverture de 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 (PMP, *Personal Music Player*) est un équipement portatif 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.).

EXEMPLES Lecteurs de CD ou de minidisques portables, les lecteurs audio MP3, les téléphones portables de type MP3, les PDA ou des équipements analogues.

Les lecteurs de musique individuels doivent satisfaire aux exigences du 10.6.2 ou du 10.6.3.

NOTE 1 La protection contre les sources d'énergie acoustique issues des applications de télécommunication est référencée dans le document P.360 de l'UIT-T.

NOTE 2 Le Comité a l'intention d'autoriser d'autres méthodes, mais uniquement dans le but d'utiliser la méthode de mesure de dose (voir 10.6.3) qui sera spécifiée ultérieurement. Par conséquent, les fabricants sont invités à mettre en œuvre 10.6.3 dès que possible.

Les **dispositifs** d'écoute vendus séparément doivent satisfaire aux exigences du 10.6.6.

Ces exigences s'appliquent au mode audio (musique) ou vidéo uniquement.

Pour les équipements clairement conçus ou essentiellement destinés à être 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.

Les exigences ne s'appliquent à aucun des éléments suivants:

– **équipements professionnels**;
– appareils de correction auditive et autres **dispositifs** d'aide à l'audition;
– 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, car cette technologie n'est pratiquement plus utilisée et qu'elle devrait disparaître d'ici quelques années. Cette exemption n'est pas étendue à d'autres technologies.
– lecteur raccordé à un amplificateur externe qui ne permet pas 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) et avec un connecteur propriétaire entre le lecteur et son **dispositif** d'écoute ou lorsque la combinaison lecteur/**dispositif** d'écoute est connue par d'autres moyens (réglage ou détection automatique, par exemple), la sortie acoustique $L_{\mathrm{Aeq},T}$ doit être inférieure ou égale à la valeur de sortie acoustique RS1 correspondante du Tableau 38 lors de la lecture du "bruit de simulation de programme" fixe décrit dans l'EN 50332-1;
– pour les équipements équipés d'un connecteur normalisé (prise téléphonique de 3,5 mm, par exemple) permettant de connecter un **dispositif** d'écoute pour un usage général, la tension de sortie efficace non pondérée doit être inférieure ou égale à la valeur de sortie analogique RS1 correspondante du Tableau 38 lors de la lecture du "bruit de simulation de programme" fixe décrit dans l'EN 50332-1;
– pour les équipements fournis avec une sortie numérique, le signal de sortie doit être inférieur ou égal à la valeur de sortie numérique RS1 correspondante du Tableau 38 lors de la lecture du "bruit de simulation de programme" fixe décrit dans l'EN 50332-1.

NOTE 1 Sauf spécification contraire dans le présent document, lorsque le terme "sortie acoustique" est utilisé en 10.6.2, $L_{\mathrm{Aeq},T}$ correspond au niveau de pression acoustique équivalent pondéré A sur 30 s.

Si le lecteur est en mesure d'analyser une chanson et lorsque la pression acoustique moyenne (longue durée $L_{\mathrm{Aeq},T}$) mesurée sur la durée d'une chanson est inférieure à la moyenne produite par le bruit de simulation de programme, la sortie est considérée comme appartenant à la classe RS1 tant que la pression acoustique moyenne de la chanson ne dépasse pas 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 $L_{\mathrm{Aeq},T}$) largement inférieure au bruit de simulation de programme moyen.

Par exemple, si le lecteur est réglé sur le bruit de simulation de programme à 85 dB(A), mais que la pression acoustique moyenne de la chanson n'est que de 65 dB(A), la sortie est considérée comme appartenant à la classe RS1 tant que le niveau acoustique moyen de la chanson n'est pas supérieur à la limite de base de 85 dB(A).

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) et avec un connecteur propriétaire entre le lecteur et son **dispositif** d'écoute ou lorsque la combinaison lecteur/**dispositif** d'écoute est connue par d'autres moyens (réglage ou détection automatique, par exemple), la sortie acoustique $L_{\mathrm{Aeq},T}$ doit être inférieure ou égale à la valeur de sortie acoustique RS2 correspondante du Tableau 38 lors de la lecture du "bruit de simulation de programme" fixe décrit dans l'EN 50332-1;
- pour les équipements équipés d'un connecteur normalisé (prise téléphonique de 3,5 mm, par exemple) permettant de connecter un **dispositif** d'écoute pour un usage général, la tension de sortie efficace non pondérée doit être inférieure ou égale à la valeur de sortie analogique RS2 correspondante du Tableau 38 lors de la lecture du "bruit de simulation de programme" fixe décrit dans l'EN 50332-1;
- pour les équipements fournis avec une sortie numérique, le signal de sortie doit être inférieur ou égal à la valeur de sortie numérique RS2 correspondante du Tableau 38 lors de la lecture du "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 Exigences relatives aux systèmes reposant sur la dose

10.6.3.1 Exigences générales

Les lecteurs de musique individuels doivent donner les mises en garde ci-dessous lors de l'essai réalisé conformément à l'EN 50332-3.

Le fabricant peut proposer des réglages facultatifs qui permettent aux utilisateurs de modifier le moment et la manière de recevoir les notifications et les mises en garde, afin d'améliorer l'expérience sans mettre en échec les **protections**. Cela permet aux utilisateurs d'être informés de la méthode qui répond au mieux à leurs capacités physiques et à leurs besoins d'utilisation du **dispositif**. Si ce type de réglages est proposé, un administrateur (contrôle parental, administrateurs professionnels/éducatifs, etc.) doit être en mesure de bloquer tous les réglages facultatifs dans une configuration spécifique.

Le lecteur de musique individuel doit être accompagné d'explications faciles à comprendre relatives au système de gestion des doses et à la manière de l'utiliser. Il convient que l'utilisateur n'oublie pas que d'autres sources peuvent contribuer de manière importante à l'**exposition acoustique** (le travail, les transports, les concerts, les clubs, le cinéma, les courses automobiles, etc.).

10.6.3.2 Mise en garde en fonction de la dose et diminution automatique

Lorsqu'une dose égale à 100 % de la CSD est atteinte (RS2) et qu'il y a une augmentation de la dose acoustique calculée tous les 100 % au minimum, le **dispositif** doit avertir l'utilisateur et exiger un acquittement. Si l'utilisateur n'envoie pas d'acquittement, le niveau de sortie doit diminuer automatiquement à RS1.

NOTE La valeur 100 % de la CSD repose sur une valeur de 80 dB(A) pendant 40 h.

Les mises en garde doivent au moins clairement indiquer que l'écoute au-dessus de 100 % de la CSD engendre des risques de dommages ou de perte auditive.

10.6.3.3 Mise en garde en fonction de l'exposition et exigences

L'exigence reposant uniquement sur la dose a pour objet d'informer et d'éduquer les utilisateurs en ce qui concerne la nécessité de pratiques d'écoute sûres.

Outre les exigences en fonction de la dose, un système doit par conséquent, au choix:

- limiter le niveau d'exposition intégré de 30 s (MEL30) à la limite RS2 correspondante du Tableau 38. Le temps d'établissement du limiteur doit être de 20 s ou plus rapide. Cette fonctionnalité de limitation est, après avoir appliqué le temps d'établissement de 20 s du limiteur PMP, doit être mesurée conformément à l'EN 50332-1 ou à l'EN 50332-2, selon le cas;
- mettre en garde l'utilisateur si le **niveau d'exposition momentané (MEL)** est supérieur ou égal à 100 dB(A). La mise en garde peut être visuelle ou sonore. Si la mise en garde est visuelle, elle doit rester visible pendant au moins 5 s. Si elle est sonore, elle doit interrompre le programme clairement et sans équivoque pendant au moins 1 s.

10.6.4 Méthodes de mesure

Toutes les commandes de volume doivent être réglées au maximum pendant les essais.

Les mesurages doivent être réalisés conformément à l'EN 50332-1 ou à l'EN 50332-2, selon le cas.

10.6.5 Protection des personnes

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.

NOTE 1 La commande de volume n'est pas considérée comme une **protection.**

Une **protection de l'équipement** doit empêcher l'exposition d'une **personne ordinaire** à une source RS2, sauf si toutes les conditions suivantes sont remplies:

- une **protection par instructions** est fournie (voir ci-dessous); et
- la **protection par instructions** est acquittée par l'utilisateur. Le niveau de sortie ne doit pas être supérieur à RS1 tant que l'acquittement n'a pas eu lieu. L'acquittement doit être répété au moins une fois toutes les 20 h d'écoute cumulées.

  NOTE 2 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.

Le niveau de sortie doit automatiquement revenir à un niveau de sortie qui ne dépasse pas RS1 lorsque l'alimentation est coupée.

Une **personne qualifiée** ne doit pas être exposée de manière non intentionnelle à RS3.

Lorsque cela est exigé, une **protection par instructions** conforme à l'Article F.5 doit être utilisée, sauf que la **protection par instructions** doit être placée sur l'équipement, sur l'emballage ou dans le manuel d'instructions. En variante, la **protection par instructions** peut être indiquée sur l'affichage de l'équipement en cours d'utilisation. La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: le symbole  de l'IEC 60417-6044 (2011-01)
– élément 2: "Pression acoustique élevée" ou texte équivalent
– élément 3: "Risque de détérioration de l'audition" ou texte équivalent
– élément 4: "Ne pas écouter à des niveaux de volume élevés pendant des périodes prolongées" ou texte équivalent

10.6.6 Exigences relatives aux dispositifs d'écoute (casques, écouteurs, etc.)

10.6.6.1 Dispositifs d'écoute avec fils à entrée analogique

Avec une sortie de pression acoustique L_{Aeq} de 94 dB(A) du **dispositif** d'écoute, et avec les réglages de volume et de son du **dispositif** d'écoute (commande de niveau de volume intégrée, fonction acoustique supplémentaire telle que l'égalisation, etc.) établis pour la combinaison de positions permettant d'optimiser le niveau de sortie acoustique mesuré, la tension d'entrée du **dispositif** d'écoute lors de la lecture du "bruit de simulation de programme" fixe décrits dans l'EN 50332-1 doit être ≥ 75 mV.

