



BSI Standards Publication

Audio/video, information and communication technology equipment

Part 2: Explanatory information related to IEC 62368-1:2023

National foreword

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TECHNICAL REPORT

**Audio/video, information and communication technology equipment -
Part 2: Explanatory information related to IEC 62368-1:2023**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Audio/video, information and communication technology equipment -
Part 2: Explanatory information related to IEC 62368-1:2023**

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IEC TR 62368-2 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 a Technical Report.

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) It takes into account changes made in the fourth edition of IEC 62368-1 (IEC 62368-1:2023) as identified in the Foreword of IEC 62368-1:2023.

The text of this Technical Report is based on the following documents:

Draft	Report on voting
108/794/DTR	108/825/RVDTR

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 Technical Report 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.

In this document, the following print types are used:

- notes/explanatory matter: in smaller roman type;
- tables and figures that are included in the rationale have linked fields (shaded in grey if “field shading” is active);
- terms that are defined in IEC 62368-1: in **bold type**.

Where coloured shading is used:

- green colour stands for level 1 energy sources
- yellow/orange colour stands for level 2 energy sources
- red colour stands for level 3 energy sources.

In this document, where the term (HBSDT) is used, it stands for Hazard Based Standard Development Team, which is the Working Group of IEC TC 108 responsible for the development and maintenance of IEC 62368-1.

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

In this document, only those subclauses from IEC 62368-1 considered to need further background reference information or explanation to benefit the user in applying the relevant requirements are included. Therefore, not all numbered subclauses are cited. Unless otherwise noted, all references are to clauses, subclauses, annexes, figures or tables located in IEC 62368-1:2023.

The entries in this document can have one or two of the following subheadings in addition to the Rationale statement:

Source – where the source is known and is a document that is accessible to the general public, a reference is provided.

Purpose – where there is a need and when it can prove helpful to the understanding of the Rationale, a Purpose statement has been added.

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, or
- revised.

INTRODUCTION

IEC 62368-1 is based on the principles of hazard-based safety engineering, which is a different way of developing and specifying safety considerations than that of the current practice. While IEC 62368-1 is different from traditional IEC safety documents in its approach and while it is believed that IEC 62368-1 provides a number of advantages, its introduction and evolution are not intended to result in significant changes to the existing safety philosophy that led to the development of the safety requirements contained in IEC 60065 and IEC 60950-1. The predominant reason behind the creation of IEC 62368-1 is to simplify the problems created by the merging of the technologies of ITE and CE. The techniques used are novel, so a learning process and experience in its application are needed.

0 Principles of this product safety standard

Clause 0 is informative and provides a rationale for the normative clauses of IEC 62368-1:2023.

0.5.1 General

ISO/IEC Guide 51:2014, 6.3.5 states:

“When reducing risks, the order of priority shall be as follows:

- a) inherently safe design;*
- b) guards and protective **devices**;*
- c) information for end users.*

*Inherently safe design measures are the first and most important step in the risk reduction process. This is because protective measures inherent to the characteristics of the product or system are likely to remain effective, whereas experience has shown that even well-designed guards and protective **devices** can fail or be violated and information for use might not be followed.*

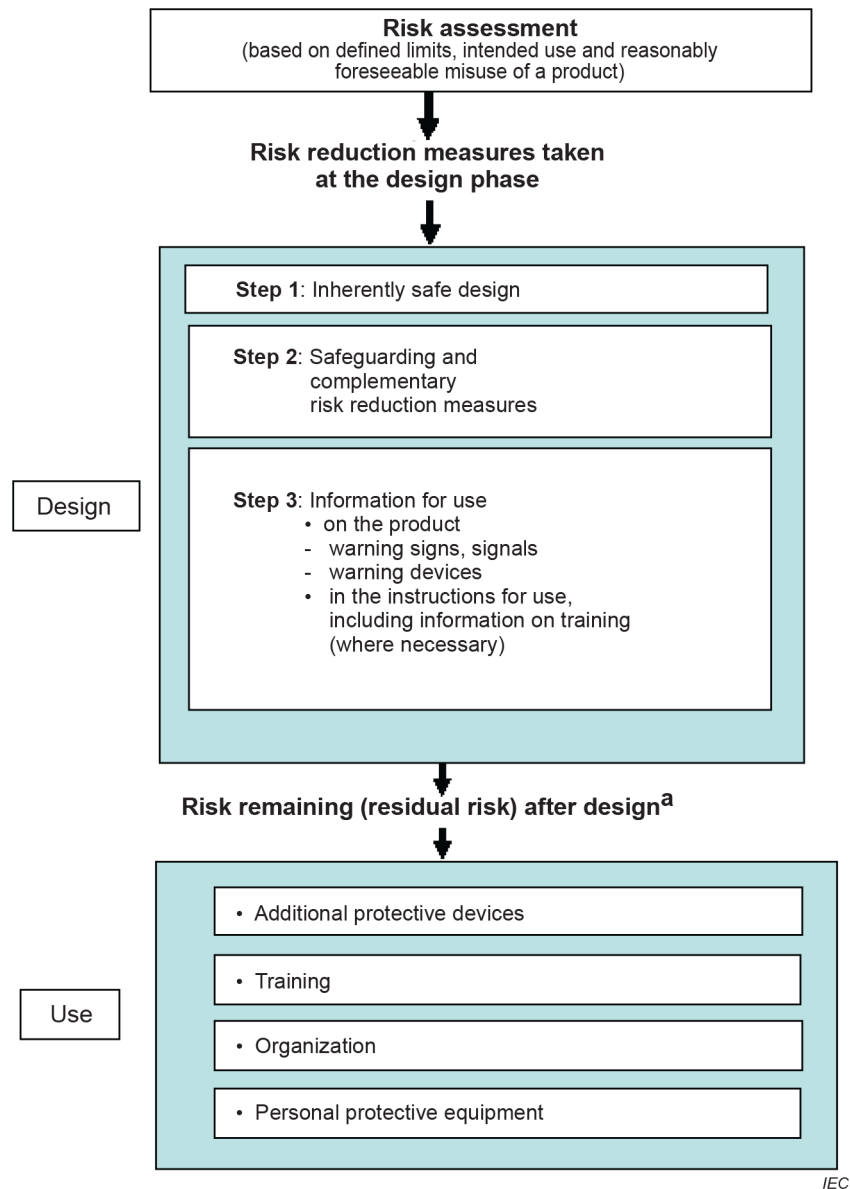
*Guards and protective **devices** shall be used whenever an inherently safe design measure does not reasonably make it possible either to remove hazards or to sufficiently reduce risks. Complementary protective measures involving additional equipment (for example, emergency stop equipment) might have to be implemented.*