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.

10.6.6.2 Dispositifs d'écoute avec fils à entrée numérique

Avec un **dispositif** d'écoute permettant de lire le "bruit de simulation de programme" fixe décrit dans l'EN 50332-1, et avec les réglages de volume et de son du **dispositif** d'écoute (commande de niveau de volume intégrée, fonction acoustique supplémentaire telle que l'égalisation, etc.) établis pour la combinaison de positions permettant d'optimiser le niveau de sortie acoustique mesuré, la sortie acoustique $L_{\text{Aeq},T}$ du dispositif d'écoute doit être ≤ 100 dB(A) avec un signal d'entrée de –10 **dBFS**.

10.6.6.3 Dispositifs d'écoute sans fil

En mode sans fil,

– avec un **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 les réglages de volume et de son du **dispositif** de réception (commande de niveau de volume intégrée, fonction acoustique supplémentaire telle que l'égalisation, etc.) établis pour la combinaison de positions permettant d'optimiser le niveau de sortie acoustique mesuré pour le bruit de simulation de programme mentionné ci-dessus;
– la sortie acoustique $L_{\text{Aeq},T}$ du **dispositif** d'écoute doit être ≤ 100 dB(A) avec un signal d'entrée de –10 **dBFS**.

10.6.6.4 Méthode de mesure

Les mesurages doivent être réalisés conformément à l'EN 50332-2 selon le cas.

Annexe A
(informative)

Exemples d'équipements relevant du domaine d'application du présent document

Certains exemples d'équipements relevant du domaine d'application du présent document 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 d'instrument de musique)	Équipement de réception et amplificateurs audio et/ou vidéo, équipement destiné à l'alimentation d'autres équipements relevant du domaine d'application du présent document, instruments de musique électroniques et accessoires électroniques tels que générateurs de rythme, générateurs de tons, syntoniseurs et appareils analogues utilisés avec des instruments de musique électroniques ou non électroniques, équipement audio et/ou vidéo pour l'enseignement, vidéoprojecteurs, caméras et moniteurs vidéo, caméras de surveillance réseau, 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, tablettes, téléphones multifonctions, dispositifs vestimentaires, traceurs, imprimantes (y compris les imprimantes 3D), 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, kiosque télématique, 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 exhaustive; les équipements qui ne figurent pas dans cette liste ne sont pas forcément exclus 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 Applicabilité de l'essai

La présente Annexe B spécifie différents essais et différentes conditions d'essai applicables à l'équipement.

S'il est évident qu'un essai particulier ne s'applique pas ou qu'il n'est pas nécessaire après vérification des données disponibles, l'essai ne doit pas être effectué. Les essais inclus dans le présent document doivent être effectués uniquement s'ils sont en relation avec la sécurité.

Afin de savoir si un essai s'applique 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 l'emploi d'une **protection** afin de réduire la probabilité de blessures ou de départ de feu.

B.1.2 Type d'essai

Sauf spécification contraire, les essais spécifiés sont des **essais de type**.

B.1.3 Échantillons d'essai

Sauf spécification contraire dans le présent document, l'échantillon soumis à l'essai doit être représentatif de l'équipement réel ou doit être l'équipement réel proprement dit.

Au lieu d'effectuer les 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 du présent document. Si l'un de ces essais indique la probabilité d'une 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.1.4 Conformité par examen des données pertinentes

Dans le présent document, 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.1.5 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, celle-ci repose sur l'hypothèse selon laquelle la température ambiante du local d'essai est de 25 °C avec l'équipement en service. Le fabricant peut cependant spécifier une température ambiante maximale différente.

Sauf spécification contraire dans le présent document, 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 qui doivent être poursuivis jusqu'à l'obtention de températures en régime établi, le régime établi est considéré comme étant 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, le régime établi est considéré comme étant 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.

Pour les **conditions normales de fonctionnement**, les mesurages sont réalisés avec l'EUT fonctionnant à la tension d'alimentation la plus défavorable (voir B.2.3).

B.1.6 Conditions de sortie spécifiques

Lorsque l'équipement est conçu de telle sorte qu'une ou que plusieurs de ses sources d'alimentation exigent une charge, un protocole ou un logiciel spécifique pour activer la sortie d'alimentation, pour maintenir la sortie d'alimentation active ou pour atteindre la tension de sortie, le courant ou la puissance prévus disponibles dans les **conditions normales de fonctionnement**, les **conditions anormales de fonctionnement** et les **conditions de premier défaut**, une méthode visant à obtenir cette valeur en sortie doit être employée.

Si la source d'alimentation relève d'un type qui exige l'établissement d'une liaison ou la négociation avec une charge, ou qui détecte les charges de manière intelligente, et par conséquent n'autorise pas la sortie de tensions ou courants qui auraient normalement eu lieu dans des charges résistives, la source doit être connectée à un **dispositif** de terminaison ou à une impédance qui active la tension ou le courant de la source et génère la puissance dans les conditions spécifiées.

Si la source d'alimentation relève d'un type qui ne transmet pas de tensions ou de courants normaux dans une charge résistive, la source doit être connectée à un **dispositif** de terminaison ou à une impédance qui active la tension et génère les conditions les plus défavorables.

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, comme cela est spécifié par le fabricant;

– le mode de fonctionnement, y compris les chargements externes dus à l'équipement interconnecté; et

– l'ajustement d'une commande.

Pour les **amplificateurs audio** et les équipements comprenant un **amplificateur audio**, des conditions d'essai supplémentaires s'appliquent (voir Annexe E).

B.2.2 Fréquence d'alimentation

Afin de déterminer la fréquence d'alimentation la plus défavorable pour un essai, plusieurs fréquences dans la plage des **fréquences assignées** doivent être prises en compte (50 Hz et 60 Hz, par exemple), mais il n'est pas nécessaire de prendre en compte la tolérance sur une **fréquence assignée** (50 Hz ± 0,5 Hz, par exemple).

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** en courant alternatif et entre +20 % et −15 % pour le **réseau d'alimentation** en courant continu. Si le fabricant spécifie que l'équipement est destiné à n'être raccordé qu'à un système d'alimentation électrique conditionné (ASI, par exemple), une tolérance plus faible peut être établie si cet équipement est également accompagné d'instructions qui spécifient une telle restriction.

B.2.4 Tensions normales de fonctionnement

Les tensions suivantes doivent être prises en considération:

– les tensions normales de fonctionnement générées à l'intérieur de l'équipement, y compris les tensions de crête répétitives comme les tensions associées aux alimentations à découpage; et

– les tensions normales de fonctionnement générées à l'extérieur de l'équipement pour tous les ID du Tableau 13. Tout signal de sonnerie transmis par des **circuits externes**, comme cela est indiqué dans le Tableau 13, ID 1a, 1b, 1c et 2, doit également être inclus.

Les **tensions transitoires du réseau d'alimentation** générées en externe et les tensions transitoires du **circuit externe** ne doivent pas être prises en compte:

– lors de la détermination des **tensions de service**, parce que ces tensions transitoires ont été prises en compte dans les procédures de détermination des **distances d'isolement** minimales (voir 5.4.2); et

– 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 d'entrée ou la puissance d'entrée, les variables suivantes doivent être prises en considération:

– *les charges dues aux caractéristiques optionnelles, 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 pour utiliser de la puissance de l'EUT;*

– *les charges qui pourraient être connectées à une prise de courant normalisée 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.3;*

– *pour les équipements dont la fonction principale est d'afficher des images animées, les réglages suivants doivent s'appliquer:*

  - *le "signal à trois barres verticales" doit être utilisé tel que défini en 3.2.1.3 de l'IEC 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 comme cela est défini à l'Annexe E du présent document.*

Des charges artificielles peuvent être utilisées pour simuler de telles charges lors de l'essai.

Dans chacun des cas, les valeurs sont lues lorsque la puissance d'entrée ou le courant d'entrée s'est stabilisé. Si le courant ou la puissance varie pendant le cycle de fonctionnement normal, le courant ou la puissance en régime établi est consigné comme l'indication moyenne de la valeur, mesurée sur un ampèremètre ou un wattmètre en valeur efficace, sur une période représentative.

Pour l'équipement alimenté par le ***réseau d'alimentation****, la puissance d'entrée ou le courant d'entrée mesuré 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 %, les conditions à court terme n'étant pas prises en compte. Pour les équipements non alimentés par le* ***réseau d'alimentation****, le courant d'entrée ou la puissance d'entrée mesurés doivent être inférieurs ou égaux aux caractéristiques assignées des équipements.*

La conformité est vérifiée en mesurant le courant d'entrée ou la puissance d'entrée de l'équipement dans les conditions suivantes:

– *lorsque l'équipement contient plusieurs* ***tensions assignées****, la puissance d'entrée ou le courant d'entrée est mesuré pour chaque* ***tension assignée****; et*

– *lorsque l'équipement contient une ou plusieurs* ***plages de tensions assignées****, la puissance d'entrée ou le courant d'entrée est mesuré à chaque extrémité de chaque* ***plage de tensions assignées****:*

  • *lorsqu'une seule valeur du* ***courant assigné*** *ou de la* ***puissance assignée*** *est marquée, elle est comparée à la valeur la plus élevée de la puissance d'entrée ou du courant d'entrée mesuré dans la* ***plage de tensions assignées*** *correspondante, et*

  • *lorsque deux valeurs de* ***courant assigné*** *ou de* ***puissance assignée*** *sont marquées, séparées par un trait d'union, elles sont comparées aux deux valeurs mesurées 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 mesurées sur l'équipement doivent être conformes au B.2.6.2 ou au B.2.6.3, le cas échéant, toutes les températures étant exprimées en degrés Celsius (°C); où

T est la température mesurée sur la partie considérée dans les conditions d'essai spécifiées;

T_{max} est la température maximale spécifiée pour la conformité à l'essai;

T_{amb} est la température ambiante pendant l'essai;

T_{ma} est la température ambiante maximale spécifiée par le fabricant ou une température de 25 °C, si cette valeur est plus élevée.

B.2.6.2 Echauffement/refroidissement dépendant de la température de fonctionnement

En ce qui concerne les équipements dont la conception est telle que la valeur d'échauffement ou de refroidissement dépend de la température (par exemple, l'équipement contient un ventilateur qui s'accélère à mesure que la température augmente), le mesurage de la température est effectué 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.

En variante, la température peut être mesurée dans des conditions de température ambiante en mettant le **dispositif** de chauffage/refroidissement sur son réglage le plus inefficace ou en mettant en échec le **dispositif**.

B.2.6.3 Echauffement/refroidissement indépendant de la température de fonctionnement

En ce qui concerne les équipements dont la conception est telle que la valeur d'échauffement ou de refroidissement ne dépend pas de la température ambiante, la méthode spécifiée en B.2.6.2 peut être utilisée. En variante, 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 $(T_{\text{max}} + T_{\text{amb}} - T_{\text{ma}})$.

Pendant l'essai, il convient que T_{amb} ne dépasse pas T_{ma} sauf en cas d'accord entre toutes les parties impliquées.

B.2.6.4 Equipements destinés à être encastrés ou montés dans des baies

L'équipement destiné à être encastré ou monté dans des baies, ou à être intégré dans un équipement de plus grandes dimensions, est soumis à l'essai dans les conditions réelles ou simulées les plus défavorables spécifiées dans les instructions d'installation.

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, fournitures 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 à l'Annexe E;
– pour les équipements contenant 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; et
– pour les équipements qui utilisent de l'**isolant liquide** décrit en 5.4.12.1, une fuite de liquide.

Avant d'appliquer l'une des **conditions anormales de fonctionnement** susmentionnées, l'équipement doit être soumis aux **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 un par un recouverts de carton (papier rigide épais ou carton mince) d'une masse volumique minimale de 200 g/m^2, dont les dimensions ne sont pas inférieures à chaque surface soumise à l'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 doivent être recouvertes en même temps. Les surfaces extérieures ne doivent pas dépasser les limites de TS2 du Tableau 37;
– une **protection par instructions** doit être fournie conformément à l'Article F.5, excepté que l'élément 3 est facultatif.

  La **protection par instructions** doit comporter les éléments suivants:

  - élément 1a: non disponible
  - élément 2: "Ne pas couvrir les ouvertures de ventilation" ou texte équivalent
  - élément 3: facultatif
  - élément 4: "Cet équipement n'est pas destiné à être utilisé sur un support souple (literie, couvertures, etc.)." ou texte équivalent

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

Un équipement destiné à être alimenté par le **réseau d'alimentation** et équipé d'un **dispositif** de réglage de tension destiné à être réglé par une **personne ordinaire** ou une **personne avertie** est soumis à l'essai en plaçant 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 prises de courant et des socles femelles de connecteurs directement connectés au **réseau d'alimentation**, sont connectées aux impédances de charge les plus défavorables, y compris le court-circuit.

La source doit être reliée à un **dispositif** de terminaison ou à une impédance qui active la tension ou le courant de la source afin de générer les **conditions anormales de fonctionnement** les plus défavorables.

B.3.6 Polarité de batterie inversée

S'il est possible pour une **personne ordinaire** d'insérer les **batteries** remplaçables avec inversion de la polarité, 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.3.2.

B.3.8 Critères de conformité pendant et après les 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 satisfaire 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 de la simulation de **conditions de premier défaut**, les parties, fournitures 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
– compromettent 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** qui surcharge les bornes de sortie externes ou une **personne ordinaire** qui règle 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-circuit de deux broches quelles qu'elles soient et l'ouverture de n'importe quelle broche de composant, une à la fois; et
– une défaillance de l'**isolation fonctionnelle**.

B.4.2 Dispositif de contrôle de la température

A l'exception des **protections** de contrôle de la température, selon G.3.1 à G.3.4, un **dispositif** ou composant unique d'un circuit contrôlant la température durant les mesurages de température doit être mis en circuit ouvert ou court-circuité, si cette condition est la plus défavorable.

Les températures doivent être mesurées selon les indications de B.1.5.

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 par examen et par consultation des données disponibles, ou par l'essai du G.5.4.

B.4.4 Isolation fonctionnelle

B.4.4.1 Distances d'isolement pour l'isolation fonctionnelle

Sauf si la **distance d'isolement** pour l'**isolation fonctionnelle** est conforme:

– à la **distance d'isolement** pour l'**isolation principale**, comme cela est spécifié en 5.4.2; ou
– à la **distance d'isolement** pour l'**isolation principale** des cartes imprimées comme cela est spécifié dans le Tableau F.2 de l'IEC 60664-1:2020 pour les circuits utilisés dans des environnements de **degré de pollution** 1 et de **degré de pollution** 2; ou
– à l'essai de rigidité diélectrique du 5.4.9.1 pour l'**isolation principale**;

les **distances d'isolement** pour l'**isolation fonctionnelle** doivent être court-circuitées.

B.4.4.2 Lignes de fuite pour l'isolation fonctionnelle

Sauf si la **ligne de fuite** pour l'**isolation fonctionnelle** est conforme:

- à la **ligne de fuite** pour l'**isolation principale**, comme cela est spécifié en 5.4.3; ou
- à la **ligne de fuite** pour l'**isolation principale** des cartes imprimées comme cela est spécifié dans le Tableau F.5 de l'IEC 60664-1:2020 pour les circuits utilisés dans des environnements de **degré de pollution** 1 et de **degré de pollution** 2; ou
- à l'essai de rigidité diélectrique du 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

Sauf si l'**isolation fonctionnelle** est conforme

- à la distance de séparation indiquée dans le Tableau G.13; ou
- à l'essai de rigidité diélectrique du 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 semiconducteurs

Les électrodes dans les tubes électroniques et les broches des **dispositifs** semiconducteurs 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.

B.4.6 Court-circuit ou déconnexion des composants passifs

Les résistances, condensateurs, enroulements, haut-parleurs, VDR et autres composants passifs doivent être court-circuités ou déconnectés, si cette condition est la plus défavorable.

Ces **conditions de premier défaut** ne s'appliquent à aucun des éléments suivants:

- thermistances CTP conformes aux Articles 17, 19, J.17 et J.19 de l'IEC 60730-1:2013;
- thermistances CTP assurant l'action de type 2.AL spécifiée dans l'IEC 60730-1;
- résistances conformes aux essais cités en 5.5.6;
- condensateurs conformes à l'IEC 60384-14 et évalués selon 5.5.2 du présent document;
- composants d'isolation (optocoupleurs et transformateurs, par exemple) conformes aux exigences pour ces composants à l'Annexe G pour l'**isolation renforcée**;
- d'autres composants qui servent de **protection** conforme aux exigences correspondantes de l'Annexe G ou aux exigences de sécurité de la norme de composant IEC applicable.

B.4.7 Fonctionnement en continu des composants

Les moteurs, les bobines relais ou dispositifs analogues, 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 établi, 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 de distribution d'alimentation 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 afin de provoquer une alimentation en continu du composant.*

La durée de l'essai doit être la suivante:

– *pour 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 par suite d'autres conséquences de la condition de défaut simulée, si cette durée est plus courte; et*
– *pour les autres équipements et composants: 5 min ou jusqu'à l'interruption du circuit à la suite d'une défaillance du composant (un claquage, par exemple) ou par suite d'autres conséquences de la condition de défaut simulée, si cette durée est plus courte.*

B.4.8 Critères de conformité pendant et après les conditions de premier défaut

*Pendant et après une **condition de premier défaut**, une partie **accessible** ne doit pas dépasser la classe d'énergie correspondante spécifiée en 5.3, 8.3, en 9.4, 10.3, en 10.4.1, 10.5.1 et en 10.6.5 pour la personne concernée en fonction du danger considéré. Pendant et après les **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**.*

*Après une **condition de premier défaut** qui peut avoir un impact sur une isolation utilisée comme **protection**, l'isolation doit résister à l'essai de rigidité diélectrique du 5.4.9.1 pour l'isolation correspondante.*

*Pendant et après une **condition de premier défaut**, l'ouverture d'un conducteur sur une carte imprimée ne doit pas être utilisée comme **protection**, sauf dans les situations suivantes, auquel cas la condition de défaut doit être répétée 3 fois:*

– *il est admis que les conducteurs d'une carte imprimée à **matériau de classe V-1** ou à **matériau de classe VTM-1** s'ouvrent 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**.*

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 C définit les exigences et procédures d'essai applicables aux matériaux qui possèdent des propriétés de **protection** et qui sont exposés aux rayonnements UV.