The end user has a role to play in the risk reduction procedure by complying with the information provided by the designer/supplier. However, information for use shall not be a substitute for the correct application of inherently safe design measures, guards or complementary protective measures.”

In general, this principle is used in IEC 62368-1. The table below shows a comparison between the hierarchy required in ISO/IEC Guide 51 and the hierarchy used in IEC 62368-1.

ISO/IEC Guide 51	IEC 62368-1
a) inherently safe design	1. inherently safe design by limiting all energy hazards to class 1
b) guards and protective devices	2. equipment safeguards
	3. installation safeguards
	4. personal safeguards
c) information for end users	5. behavioural safeguards
	6. instructional safeguards

Risk assessment has been considered as part of the development of IEC 62368-1 as indicated in the following from ISO/IEC Guide 51 (Figure 1 in this document). See also the Hazard Based Safety Engineering (HBSE) Process Flow (Figure 2 in this document) that also provides additional details for the above comparison.



^a An example is the risk remaining in a product or a system when supplied to a customer, or in a structural feature, after installation.

Figure 1 – Risk reduction as given in ISO/IEC Guide 51

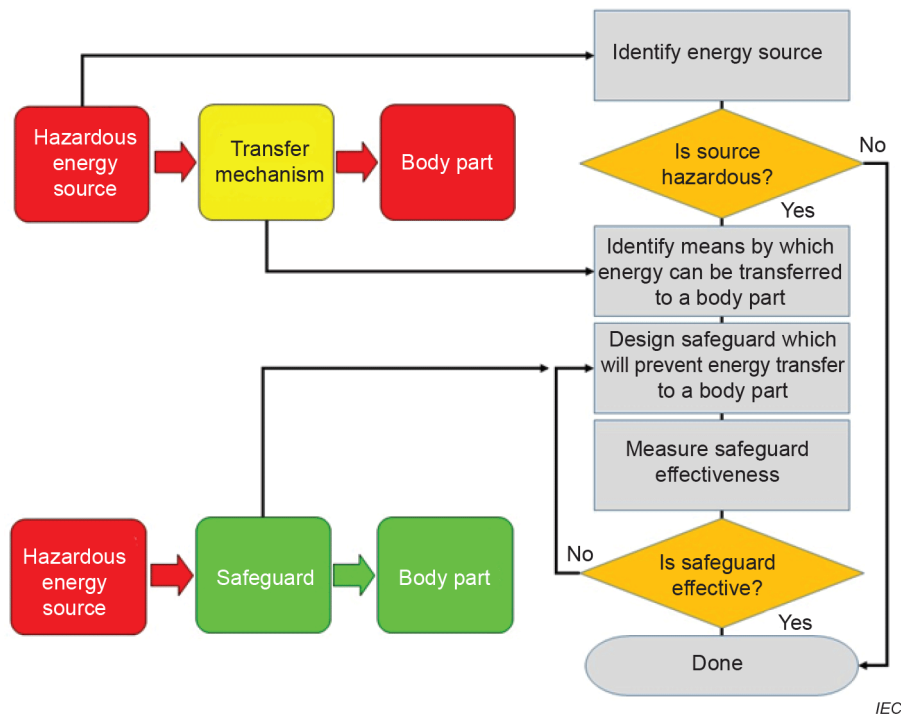


Figure 2 – HBSE Process Chart

0.5.7 Equipment safeguards during skilled person service conditions

Purpose: To explain the intent of requirements for providing **safeguards** against involuntary reaction.

Rationale: By definition, a **skilled person** has the education and experience to identify all class 3 energy sources to which he can be exposed. However, while servicing one class 3 energy source in one location, a **skilled person** can be exposed to another class 3 energy source in a different location.

In such a situation, either of two events is possible. First, something can cause an involuntary reaction of the **skilled person** with the consequences of contact with the class 3 energy source in the different location. Second, the space in which the **skilled person** is located can be small and cramped, and inadvertent contact with a class 3 energy source in the different location is likely.

In such situations, IEC 62368-1:2023 can require an equipment **safeguard** solely for the protection of a **skilled person** while performing servicing activity.

0.10 Thermally-caused injury (skin burn)

Purpose: The requirements basically address **safeguards** against thermal energy transfer by conduction. They do not specifically address safeguards against thermal energy transfer by convection or radiation. However, as the temperatures from hot surfaces due to conduction are always higher than the radiated or convected temperatures, the requirements against convection and radiation are considered to be covered by the requirements against conducted energy transfer.

1 Scope

Purpose: To identify the purpose and applicability of IEC 62368-1:2023 and the exclusions from the scope.

Rationale: The scope excludes requirements for functional safety. Functional safety is addressed in IEC 61508-1. Because the scope includes computers that can control safety systems, functional safety requirements would necessarily include requirements for computer processes and software.

The requirements provided in IEC 60950-23 can be modified and added to IEC 62368 as another –X document. However, because of the hazard-based nature of IEC 62368-1, the requirements from IEC 60950-23 have been incorporated into the body of IEC 62368-1 and made more generic.

The intent of the addition of the IEC 60950-23 requirements is to maintain the overall intent of the technical requirements from IEC 60950-23, incorporate them into IEC 62368-1 following the overall format of IEC 62368-1 and simplify and facilitate the application of these requirements.

Robots traditionally are covered under the scopes of ISO documents, typically maintained by ISO TC 299. ISO TC 299 has working groups for personal care robots and service robots, and produces for example, ISO 13482, *Robots and robotic devices – Safety requirements for personal care robots*.

2 Normative references

The list of normative references is a list of all documents that have a normative reference to them in the body of the document. As such, referenced documents are indispensable for the application of IEC 62368-1. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Recently, there were some issues with test houses that wanted to use the latest edition as soon as it was published. As this creates serious problems for manufacturers, since they have no chance to prepare, it was felt to be important that a reasonable transition period be taken into account. This is in line with earlier decisions taken by the SMB that allow transition periods to be mentioned in the foreword of the documents. Therefore IEC TC 108 decided to indicate this in the introduction of the normative references clause, to instruct test houses to take into account any transition period, effective date or date of withdrawal established for the document.

These documents are referenced, in whole, in part, or as alternative requirements to the requirements contained in IEC 62368-1. Their use is specified, where necessary, for the application of the requirements of IEC 62368-1. The fact that a standard is mentioned in the list does not mean that compliance with the document or parts of it is required.

3 Terms, definitions and abbreviations

Rationale is provided for definitions that deviate from IEC definitions or from Basic or Group Safety publication definitions.

3.3.1.1 audio amplifier

Rationale: An **audio power amplifier** is an amplifying device for audio signals with a rated output power of more than 15 W and intended to drive a sound transducer (i.e. headphones, speakers, etc.) or other amplifiers such as headphone amplifiers or line driver amplifiers. The 15 W rated output power is chosen because it is near to the PS1 definition. To determine if the device is an **audio amplifier**, single fault simulation of subclause 6.2 does not need to be considered.

3.3.2.1 electrical enclosure

Source: IEC 60050-195:2021, 195-06-13, modified

Purpose: To support the concept of **safeguards** as used in IEC 62368-1.

Rationale: The IEV definition is modified to use the term “**safeguard**” in place of the word “protection”. The word “**safeguard**” identifies a physical “thing” whereas the word “protection” identifies the act of protecting. IEC 62368-1 sets forth requirements for use of physical **safeguards** and requirements for those **safeguards**. The **safeguards** provide “protection” against injury from the equipment.

3.3.3.2 fixed equipment

Source: IEC 60050-826:2022, 826-16-07, modified

Purpose: To support the concept of “fixed equipment” and ensure the stability of certified products.

Rationale: The means of securement by the manufacturer must be in accordance with the accepted definition of “**fixed equipment**” (IEC 60050-826:2022, 826-16-07) and reasonably sufficient to overcome the forces of instability.

3.3.5.1 basic insulation

Source: IEC 60050-195:1998, 195-06-06

Purpose: To support the concept of **safeguards** as used in IEC 62368-1.

Rationale: The IEV definition is modified to use the term “**safeguard**” in place of the word “protection”. The word “**safeguard**” identifies a physical “thing” whereas the word “protection” identifies the act of protecting. IEC 62368-1 sets forth requirements for use of physical **safeguards** and requirements for those **safeguards**. The **safeguards** provide “protection” against injury from the equipment.

3.3.5.2 double insulation

Source: IEC 60050-195:2021, 195-06-08

Purpose: To support the concept of **safeguards** as used in IEC 62368-1.

Rationale: See 3.3.5.1, **basic insulation**.

3.3.5.6 solid insulation

Source: IEC 60050-212:2015, 212-11-02, modified

3.3.5.7 supplementary insulation

Source: IEC 60050-195:1998, 195-06-07

Purpose: To support the concept of **safeguards** as used in IEC 62368-1.

Rationale: See 3.3.5.1, **basic insulation**.

3.3.6.16 restricted access area

Source: IEC 60050-195:1998, 195-04-04

Purpose: To use the concept of “**instructed persons**” and “**skilled persons**” as used in IEC 62368-1.

Rationale: The IECV definition is modified to use the terms “**instructed persons**” and “**skilled persons**” rather than “electrically **instructed persons**” and “electrically **skilled persons**.”

3.3.7.7 reasonably foreseeable misuse

Source: ISO/IEC Guide 51:2014, 3.7, modified

Rationale: Misuse depends on personal objectives, personal perception of the equipment, and the possible use of the equipment (in a manner not intended by the manufacturer) to accomplish those personal objectives. Equipment within the scope of IEC 62368-1 ranges from small handheld equipment to large, permanently installed equipment. There is no commonality among the equipment for readily predicting human behaviour leading to misuse of the equipment and resultant injury. Where a possible **reasonably foreseeable misuse** that can lead to an injury is not covered by the requirements of the document, manufacturers are encouraged to consider **reasonably foreseeable misuse** of equipment and provide **safeguards**, as applicable, to prevent injury in the event of such misuse. (Not all **reasonably foreseeable misuse** of equipment results in injury or potential for injury.)

3.3.8.1 instructed person

Source: IEC 60050-826:2004, 826-18-02

Rationale: The IECV definition is modified to use the terms “energy sources”, “**skilled persons**”, and “**precautionary safeguard**”. The definition is made stronger by using the term “instructed” rather than “advised”.