C.1.2 Exigences

Les exigences suivantes s'appliquent aux équipements ou parties d'équipement exposés à des lampes qui produisent un rayonnement UV significatif dans le spectre compris entre 180 nm et 400 nm, et aux équipements pour installation extérieure exposés à la lumière du soleil.

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 rayonnements 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 pour la méthode d'essai	Rétention minimale après l'essai
Pièces fournissant un support mécanique	Résistance à la traction [a]	ISO 527 (toutes les parties)	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 du présent document	[d]

[a] Les essais de résistance à la traction et à la flexion doivent être effectués sur des éprouvettes dont l'épaisseur n'est pas supérieure aux épaisseurs réelles.

[b] La face de l'échantillon exposée aux rayonnements UV doit être en contact avec les deux points de charge lorsque la méthode aux trois points de charge est utilisée.

[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 les essais effectués sur des éprouvettes de 4,0 mm d'épaisseur pour les essais de choc Charpy sont considérés comme étant représentatifs d'autres épaisseurs, jusqu'à 0,75 mm.

[d] Il est admis que la **classe d'inflammabilité du matériau** varie tant qu'elle ne tombe pas au-dessous de la valeur spécifiée à l'Article 6 du présent document.

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 aux rayonnements 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 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 entre 16 h et 96 h, après quoi ils sont soumis à l'essai selon la norme correspondant à l'essai considéré.

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 l'essai en même temps que les échantillons conditionnés.

La rétention spécifiée dans le Tableau C.1 doit être utilisée.

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 pendant au moins 720 h. L'appareillage d'essai doit fonctionner avec une température de corps noir de 63 °C ± 3 °C dans une humidité relative de (50 ± 5) %; ou*
- *une lampe à arc au xénon (voir C.2.4) avec une exposition en continu pendant au moins 1 000 h. 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, une température du panneau noir de 63 °C ± 3 °C dans une humidité relative de (50 ± 5) %.*

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, doit être utilisé conformément aux procédures données dans l'ISO 4892-1 et l'ISO 4892-4 en utilisant un filtre de type 1, avec arrosage à l'eau.

C.2.4 Essai d'exposition à la lumière sous une lampe à arc au xénon

L'appareillage décrit dans l'ISO 4892-2:2013, ou son équivalent, est utilisé conformément aux procédures données dans l'ISO 4892-1 et l'ISO 4892-2 en utilisant le cycle 1 de la méthode A décrite dans le Tableau 3, sans arrosage à l'eau.

Annexe D
(normative)

Générateurs d'essai

D.1 Générateurs d'impulsions d'essai

Ces circuits produisent des impulsions d'essai, comme cela est indiqué 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; et
– l'impulsion du circuit 3 est représentative des tensions induites dans les câblages 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 des tensions transitoires dans les **circuits externes**, comme cela est indiqué dans le Tableau 13, ID 1a et 3a sans mise à la terre.

Le circuit 2 du Tableau D.1 produit des impulsions 1,2/50 µs (1,2 µs de temps de montée virtuel, 50 µs de temps virtuel à mi-hauteur) destinées à simuler des tensions transitoires dans les **circuits externes**, comme cela est indiqué dans le Tableau 13, ID 1b et 3a avec mise à la terre, ainsi que 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 (voir 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) doit rester substantiellement la même que dans des conditions de circuit ouvert. Les composants en parallèle avec la ***distance d'isolement*** *peuvent être déconnectés pendant cet essai.*

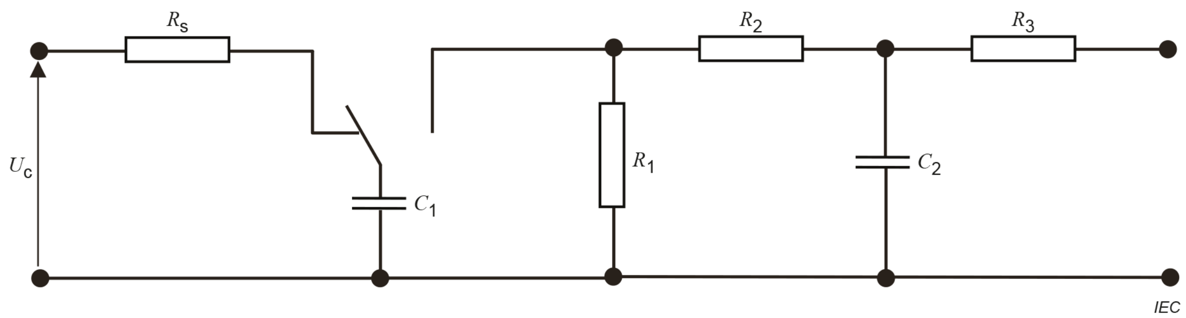


Figure D.1 – Générateur de tension de choc de 1,2/50 µs et 10/700 µs

D.2 Générateur d'essai de l'interface d'antenne

Le circuit de la Figure D.2, utilisant les valeurs de composants du circuit 3 du Tableau D.1, est utilisé pour générer des impulsions, le condensateur C_1 étant chargé initialement à la tension U_c.

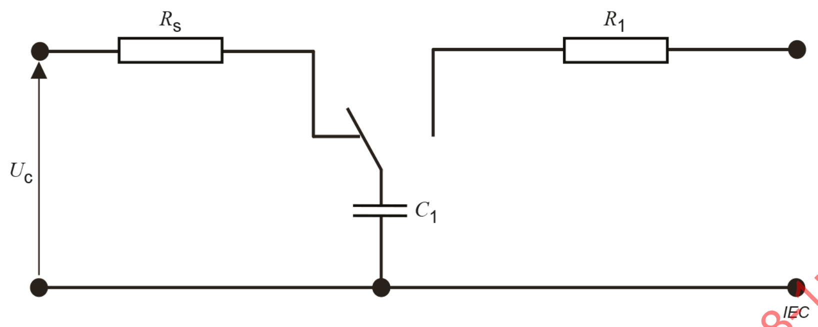


Figure D.2 – Circuit du générateur d'essai pour l'interface d'antenne

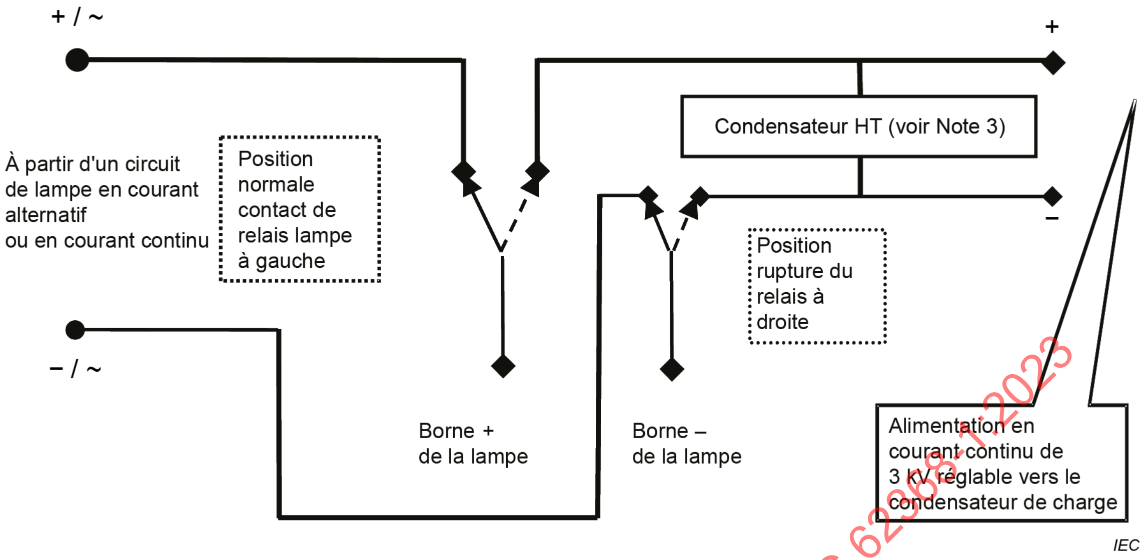
Tableau D.1 – Valeurs des composants pour la Figure D.1 et la Figure D.2

	Choc 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 reposent sur la recommandation K.44 de l'UIT-T.

D.3 Générateur d'impulsions électroniques



NOTE 1 La pression de fonctionnement de la lampe peut être convertie en énergie (Joules). Le niveau d'énergie de fonctionnement est généralement 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 l'IEC 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 électroniques

Annexe E
(normative)

Conditions d'essai pour les équipements destinés à amplifier les signaux audio

E.1 Classification des sources d'énergie électrique pour les signaux audio

Lors de la classification des signaux audio en source d'énergie électrique conformément au Tableau E.1, l'équipement doit fonctionner pour fournir la **puissance de sortie non écrêtée** maximale sur son **impédance assignée de charge**. 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.