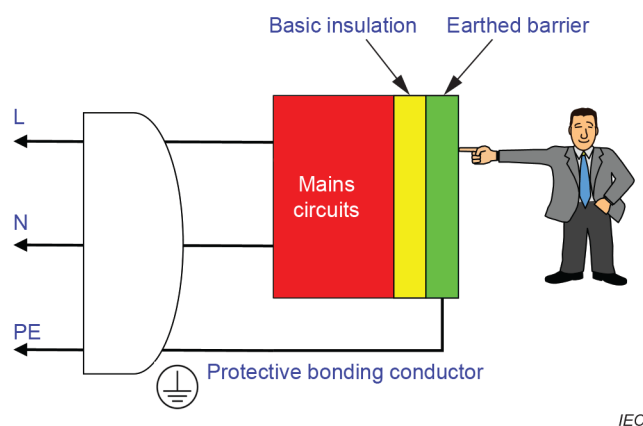
3.3.8.3 skilled person

Source: IEC 60050-826:2022, 826-18-01, modified

Rationale: The IECV definition is modified to be applicable to all hazards.

3.3.11.9 protective bonding conductor

Rationale: The **protective bonding conductor**, is not a complete **safeguard**, but a component part of the earthing system **safeguard**. The **protective bonding conductor** provides a fault current pathway from a part (insulated from ES3 by **basic insulation** only) to the equipment **protective earthing** terminal, see Figure 3.



IEC

Figure 3 – Protective bonding conductor as part of a safeguard

The parts that must be earthed via a **protective bonding conductor** are those that have only **basic insulation** between the parts and ES3, and are connected to **accessible** parts.

Only the fault current pathway must be a **protective bonding conductor**. Other earthing connections of **accessible** conductive parts can be by means of a functional earth conductor to the equipment PE terminal or to a **protective bonding conductor**.

3.3.14.3 prospective touch voltage

Source: IEC 60050-195:2021, 195-05-09, modified

Purpose: To properly identify electric shock energy source voltages.

Rationale: The IEV definition is modified to delete “animal”. The word “person” is also deleted as all of the requirements in the document are with respect to persons.

3.3.14.8 working voltage

Source: IEC 60664-1:2020, 3.1.7

Purpose: To distinguish between **RMS working voltage** and the peak of the **working voltage**.

Rationale: The IEC 60664-1 definition is modified to delete “RMS”. IEC 62368-1 uses both **RMS working voltage** and peak of the **working voltage**; each term is defined.

3.3.15.2 class II construction

Source: IEC 60335-1:2010, 3.3.11

Purpose: Although the term is not used in the document, for completeness, it was decided to retain this definition.

Rationale: The word “appliance” is changed to “equipment”.

4 General requirements

Purpose: To explain how to investigate and determine whether or not safety is involved.

Rationale: In order to establish whether or not safety is involved, the circuits and construction are investigated to determine whether the consequences of possible fault conditions would lead to an injury. Safety is involved if, as a result of a **single fault condition**, the consequences of the fault lead to a risk of injury.

If a fault condition leads to a risk of injury, the part, material, or **device** whose fault was simulated must be regarded as a **safeguard**.

Rationale is provided for questions regarding the omission of some traditional requirements appearing in other safety documents. Rationale is also provided for further explanation of new concepts and requirements in IEC 62368-1.

Reasonable foreseeable misuse

Rationale: Apart from Annex M, IEC 62368-1 does not specifically mention foreseeable misuse or **abnormal operating conditions**. Nevertheless, the requirements of the document cover many kinds of foreseeable misuse, such as covering of ventilation openings, paper jams, stalled motors, etc.

functional insulation

Rationale: IEC 62368-1 does not include requirements for **functional insulation**. By its nature, **functional insulation** does not provide a **safeguard** function against electric shock or electrically-caused fire and therefore must be faulted. Obviously, not all **functional insulations** are faulted as this would be prohibitively time-consuming. Sites for **functional insulation** faults must be based upon physical examination of the equipment, and upon the electrical schematic.

Note that **basic insulation** and **reinforced insulation** can also serve as **functional insulation**, in which case the insulation is not faulted.

functional components

Rationale: IEC 62368-1 does not include requirements for functional components. By their nature, individual functional components do not provide a **safeguard** function against electric shock, electrically-caused fire, thermal injury, etc., and therefore are candidates for fault testing. Obviously, not all functional components are faulted as this would be prohibitively time-consuming. Candidate components for fault testing must be based upon physical examination of the equipment, upon the electrical schematic diagrams, and whether a fault of that component might result in conditions for electric shock, conditions for ignition and propagation of fire, conditions for thermal injury, etc.

As with all **single fault condition** testing (Clause B.4), upon faulting of a functional component, IEC 62368-1 does not allow there to be any safety consequences (for example, a benign consequence), and requires a **basic safeguard**, **supplementary safeguard**, or **reinforced safeguard** to remain effective.

In some cases, a pair of components comprise a **safeguard**. If the fault of one of the components in the pair is mitigated by the second component, then the pair is designated as a **double safeguard**. For example, if two diodes are employed in series to protect a **battery** from reverse charge, then the pair comprises a **double safeguard** and the components must be limited to the manufacturer and part number actually tested. A second example is that of an X-capacitor and discharge resistor. If the discharge resistor fails open, then the X-capacitor will not be discharged. Therefore, the X-capacitor value is not to exceed the ES2 limits specified for a charged capacitor. Again, the two components comprise a **double safeguard** and the values of each component are limited to values for ES1 under **normal operating conditions** and the values for ES2 under **single fault conditions**.

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

Purpose: To accept components as **safeguards**.

Rationale: IEC 62368-1 includes requirements for **safeguard** components. A **safeguard** component is a component specifically designed and manufactured for both functional and **safeguard** parameters. Examples of **safeguard** components are capacitors complying with IEC 60384-14 and other components that comply with their related IEC component document.

Acceptance of components and component requirements from IEC 60065 and IEC 60950-1

Purpose: To accept both components and **subassemblies** investigated to the legacy documents, IEC 60065 and IEC 60950-1, and components complying with individual component requirements within previous documents during the transition period.

In IEC 62368-1:2023, the transitional measures were removed.

4.1.5 Constructions and components not specifically covered

For constructions not covered, consideration must be given for the hierarchy of **safeguards** in accordance with ISO/IEC Guide 51.

4.1.6 Orientation during transport and use

See also 4.1.4

In general, equipment is assumed to be installed and used in accordance with the manufacturer's instructions. However, in some cases where equipment can be installed by an **ordinary person**, it is recognized that it is common practice to mount equipment as desired if screw holes are provided, especially if they allow mounting to readily available brackets. Hence, the exception that is added to 4.1.6.

Examples of the above: a piece of equipment, such as a television set or a video projector, that has embedded screw mounting holes that allow it to be attached to a wall or other surface through the use of commercially available vertically or tilt-mountable brackets, must take into account that the mounting surface itself is not always vertical.

It is also recognized that **transportable equipment**, by its nature, can be transported in any and all orientations.

4.1.8 Liquids, refrigerants and liquid filled components (LFCs)

The one-litre (1 l) restriction was placed in 4.1.8 since the origin of some of the requirements in Clause G.15 came from requirements in documents often applied to smaller systems. Nevertheless, such a limitation does not always negate the allowed application of 4.1.8 and Clause G.15 to systems with larger volumes of liquid, but it can impact direct (automatic) applicability to the larger systems.

4.2 Energy source classifications

Classification of energy sources can be done whether the source is **accessible** or not. The requirements for parts can differ on whether the part is **accessible** or not.

4.2.1 Class 1 energy source

A class 1 energy source is a source that is expected not to create any pain or injury. Therefore, IEC 62368-1 permits a class 1 energy source to be **accessible** by any person.

Under some specific **abnormal operation conditions** or **single fault conditions**, a class 1 energy source can reach class 2 limits. However, this source still remains a class 1 energy source. In this case, IEC 62368-1 requires an **instructional safeguard**.

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

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

4.2.2 Class 2 energy source

A class 2 energy source is a source that can create pain, but which is unlikely to create any serious injury. Therefore, it is essential for a class 2 energy source not to be **accessible** by an **ordinary person**. However, IEC 62368-1 permits a class 2 energy source to be **accessible** by:

- an **instructed person**; and
- a **skilled person**.

The energy in a class 2 source, under contact with a body part, can be painful, but is not likely to cause an injury. For fire, the energy in a class 2 source can cause ignition under some conditions.

4.2.3 Class 3 energy source

A class 3 energy source is a source that is likely to create an injury. Therefore, it is essential that a class 3 energy source is not **accessible** to an **ordinary person** or an **instructed person**. IEC 62368-1 permits a class 3 energy source, in general, to be **accessible** to a **skilled person**.

Any source can be declared a class 3 energy source without measurement, in which case all the **safeguards** applicable to class 3 are required by IEC 62368-1.

The energy in a class 3 source, under contact with a body part, is capable of causing injury. For fire, the energy in a class 3 source can cause ignition and the spread of flame where fuel is available.

4.3.2 Safeguards for protection of an ordinary person

The required **safeguards** for the protection of an **ordinary person** are given in Figure 4 in this document.

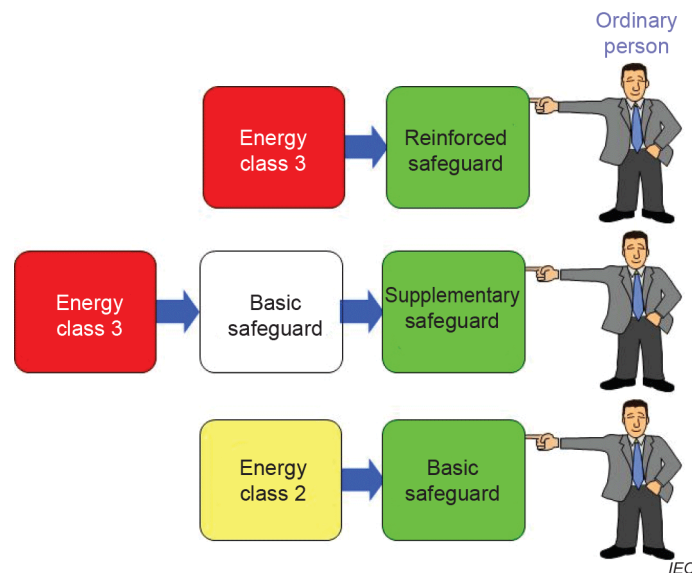


Figure 4 – Safeguards for protecting an ordinary person

4.3.3 Safeguards for protection of an instructed person

The required **safeguards** for the protection of an **instructed person** are given in Figure 5 in this document.

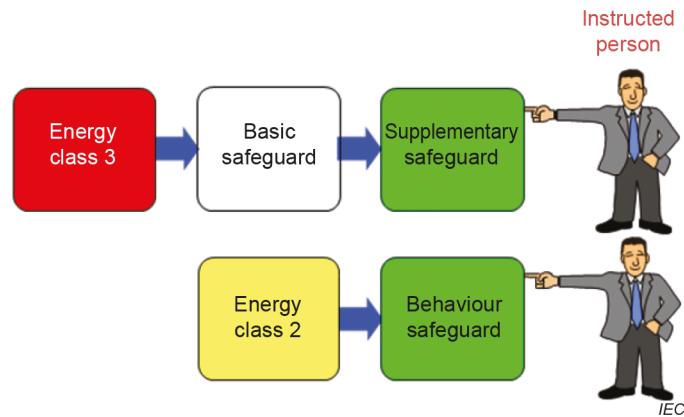


Figure 5 – Safeguards for protecting an instructed person

4.3.4 Safeguards for protection of a skilled person

The required **safeguards** for the protection of a **skilled person** are given in Figure 6 in this document.