Tableau E.1 – Classes de la source d'énergie électrique des signaux audio et protections

<table>
<tr><th>Classe</th><th>Tension de signal audio

V en valeur efficace</th><th>Exemples de protections entre la source d'énergie et une personne ordinaire</th><th>Exemples de protections entre la source d'énergie et une personne avertie</th></tr>
<tr><td>ES1</td><td>0 jusqu'à 71</td><td>Aucune protection nécessaire</td><td>Aucune protection nécessaire</td></tr>
<tr><td rowspan="2">ES2</td><td rowspan="2">Au-dessus de 71 et jusqu'à 120</td><td>Bornes isolées [a]
marquées ISO 7000,
symbole 0434a (2004-01) ou
symbole 0434b (2004-01)</td><td rowspan="2">Aucune protection nécessaire</td></tr>
<tr><td>Protection par instructions pour les parties non isolées des bornes et des câblages nus [b]</td></tr>
<tr><td>ES3</td><td>Au-dessus de 120</td><td colspan="2">Connecteurs conformes aux exigences de l'IEC 61984 et marqués du symbole de l'IEC 60417-6042 (2010-11)</td></tr>
<tr><td colspan="4">[a] Les bornes qui ne comportent pas de parties conductrices accessibles après l'installation des câblages sont installées conformément aux instructions.
[b] Une protection par instructions indiquant que le contact des bornes ou des câblages non isolés peut provoquer une sensation désagréable.</td></tr>
</table>

E.2 Signaux audio utilisés durant l'essai

E.2.1 Signal d'essai de bruit rose

Un signal d'essai de **bruit rose** de largeur de bande limitée doit être utilisé pour le fonctionnement, après l'établissement de la **puissance de sortie non écrêtée** à l'aide d'un signal sinusoïdal. Le signal d'essai du **bruit rose** doit être limité par un filtre passe-bande dont les caractéristiques sont représentées à la Figure E.1.

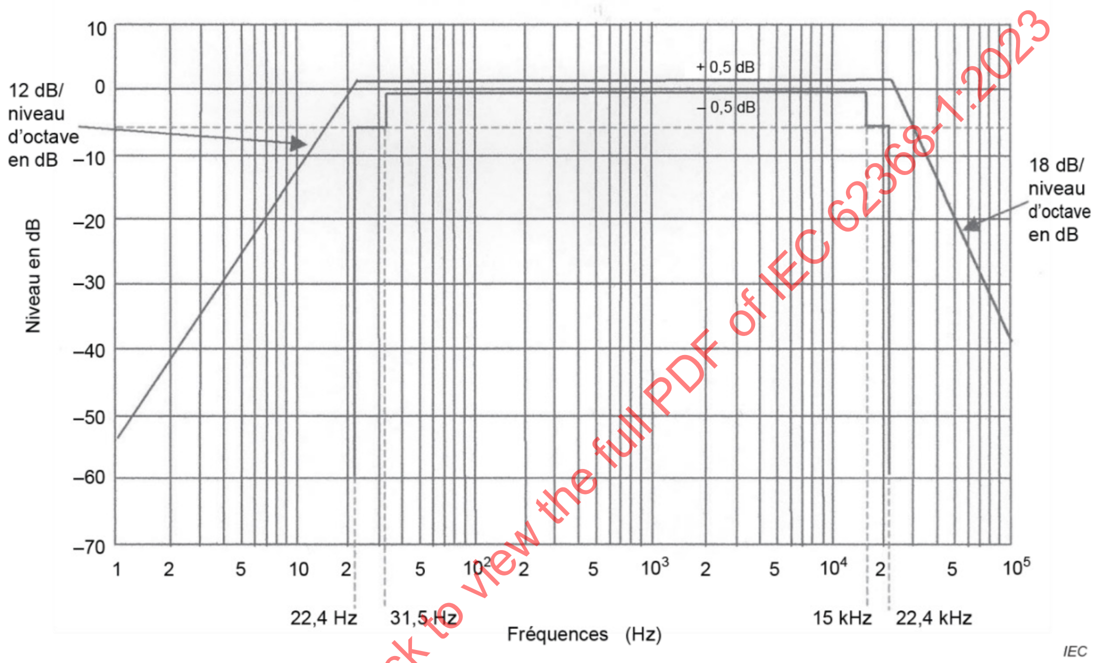
NOTE 1 Le filtre du **bruit rose** peut être intégré au générateur ou ajouté en externe.

L'équipement utilisé pour mesurer le signal de sortie doit indiquer les valeurs efficaces vraies pour des facteurs de crête jusqu'à au moins 3. La réponse en fréquence doit être au moins conforme à celle représentée à la Figure E.1.

Afin d'obtenir un signal d'essai de **bruit rose**, un signal à large bande peut être utilisé comme cela est spécifié en 6.1 de l'IEC 60268-1:1985, avec un filtre passe-bande dont la réponse en fréquence se situe dans les limites indiquées à la Figure E.1.

Un filtre passe-bande qui affiche un facteur de transmission substantiellement constant entre 22,4 Hz et 22,4 kHz et qui diminue en dehors de cette bande de fréquences à des taux spécifiés pour les filtres de bande d'octave affichant des fréquences à mi-bande de 31,5 Hz et 16 000 Hz spécifiés dans l'IEC 61260-1:2014 présente une réponse respectant les limites de la présente exigence.

Pour les mesurages en large bande, voir le 6.1 de l'IEC 60268-1:1985.



S'il existe des signaux puissants juste au-dessus ou au-dessous des limites de bande, les résultats dépendent dans une certaine mesure de la réponse en fréquence du filtre utilisé.

Figure E.1 – Filtre passe-bande pour le mesurage du bruit en bande large

E.2.2 Signal sinusoïdal

Lorsque la fonction d'amplification n'est pas altérée, une onde sinusoïdale de 1 kHz ou d'une fréquence correspondant à la moyenne géométrique entre les points de réponse supérieurs et inférieurs à –3 dB pour la partie pertinente de l'équipement peut être utilisée afin d'alimenter chaque canal.

Si le résultat mesuré à l'aide d'une onde sinusoïdale n'est pas conforme au présent document, le mesurage du signal d'essai du **bruit rose** est déterminant.

E.3 Conditions de fonctionnement d'un équipement contenant un amplificateur audio

E.3.1 Conditions normales de fonctionnement

La source doit être reliée à un dispositif de terminaison ou à une impédance qui active la source de tension ou de courant afin de générer les **conditions normales de fonctionnement** les plus défavorables.

NOTE La source est un équipement contenant un **amplificateur audio**, ou l'**amplificateur audio** lui-même.

Les équipements contenant un **amplificateur audio** doivent fonctionner comme suit:

– établir la **puissance de sortie non écrêtée** à l'aide d'une onde sinusoïdale décrite en E.2.2. Si un écrêtage visible ne peut pas être atteint, la puissance maximale atteignable doit être considérée comme la **puissance de sortie non écrêtée**. Définir la puissance de manière à fournir au minimum 1/8 de la **puissance de sortie non écrêtée** à l'**impédance assignée de charge** à l'aide d'un signal d'essai de **bruit rose** avec un filtre passe-bande comme cela est décrit en E.2.1. A la place du signal de **bruit rose**, les équipements peuvent fonctionner en utilisant une source de signal audio sinusoïdal comme cela est spécifié en E.2.2. Lorsqu'un amplificateur n'est pas conçu pour fonctionner à 1 000 Hz, la **fréquence de réponse de crête** doit être utilisée;

– les orgues ou instruments analogues qui comportent un générateur de tonalités et qui peuvent générer une tonalité continue ne doivent pas être mis en fonctionnement avec le signal de 1 000 Hz mais plutôt avec toute combinaison de deux touches de pédalier basse, s'il y en a, et avec dix touches manuelles enfoncées. Tous les registres et jeux qui peuvent augmenter la puissance de sortie doivent être activés, et l'équipement doit être réglé afin de fournir 1/8 de la puissance de sortie maximale atteignable;

– pour les **amplificateurs audio** utilisés dans un instrument de musique électronique qui ne génèrent pas une tonalité continue, le signal de **bruit rose** décrit en E.2.1 est appliqué à la borne d'entrée du signal ou à l'étage d'entrée approprié de l'**amplificateur audio** afin de fournir au minimum 1/8 de la puissance de sortie maximale atteignable.

De plus, tous les éléments suivants doivent être pris en considération:

– si l'utilisateur dispose des commandes de tonalité, ceux-ci doivent être réglés en position moyenne;

– l'**impédance assignée de charge** la plus défavorable ou le haut-parleur réel, lorsqu'il est fourni, est connecté à la sortie de l'amplificateur;

– toutes les voies de l'amplificateur fonctionnent en même temps;

– pour les équipements qui contiennent des amplificateurs multicanaux dont certains canaux ne peuvent pas fonctionner indépendamment, ces canaux doivent être mis en fonctionnement en utilisant l'**impédance assignée de charge** au niveau de puissance de sortie qui correspond, par conception, à au moins 1/8 de la **puissance de sortie non écrêtée** du canal ou des canaux d'amplificateur réglables;

– lorsqu'il n'est pas possible d'assurer un fonctionnement continu, l'amplificateur doit fonctionner au niveau maximal de puissance de sortie qui permet le fonctionnement continu;

– lorsque la fonction prévue de l'amplificateur dépend de la différence de phase entre deux canaux, il doit y avoir une différence de phase de 90° entre les signaux appliqués aux deux canaux.

E.3.2 Conditions anormales de fonctionnement

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 atteignable dans l'**impédance assignée de charge** la plus défavorable connectée aux bornes de sortie. Un court-circuit des bornes de sortie est également considéré comme une **condition anormale de fonctionnement**.

E.3.3 Conditions de mesure de la température de l'équipement audio

La température doit être mesurée en positionnant l'équipement conformément aux instructions fournies 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 ouverte à l'avant, en laissant un espace libre de 1 cm le long des côtés et de la partie supérieure de l'équipement et une profondeur de 5 cm à l'arrière de l'équipement.

Annexe F
(normative)

Marquages des équipements, instructions et protections par instructions

F.1 Généralités

La présente Annexe F 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 du présent document.