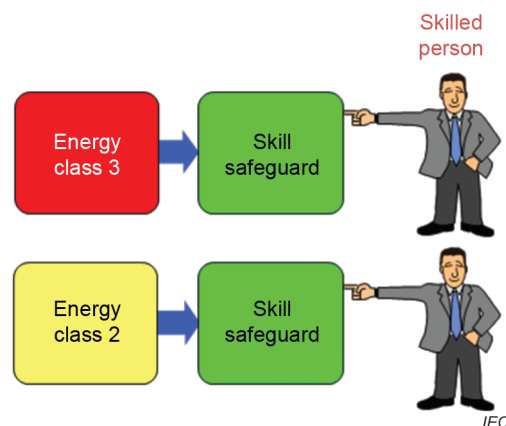


Figure 6 – Safeguards for protecting a skilled person

Table 1 in this document gives a general overview of the required number of **safeguards** depending on the energy source and the person to whom the energy source is **accessible**. The different clauses have requirements that sometimes deviate from the general principle as given above. These cases are clearly defined in the requirements sections of the document.

Table 1 – General summary of required safeguards

Person	Number of safeguards required to be interposed between an energy source and a person		
	Class 1	Class 2	Class3
Ordinary person	0	1	2
Instructed person	0	0	2
Skilled person	0	0	0 or 1

For a **skilled person**, there is normally no **safeguard** required for a class 3 energy source. However, if there are multiple class 3 energy sources **accessible** or if the energy source is not obvious, IEC 62368-1 requires a **safeguard**.

4.4.2 Composition of a safeguard

Purpose: To specify design and construction criteria for a single **safeguard** (**basic safeguard**, **supplementary safeguard** or **reinforced safeguard**) comprised of more than one element, for example, a component or a **device**.

Rationale: **Safeguards** need not be a single, homogeneous component. Indeed, some parts of IEC 62368-1 require a single **safeguard** be comprised of two or more elements. For example, for thin insulation, two or more layers are required to qualify as **supplementary insulation**. Another example is protective bonding and **protective earthing**, both of which are comprised of wires, terminals, screws, etc.

If a **safeguard** is comprised of two or more elements, then the function of the **safeguard** is not to be compromised by a failure of any one element. For example, if a screw attaching a **protective earthing** wire becomes loosened, then the current-carrying capacity of the **protective earthing** circuit can be compromised, making its reliability uncertain.

4.4.3 Safeguard robustness

Rationale: **Safeguards** must be sufficiently robust to withstand the rigors of expected use throughout the equipment lifetime. Robustness requirements are specified in the various clauses.

4.4.3.4 Impact tests

Rationale: **Stationary equipment** can, in some cases, be developed for a specific installation in which it is not possible for certain surfaces to be subjected to an impact when installed as intended. In those cases, the impact test is not necessary when the installation makes clear that the side cannot be impacted.

4.4.3.6 Glass impact tests

Source: IEC 60065

Purpose: Verify that any glass that breaks does not cause skin-lacerating injury, or expose class 3 hazards behind the glass.

Rationale: When it comes to glass, two hazards can be present in case the glass breaks:

- access to sharp edges from the broken glass itself
- exposure of class 3 energy hazards in case the glass is used as (part of) the **enclosure**.

In case the glass breaks during the impact test, Clause T.9 is applied to ensure the expelled fragments will be at MS2 level or less.

Platen glass has a long history of being exempted, because it is quite obvious for people that, if broken, the broken glass is hazardous and contact must be avoided. There is no known history of serious injuries with this application. Platen glass is the glass that is typically used in scanners, copiers, etc. Accidents are rare, probably also because they are protected by an additional cover most of the time, which limits the probability that an impact will occur on the glass.

CRTs are exempted because they have separate requirements.

The test value for floor standing equipment is higher because it is more likely to be impacted by persons or carts and dollies at a higher force while in normal use.

The exemption for glass below certain sizes is taken over from IEC 60065. There is no good rationale to keep the exemption, other than that there are no serious accidents known from the field. The HBSDT decided that they want to keep the exemption in.

The flow chart in Figure 7 in this document shows the intent for the requirements.

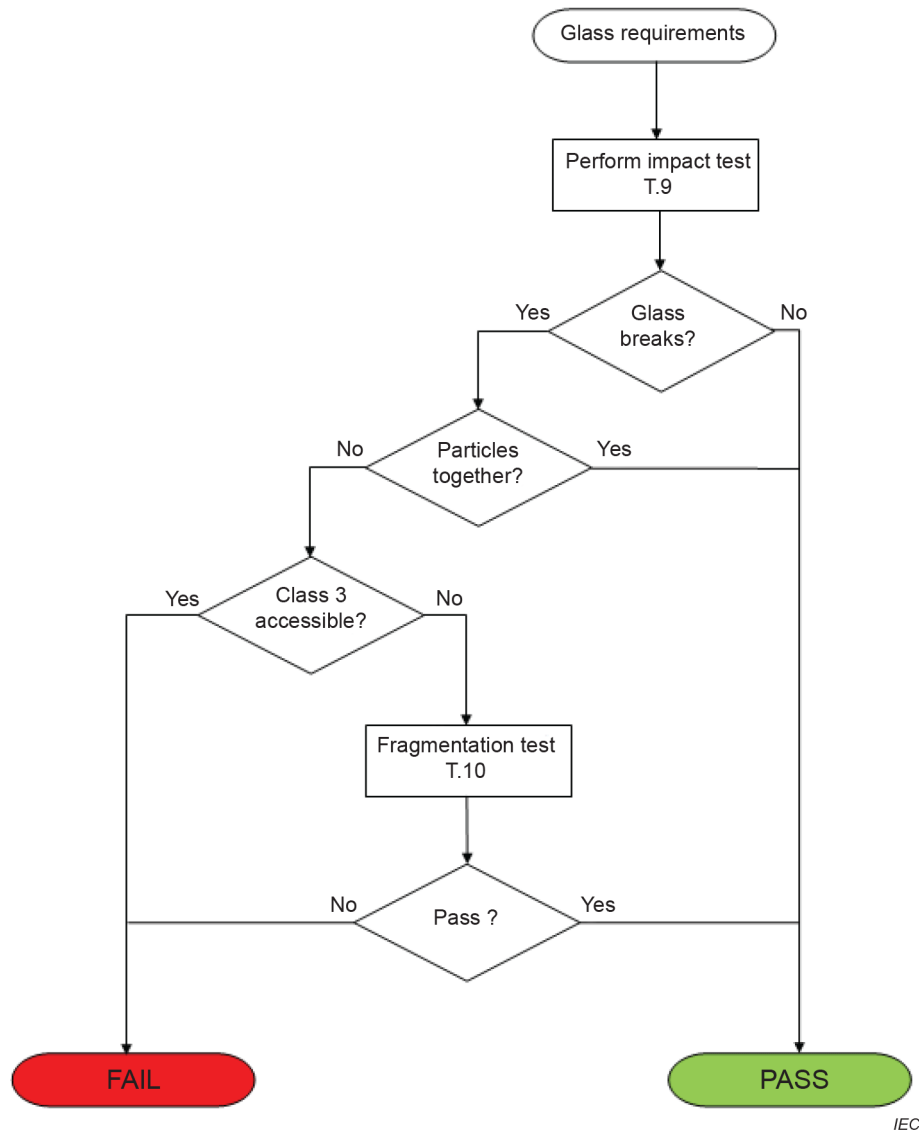


Figure 7 – Flow chart showing the intent of the glass requirements

4.4.3.10 Compliance criteria

The value of 30 g for the weight limit is chosen based on the maximum dimension of a side of 50 mm. A typical piece of glass with a size of 50 mm × 50 mm × 4 mm (roughly 2,80 g/cm³) would have a weight of around 30 g.

4.6 Fixing of conductors and conductive parts

Source: IEC 60950-1

Purpose: To reduce the likelihood that conductors can be displaced such that they reduce the **creepage distances** and **clearances**.

Rationale: These requirements have been successfully used for products in the scope of IEC 62368-1 for many years.

For parts that are conductive but not intended to carry current, their displacement is not to defeat a **safeguard**, such as reducing a **clearance** or **creepage distance**.

For example, a conductive screw fixing a radiator on a transistor in a class II power supply is not to detach easily because it can eventually bridge a safety insulation.

4.7 Equipment for direct insertion into mains socket-outlets

Source: IEC 60065:2014, 15.5; IEC 60950-1:2005, 4.3.6; IEC 60335-1:2010, 22.3 and IEC 60884-1:2013, 14.23.2

Purpose: Determine that equipment incorporating integral pins for insertion into **mains** socket-outlets does not impose undue torque on the socket-outlet due to the mass and configuration of the equipment. This type of equipment often is known as **direct plug-in equipment** or direct plug-in transformers.

Rationale: Socket-outlets are required to comply with the safety requirements in IEC 60884-1:2013, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*, including subclause 14.23.2. The requirements result in socket designs with certain design limitations. Equipment incorporating integral pins for insertion into **mains** socket-outlets must not exceed these design limitations.

For **direct plug-in equipment**, including equipment for direct insertion into a **mains** socket-outlet, normal use can be considered by representative testing. The intent is not to require testing in all orientations. Subclause 4.1.6 is not applicable unless the manufacturer specifically supplies instructions representing multiple mounting positions or configurations.

4.8 Equipment containing coin or button cell batteries

Rationale: The determination whether the **battery** is unlikely to be removed by children due to location within the equipment is an engineering judgment not requiring Annex V. A **coin or button cell battery** located inside pluggable equipment without a dedicated **battery** compartment is an example of a **battery** that would be considered unlikely to be removed by children.

4.8.3 Construction

Purpose: The purpose of this clause is to ensure that children cannot easily access user replaceable **coin or button cell batteries** for equipment with covers or doors that do not require a **tool** to be removed. The following examples are provided to explain the possible options within IEC 62368-1:

- 1) Conforming example: A cover requiring two movements: a push (movement 1) and twist (movement 2) while continuing to push.
- 2) Conforming example: A cover with two latches or mechanisms that requires pressing both to release with the use of two fingers.
- 3) Conforming example: A cover requiring two movements: a squeeze (movement 1) and twist (movement 2) while continuing to squeeze.
- 4) Non-conforming example: A cover that can be removed with two movements: push (movement 1), release the push, then a twist (movement 2).

For the sake of documentation:

- the language “independent and simultaneous” was changed to “different and interdependent” to clarify the non-conforming construction example 4. There was a potential hazard condition as the sequential movement allows for the first movement and then at another time the second movement. This allows for random movements to open the door or cover over a period of time. The two movements must work together to be effective.
- “the application of a minimum of two sequential hand movements where the first movement enables the second movement” was deleted and replaced with bullet number 2 in the second bulleted list to allow for conforming construction example 2. Both latches or mechanisms can be enabled at the same time if separated requiring two fingers or hand parts.