Sauf si des symboles sont 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 F ne s'applique pas au marquage des composants. Les marquages des composants sont spécifiés dans la norme de composant applicable.

La présente Annexe F peut s'appliquer aux **sous-ensembles** tels que les blocs d'alimentation. Les ensembles de composants et de parties qui nécessitent d'autres éléments pour former un équipement complet au sens du présent document sont considérés comme des **sous-ensembles** et ne sont pas considérés comme des composants. Il n'est pas nécessaire que ces **sous-ensembles** soient conformes aux exigences de la présente annexe.

NOTE 1 Lorsque le terme marquage est utilisé dans le présent document, il s'applique également aux instructions et aux éléments exigés d'une **protection par instructions**.

NOTE 2 Pour des exemples de marquages, consulter 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 le présent document, ne contredisent pas ceux exigés par le présent document.

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 l'IEC 60027-1.

F.2.2 Symboles graphiques

Les symboles graphiques placés sur l'équipement pour des raisons de sécurité, qu'ils soient exigés par le présent document ou non, doivent être conformes à l'IEC 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, le fabricant peut créer des symboles graphiques spécifiques et fournir leur signification dans le manuel d'instructions.

F.2.3 Critères de conformité

La conformité est vérifiée par examen.

F.3 Marquages des équipements

F.3.1 Emplacements des marquages d'équipement

Sauf spécification contraire dans le présent document, les marquages d'équipement doivent se trouver à proximité ou à côté de la pièce ou de la région à marquer.

Les marquages des équipements exigés en F.3.2, F.3.3, en F.3.6 et en F.3.7 doivent être apposés sur l'extérieur de l'équipement, à l'exception du fond, sauf spécification contraire dans le présent document ou si l'une des conditions suivantes est remplie:

1) ces marquages peuvent se trouver à un endroit aisément **accessible** à la main, par exemple:
   – sous un couvercle; ou
   – sur la surface extérieure du fond:
     • d'un **équipement à enficher directement**, d'un **équipement portatif**, d'un **équipement transportable;** ou
     • d'un **équipement mobile** d'une masse inférieure ou égale à 18 kg, sous réserve que l'emplacement du marquage soit fourni dans les instructions.
2) pour les équipements destinés à être montés sur une structure de support (baie, panneau, mur, plafond, par exemple) et si la surface extérieure de l'équipement devient en partie ou complètement invisible après l'installation, les marquages peuvent être placés sur une surface, y compris le fond, qui devient visible après le retrait de l'équipement de la structure de support.

Sauf s'il n'existe aucune confusion possible, l'emplacement des marquages exigés en F.3.3 et en F.3.6 doit toujours être aussi proche que possible du point de connexion, ou adjacent à celui-ci, même si le marquage est autorisé dans une zone aisément **accessible** à la main, sur le fond ou une autre surface autorisée.

Les marquages ne doivent pas être apposés sur des parties qui peuvent être retirées sans l'aide d'un **outil**, sauf s'ils s'appliquent uniquement à cette partie.

Pour les **équipements reliés en permanence**, les instructions d'installation doivent être fournies sous forme de marquages apposés sur l'équipement, dans les instructions ou dans un document d'instructions d'installation distinct.

Sauf si la signification du marquage est 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 Equipement avec connexion directe au réseau d'alimentation

Si un appareil est fourni avec un moyen de connexion directe au **réseau d'alimentation**, la caractéristique électrique assignée doit être marquée, comme cela est spécifié de F.3.3.3 à F.3.3.6.

F.3.3.2 Equipement sans connexion directe au réseau d'alimentation

Si un appareil n'est pas fourni avec un moyen de connexion directe au **réseau d'alimentation**, la caractéristique électrique assignée n'a pas à être marquée. Cependant, tout marquage de **puissance assignée** ou de **courant assigné** doit être conforme au B.2.5.

F.3.3.3 Nature de la tension d'alimentation

La nature de la tension d'alimentation, en courant continu, en courant alternatif ou triphasé alternatif, doit être marquée sur l'équipement et doit être placée à proximité des caractéristiques assignées de tension de l'équipement. Si un symbole est utilisé,

– le symbole ∼, IEC 60417-5032 (2002-10) doit être utilisé pour le courant alternatif;
– le symbole ⎓, IEC 60417-5031 (2002-10) doit être utilisé pour le courant continu;
– le symbole 3∼, IEC 60417-5032-1 (2002-10) doit être utilisé pour le courant alternatif triphasé;
– le symbole 3N∼, IEC 60417-5032-2 (2002-10) doit être utilisé pour le courant alternatif triphasé avec un conducteur neutre; ou
– le symbole ≂, IEC 60417-5033 (2002-10) doit être utilisé pour les tensions mixtes en courant alternatif et en 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.

La **tension assignée** peut être:

– une seule valeur nominale; ou
– une seule valeur nominale et un pourcentage de tolérance sur 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 plusieurs tensions nominales, 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). Si l'équipement est installé par une **personne qualifiée**, cette indication peut être placée dans les instructions d'installation ou à n'importe quel emplacement sur l'équipement, y compris à l'intérieur.

L'équipement multiphasé doit être marqué d'un symbole graphique conforme au F.3.3.3 ou à la notation alphanumérique des conducteurs désignés, en indiquant les caractéristiques du système d'alimentation électrique avec le nombre de phases conformément à l'IEC 61293, la tension phase-neutre, une barre oblique (/), la tension phase-phase, le symbole de 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.

EXEMPLE 3/N/PE ~ 230/400 V 50 Hz.

NOTE 1 La barre oblique (/) représente le mot "ou" et le trait d'union (-) représente le mot "à".

NOTE 2 En Australie et en Nouvelle Zélande, pour les équipements destinés à être raccordés au **réseau d'alimentation** en courant alternatif, une seule **tension assignée** doit être indiquée, 230 V ou 400 V, selon le cas. Si plusieurs **tensions assignées** ou une **plage de tensions assignées** sont indiquées, celles-ci doivent comprendre 230 V ou 400 V.

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 sur 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** est le courant d'une phase et la **puissance assignée** est la puissance totale des trois phases.

NOTE 1 Le B.2.5 établit des critères sur la manière dont sont mesurés le **courant assigné** ou la **puissance assignée**.

NOTE 2 Le **courant assigné** ou la **puissance assignée** n'ont pas à être marqués avec plus d'un chiffre significatif.

NOTE 3 Dans certains pays, pour les marquages sur les équipements, le séparateur de décimales utilisé est la virgule.

Si l'équipement comporte un socle de prise de courant 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 la puissance assignée ou le courant assigné du socle de 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 plusieurs **tensions assignées**, la **puissance assignée** ou le **courant assigné** pour chaque **tension assignée** doit être marqué sur l'équipement. La disposition des marquages doit clairement indiquer la **puissance assignée** ou le **courant assigné** associé à chaque **tension assignée** de l'équipement.

Les matériels avec une **plage de tensions assignées** peuvent être marqués avec le **courant assigné** maximal ou avec la plage de courant.

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 les différentes sources du **réseau d'alimentation** sont identiques, elles peuvent comporter un marquage indiquant le nombre d'alimentations.

EXEMPLE "240 V ~ / 10 A × N", où N représente le nombre de connexions d'alimentation de **réseau d'alimentation** identiques.

Si l'équipement comprend plusieurs connexions d'alimentation et que chaque connexion possède une **tension assignée** différente de celle des autres connexions d'alimentation, chaque connexion doit être marquée avec sa **tension assignée**.

Il n'est pas exigé de marquer les caractéristiques électriques assignées du système dans son intégralité.

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 utilise un **dispositif** de réglage de la tension qui peut être manipulé par une **personne ordinaire** ou une **personne avertie**, la modification du réglage de tension doit également modifier l'indication de la tension pour laquelle l'équipement est réglé. Le réglage doit être lisible dès que l'équipement est prêt à être utilisé.

Si l'équipement utilise un **dispositif** de réglage de la tension qui ne peut être manipulé que par une **personne qualifiée** et si la modification du réglage de tension ne modifie pas également l'indication des caractéristiques assignées de la tension, une **protection par instructions** doit préciser que, en cas de modification du réglage de tension, l'indication du réglage de 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 socles femelles de connecteurs et des socles de prises de courant reliés au réseau d'alimentation

Si un socle femelle de connecteur relié au **réseau d'alimentation** est fourni avec l'équipement, la **tension assignée** ainsi que la puissance assignée ou le courant assigné doivent être marqués à proximité du socle femelle de connecteur.

Si le socle de prise de courant du **réseau d'alimentation** est configuré conformément à l'IEC TR 60083 ou à une norme nationale pertinente, la puissance assignée ou le courant assigné doit être marqué. Si la tension du socle de prise de courant est identique à la tension du **réseau d'alimentation**, le marquage de la tension est facultatif.

F.3.5.2 Marquage d'identification de la position de l'interrupteur

La position d'un sectionneur 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 l'IEC 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 du 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:

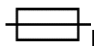
– si le fusible nécessite un pouvoir de coupure spécifique nécessaire à la fonction de **protection**, le symbole approprié indiquant le pouvoir de coupure;
– si le fusible peut être remplacé par un fusible de tension assignée différente, la tension assignée du fusible;
– si le fusible est un fusible temporisé et que la temporisation est nécessaire à la fonction de **protection**, le symbole approprié indiquant 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; et
– une **protection par instructions** adéquate doit être mise à disposition sur l'équipement ou dans les instructions d'entretien de manière à alerter une **personne qualifiée** d'un danger éventuel si les deux conditions suivantes sont réunies:
  - le fusible est utilisé dans:
    – les équipements équipés d'une fiche de prise de courant non polarisée; ou
    – le neutre des équipements équipés d'une fiche de prise de courant polarisée; ou
    – le neutre des **équipements reliés en permanence**; et
  - après le déclenchement du fusible, les parties de l'équipement qui restent sous tension aux niveaux ES3 peuvent induire un danger pendant l'entretien.

La **protection par instructions** doit comporter les éléments suivants:

– élément 1a: le symbole , IEC 60417-6042 (2010-11) et le symbole N , IEC 60417-5016 (2002-10) (modifié pour ajouter la notation alphanumérique N pour le conducteur neutre)
– élément 2: "DOUBLE PÔLE / FUSIBLE DANS LE NEUTRE" ou texte équivalent
– élément 3: facultatif
– élément 4: facultatif

Si un fusible n'est pas conçu pour être remplaçable, le marquage des caractéristiques assignées du fusible est facultatif.

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 fournie conformément à l'Article M.10.

F.3.5.5 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.3.5.6 Emplacement du marquage de bornes

Les marquages de bornes spécifiés en F.3.5.5, F.3.6.1 et F.3.6.3 ne doivent pas être placés sur les vis, les rondelles amovibles ou d'autres parties pouvant être déplacées lors du raccordement des conducteurs.

F.3.5.7 Critères de conformité

La conformité est vérifiée par examen.

F.3.6 Marquages d'équipements liés à leur classification

F.3.6.1 Matériel de classe I

F.3.6.1.1 Borne du conducteur de mise à la terre de protection

La borne prévue pour la connexion du **matériel de classe I** au **conducteur de mise à la terre de protection** de l'installation, doit être identifiée par le symbole ⏚, IEC 60417-5019 (2006-08).

Une borne prévue pour la connexion d'un **sous-ensemble** de classe I (bloc d'alimentation, par exemple) ou d'un composant (bloc de connexion, par exemple) au **conducteur de mise à la terre de protection de l'équipement** peut être identifiée par le symbole ⏚, IEC 60417-5019 (2006-08) ou le symbole ⏚, IEC 60417-5017 (2006-08).

F.3.6.1.2 Bornes des conducteurs de liaison de protection

L'identification des bornes des **conducteurs de liaison de protection** est facultative. Cependant, si de telles bornes sont identifiées, elles doivent être marquées par le symbole de terre ⏚, IEC 60417-5017 (2006-08). Toutefois, une borne de composant ou une borne de câblage de liaison sortant d'un socle de connecteur déjà marqué du symbole ⏚, IEC 60417-5019 (2006-08) est acceptable comme identification d'une borne de **conducteur de liaison de protection**.

F.3.6.2 Marquage de la classe d'équipement

Les **matériels de classe II** suivants, équipés d'une connexion de mise à la terre fonctionnelle doivent porter le symbole , IEC 60417-6092 (2013-03):

– les **équipements** utilisant un connecteur d'entrée de **réseau d'alimentation** de classe II et équipés d'une connexion séparée de **mise à la terre fonctionnelle**;

– les **équipements** utilisant un connecteur d'entrée de **réseau d'alimentation** de classe I avec la broche de mise à la terre reliée à la **mise à la terre fonctionnelle** exclusivement;

– les **équipements** utilisant un connecteur d'entrée de **réseau d'alimentation** de classe I avec la broche de mise à la terre non reliée à une **mise à la terre fonctionnelle** ou à une **mise à la terre de protection**, mais équipés d'une connexion de **mise à la terre fonctionnelle** distincte.

Tous les autres **matériels de classe II** doivent porter le symbole , IEC 60417-5172 (2003-02).

Les symboles ci-dessus ne doivent pas être utilisés pour les **matériels de classe I**.

Les matériels qui assurent la **mise à la terre de protection** à d'autres matériels ne doivent pas être classés parmi les **matériels de classe II**.

F.3.6.3 Marquage des bornes de mise à la terre fonctionnelle

Les bornes de câblage à utiliser uniquement pour la connexion de la **mise à la terre fonctionnelle** doivent être marquées du symbole , IEC 60417-5018 (2011-07). Ces bornes ne doivent porter ni le symbole , IEC 60417-5017 (2006-08) ni le symbole , IEC 60417-5019 (2006-08).

Cependant, ces symboles peuvent être utilisés sur une borne de câblage prévue sur un composant (bloc de connexion, par exemple) ou sur un **sous-ensemble**.

F.3.6.4 Critères de conformité

La conformité est vérifiée par examen.

F.3.7 Marquage de l'indice IP de l'équipement

Lorsqu'une construction IP est utilisée comme **protection:**

– la **protection** doit être conforme à l'IEC 60529; et

– le code IP doit être déclaré dans le manuel d'instructions ou sur l'équipement.

La conformité est vérifiée par examen.

F.3.8 Marquage de la sortie du bloc d'alimentation externe

Les caractéristiques suivantes doivent être marquées sur la sortie en courant continu d'un bloc d'alimentation externe:

– la caractéristique assignée de tension; et
– la caractéristique assignée de courant; et
– la polarité.

Le marquage de polarité n'est pas exigé si la configuration de broches empêche une inversion de la polarité.

Les caractéristiques suivantes doivent être marquées sur la sortie en courant alternatif d'un bloc d'alimentation externe:

– la caractéristique assignée de tension; et
– la caractéristique assignée de courant; et
– la fréquence, si celle-ci diffère de la fréquence d'entrée du bloc d'alimentation externe.

La conformité est vérifiée par examen et par mesurage.

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 dans le présent document, l'utilisation de couleurs pour la **protection par instructions** est facultative. Si une **protection par instructions** est en couleur en vue d'indiquer la sévérité du danger, la couleur doit être conforme à la série de normes ISO 3864. Les marquages gravés ou moulés peuvent n'ont pas à être apposés dans des couleurs contrastées, sous réserve 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 l'essai. Toutefois, si la fiche technique d'une étiquette confirme la conformité aux exigences d'essai, l'essai n'est pas nécessaire.

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 cela est 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". Le numéro CAS (American Chemical Society) du n-hexane est le CAS#110-54-3.

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 au présent document, 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 l'énoncé suivant ou un énoncé équivalent dans les instructions destinées à l'utilisateur.

Ces équipements ne sont pas adaptés à une utilisation dans des emplacements, où des enfants sont susceptibles d'être présents.

NOTE Cette conception d'équipements s'applique généralement aux équipements commerciaux prévus pour être installés dans des lieux n'accueillant normalement que des adultes.

Les instructions doivent comprendre les informations suivantes, s'il y a lieu:

– 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**, cela doit être indiqué dans les instructions;

– 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 qui comportent des bornes classées ES3 selon le Tableau E.1, ainsi que pour les autres équipements qui comportent des bornes marquées conformément au F.3.6.1, les instructions doivent indiquer 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 **mise à la 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 un câble d'alimentation connecté à un socle de prise de courant avec connexion de **mise à la terre de protection**, par exemple);

– pour les équipements comprenant un **conducteur de mise à la terre de protection** parcouru par le **courant dans le conducteur de protection** qui dépasse les limites ES2 spécifiées en 5.2.2.2, l'équipement doit comporter une **protection par instructions** conforme au 5.7.6;

– les symboles graphiques apposés sur l'équipement et utilisés comme une **protection par instructions** doivent être expliqués. Lorsqu'une **protection par instructions** complète est placée sur l'équipement conformément à l'Article F.5, il n'est pas nécessaire de fournir une explication supplémentaire des symboles utilisés dans les instructions;

– si un **équipement relié en permanence** n'est pas équipé d'un interrupteur d'alimentation coupant tous les pôles du **réseau d'alimentation**, les instructions d'installation doivent préciser qu'un interrupteur d'alimentation coupant tous les pôles du **réseau d'alimentation** conformément à l'Annexe L doit être ajouté à l'installation électrique du bâtiment;

– si un composant ou un module remplaçable assure 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**, ou dans les instructions destinées aux **personnes averties** ou dans les instructions destinées aux **personnes qualifiées**, selon le cas;
– pour les équipements contenant un **isolant liquide**, des instructions de sécurité doivent être fournies, le cas échéant, y compris concernant l'utilisation de l'EPI si nécessaire, en tenant compte des informations de la fiche technique de sécurité de l'**isolant liquide** et des données du fabricant;
– les instructions d'installation du **matériel pour installation extérieure** doivent inclure les détails relatifs aux dispositions particulières nécessaires à la protection contre les conditions de l'**emplacement pour installation extérieure**.

La conformité est vérifiée par examen.

F.5 Protections par instructions

Sauf spécification contraire dans le présent document, une **protection par instructions** comprend l'élément 1a et/ou l'élément 2, ainsi que l'élément 3 et l'élément 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 le présent document, l'emplacement de la **protection par instructions** doit être comme suit:

– le marquage complet de la **protection par instructions** doit être apposé sur l'équipement; ou
– l'élément 1a et/ou l'élément 2 doivent être apposés sur l'équipement, et le marquage complet de la **protection par instructions** doit figurer dans le texte du document d'accompagnement. Si seul l'élément 2 est utilisé, le texte doit être précédé du terme "Mise en garde" ou "Attention", ou d'un texte équivalent.

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'énergie de classe 2 ou de classe 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.

Une seule **protection par instructions** peut concerner plusieurs pièces, à condition que ces pièces soient très proches les unes des autres. Si ces pièces ne sont pas aisément identifiables ou si elles ne se situent pas à côté de la protection par instructions, un document d'accompagnement, le manuel d'instructions ou les instructions de l'équipement doivent préciser les emplacements de ces pièces.

Tableau F.1 – Description et exemples d'éléments de protection mise en place sous forme d'instructions

Elément	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	Un symbole comme l'ISO 7000-0434 (2004-01), ou une combinaison de ce symbole et l'ISO 7000-1641 (2004-01) faisant référence au texte d'un document d'accompagnement. Ces symboles peuvent être combinés.	
2	Texte identifiant la nature de la source d'énergie de classe 2 ou de classe 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 l'IEC 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.

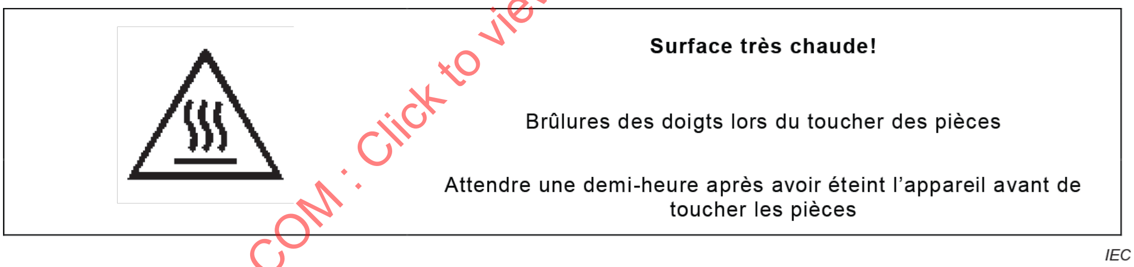
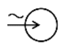
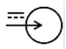


Figure F.1 – Exemple de protection par instructions

Pour des exemples de marquages, d'instructions et de **protections par instructions**, consulter le Tableau F.2.

Tableau F.2 – Exemples de marquages, d'instructions et de protections par instructions

Caractéristique assignée	Exemple
Tension en courant continu assignée	48 V DC 48 V ⎓
Tension en courant alternatif assignée	230 V ~ 230 V ~ ±10 % 100/120/220/240 V AC 100–250 V AC
Tension triphasée assignée	3/N/PE ~ 230/400 V 400 V/230 V 3Ø 208 V/120 V 3 phases 208 V/120 V 3 ~
Fréquence assignée	50 Hz à 60 Hz 50/60 Hz
Courant assigné	1 A
Puissance assignée en courant alternatif en entrée , IEC 60417-6045 (2011-01)	
Puissance assignée en courant continu en entrée, IEC 60417-6046 (2011-01)	
Instruction	**Exemple**
Positionnement de l'**élément**, IEC 60417-5002 (2002-10)	
Courant alternatif, IEC 60417-5032 (2002-10)	~
Courant continu, IEC 60417-5031 (2002-10)	⎓
Matériels de classe II, IEC 60417-5172 (2003-02)	
Attention, ISO 7000, 0434a ou 0434b (2004-01)	
Tension dangereuse, IEC 60417-5036 (2002-10)	
Terre; masse, IEC 60417-5017 (2006-08)	
Terre de protection; IEC 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 câble d'alimentation du **réseau d'alimentation**.

Un interrupteur doit satisfaire à l'ensemble des spécifications suivantes:

– satisfaire aux exigences de l'IEC 61058-1:2016, notamment:
  - 10 000 cycles de fonctionnement (voir 7.4.4 de l'IEC 61058-1:2016);
  - 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 7.9.2 de l'IEC 61058-1:2016);
  - l'interrupteur doit avoir une température de 850 °C pour le fil incandescent (voir 7.11.3 de l'IEC 61058-1:2016);
  - 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 Cela s'explique 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 l'IEC 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 l'IEC 61058-1:2016);
    – la classification de l'interrupteur selon:
      - la nature de l'alimentation (voir 7.1 de l'IEC 61058-1:2016);
      - le type de charge commandé par l'interrupteur (voir 7.2 de l'IEC 61058-1:2016);
      - la température ambiante de l'air (voir 7.3 de l'IEC 61058-1:2016).

  La conformité est vérifiée conformément à l'IEC 61058-1:2016;

– 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 du 16.4 i), p) et q) de l'IEC 61058-1:2016, excepté 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 des connecteurs qui alimentent d'autres équipements doit résister à l'essai d'endurance électrique selon l'Article 17 de l'IEC 61058-1:2016, avec une charge supplémentaire selon la Figure 8 et la Figure 9 de l'IEC 61058-1:2016. Le courant assigné total de la charge additionnelle doit correspondre au marquage apposé sur les connecteurs alimentant les autres équipements. Le courant de choc de crête de la charge additionnelle doit avoir une valeur conforme à celle indiquée dans le Tableau G.1.

Tableau G.1 – Courant de choc de crête

Courant assigné A	Courant de choc de crête A
jusqu'à 0,5 inclus	20
jusqu'à 1,0 inclus	50
jusqu'à 2,5 inclus	100
supérieur à 2,5	150

G.1.3 Méthode d'essai et critères de conformité

Les essais de l'IEC 61058-1:2016 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 et critères de conformité

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 l'IEC 61810-1:2015.

Un relais doit satisfaire aux exigences de l'IEC 61810-1:2015, en prenant en compte ce qui suit:

– les matériaux doivent être conformes à 6.4.5.2 ou satisfaire à l'essai au fil incandescent à 750 °C selon l'IEC 60695-2-11 ou à l'essai au brûleur-aiguille selon l'IEC 60695-11-5;

– 10 000 cycles de fonctionnement pour l'endurance (voir 5.6 de l'IEC 61810-1:2015) et pendant l'essai d'endurance électrique (voir l'Article 11 de l'IEC 61810-1:2015), aucune défaillance temporaire ne doit survenir;

NOTE Une défaillance temporaire constitue un événement qui est supprimé pendant l'essai au plus tard après un cycle de mise sous tension supplémentaire sans aucune influence externe (voir l'Article 11 de l'IEC 61810-1:2015).

– le relais doit être adapté à une utilisation dans les conditions de pollution applicables (voir l'Article 13 de l'IEC 61810-1:2015);

– les caractéristiques du relais en ce qui concerne les caractéristiques assignées et la classification (voir l'IEC 61810-1) doivent être appropriées à la fonction du relais dans les **conditions normales de fonctionnement**, comme suit:
  - tension assignée de la bobine et plage de tensions assignées de la bobine (voir 5.2 de l'IEC 61810-1:2015);
  - charge de contact assignée et type de charge (voir 5.8 de l'IEC 61810-1:2015);
  - tension de relâchement (voir 5.4 de l'IEC 61810-1:2015);
  - température de l'air ambiant et limites inférieure et supérieure de température (voir 5.9 de l'IEC 61810-1:2015);
  - seules les catégories de technologies de relais RT IV et RT V doivent être considérées comme étant conformes à un environnement au **degré de pollution** 1, par exemple, le relais satisfait au 5.4.1.5.2 du présent document (voir 5.10 de l'IEC 61810-1:2015);

– rigidité diélectrique (voir 10.2 de l'IEC 61810-1:2015), sauf que la tension d'essai doit être la tension d'essai exigée spécifiée en 5.4.9.1 du présent document;

– les **distances d'isolement** doivent être conformes au Tableau 14 du présent document si la **tension de tenue requise** (dénommée tension de tenue aux chocs dans l'IEC 61810-1) dépasse 12 kV;

– les **lignes de fuite** doivent être conformes au Tableau 17 du présent document si la **tension de service efficace** (dénommée tension efficace dans l'IEC 61810-1) dépasse 500 V;

– **isolation solide** conformément au 13.3 de l'IEC 61810-1:2015 ou au 5.4.4 du présent document.

La conformité est vérifiée conformément à l'IEC 61810-1 et aux exigences du présent document.

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 manœuvre à un rythme de 6 à 10 cycles par minute, en ouvrant et en fermant 150 % du courant imposé dans l'application. Lorsqu'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 résister à l'essai d'endurance de l'Article 11 de l'IEC 61810-1:2015, 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 l'IEC 61810-1 et du présent document doivent être appliqués avec les modifications indiquées en G.2.1 du présent document.*

*Après les essais, le relais ne doit présenter aucune détérioration au niveau de l'****enveloppe****, aucune réduction des* ***lignes de fuite*** *et des* ***distances d'isolement****, 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 l'IEC 60730-1, un "**disjoncteur thermique**" est un "coupe-circuit thermique".

a) Lorsqu'il est soumis à l'essai en tant que composant séparé, le **disjoncteur thermique** doit satisfaire aux exigences et aux essais de la série IEC 60730, dans la mesure du possible:
   - le **disjoncteur thermique** doit être à action de type 2 (voir 6.4.2 de l'IEC 60730-1:2013);
   - le **disjoncteur thermique** doit fournir au moins une microinterruption, de type 2.B (voir 6.4.3.2 et 6.9.2 de l'IEC 60730-1:2013);
   - 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 l'IEC 60730-1:2013);
   - 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 l'IEC 60730-1:2013);
     - 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 l'IEC 60730-1:2013);
     - 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 l'IEC 60730-1:2013);
   - le **disjoncteur thermique** doit être soumis à l'essai comme s'il était conçu pour supporter une durée prolongée de contrainte électrique entre les parties isolantes (voir 6.14.2 de l'IEC 60730-1:2013);
   - 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 l'IEC 60730-1:2013);
   - l'intervalle de contact et la distance entre les extrémités et les fils de connexion des contacts, doivent être conformes au 13.1.4 et au 13.2 de l'IEC 60730-1:2013.