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

Purpose: The purpose of this subclause is to establish opening requirements that would minimize the risk of foreign conductive objects falling into the equipment that can bridge parts within class 2 or class 3 circuits, or between PS circuits that can result in ignition or electric shock.

It is considered unlikely that a person would accidentally drop something that can consequently fall into the equipment at a height greater than 1,8 m.

4.10.3 Mains power supply cords

Rationale: Mains power supply cords are neither internal nor external wiring. They are separately covered in Clause G.7.

5 Electrically-caused injury

Purpose: Clause 5 classifies electrical energy sources and provides criteria for determining the energy source class of each conductive part. The criteria for energy source class include the source current-voltage characteristics, duration, and capacitance. Each conductive part, whether current-carrying or not, or whether earthed or not, must be classed ES1, ES2, or ES3 with respect to earth and with respect to any other simultaneously **accessible** conductive part.

The breakthrough for the hazard based standard IEC 62368-1 was in determining reasonable limits for each energy source in a way that did not present a hazard to the user. Clause 5, electrically-caused injury requirements, was developed by the electric shock team as the appointed TC 108 technical experts in this subject. For IEC 62368-1, each electrically conductive part is energy source classified according to the source voltage-current characteristics. An **accessible** part of a piece of equipment is a part that can be touched by a body part as determined by the specified test probes. **Accessible** parts define those contact points which must provide a specified, limited electric current or electric shock to the user. Based upon IEC 60479-1:2018, Figures 20 and 22, the acceptable touch current for IEC 62368-1 ES1 circuits is the 'a' line value of 0,5 mA RMS / 0,707 mA peak AC/bipolar or 2 mA DC monopolar startle-reaction currents and under IEC 62368-1 ES2 circuits is the 'b' line value of 5 mA RMS / 7,07 mA peak AC/bipolar or 25 mA DC monopolar letgo-immobilization currents. **Accessible** touch currents at or below the startle-reaction level are appropriate for normal operation of the equipment. **Accessible** touch current at or below the letgo-immobilization level are appropriate under **single fault conditions**. Since earthing/grounding is not considered reliable in cord connected equipment, the assessment of touch current usually begins by making this abnormal condition measurement in the earth/ground lead to determine that the current is below the specified limit and touching the chassis anywhere under these conditions is not hazardous. Measurement of the touch current from all **accessible** parts is also done. Using the IEC 60990 touch current measurement circuit and methods invoked in IEC 62368-1 ensure that the high frequency components of non-sinusoidal touch current found in modern switching electronics and motor drivers are properly taken into account. They are reduced to the low frequency equivalent invoking the published frequency factors in IEC 60479-2 for each of the measurement circuits specified; this is accomplished by the use of an appropriate filter in the measuring circuit. IEC 62368-1 clearly specifies the use of peak current measurements for non-sinusoidal waveforms (which is also appropriate for sinusoidal waveforms).

The 5 mA RMS value is higher than what has been used previously in IEC 60950-1 and other standards. For example, IEC 60950-1 and IEC 61010 have both used 3,5 mA RMS as the maximum current allowed under **single fault conditions**. The 5 mA RMS limit represents an acceptable value of current at the letgo-immobilization limit for all persons, both children and adults. Although this value of current is strongly felt by most adults, the person is able to pull off of it and disengage. Above this level, it can be difficult to disengage.

240 VA limit

IEC 62368-1 does not have requirements for a 240 VA energy hazard that was previously located in 2.1.1.5 of IEC 60950-1:2005.

The origin/justification of the 240 VA energy hazard requirement in the legacy documents was never precisely determined, and it appears the VA limits came from a manufacturer's specifications originally applied to exposed bus bars in mainframe computers back in the 1960's and concerns at the time service personnel inadvertently bridging them with a metal part.

However, when IEC TC 108 started the IEC 62368-1 project the intent was to take a fresh look at product safety using HBSE and only carry over a legacy requirement if the safety science and HBSE justified it. After considerable study by IEC TC 108, there was no support for carrying over the 240 VA requirement since:

- the requirements were not based on any proven science or sound technical basis;
- the 240 VA value was relatively arbitrary; and
- in practice the requirement was difficult to apply consistently (for example, on a populated printed board or inside a switch mode power supply).

In the meantime, there are energy limits for capacitors in Clause 5, which remains a more realistic concern and which were the second set of the energy hazard requirements in IEC 60950-1, the first being steady state 240 VA.

In addition, there are other requirements in IEC 62368-1 that will limit exposure to high levels of power (VA), including a VA limit for LPS outputs when those are required by Annex Q (for outputs connected to building wiring as required by 6.5.2).

Electric burn (eBurn)

Analysis of the body current generated by increasing frequency sinusoidal waveforms shows that the current continues to increase with frequency. The same analysis shows that the **touch current**, which is discounted with frequency, stabilizes.

The following paper describes the analysis fully: 'Touch Current Comparison, Looking at IEC 60990 Measurement Circuit Performance – Part 1: Electric Burn'; Peter E Perkins; IEEE PSES Product Safety Engineering Newsletter, Vol 4, No 2, Nov 2008.

The crossover frequency is different for the startle-reaction circuit than for the let go-immobilization circuit because of the separate Frequency Factor body response curves related to current levels; analysis identifies the crossover frequency where the eBurn current surpasses the **touch current**. Under these conditions, a person touching the circuit will become immobilized and will not be able to let go of the circuit. This crossover frequency is determined in the analysis. The person contacting the circuit is always expected to be able to let go.

The general conditions that apply to eBurn circuits are:

- the eBurn limit only applies to HF sinusoidal signals;
- the area of contact must be limited to a small, fingertip contact ($\sim 1\text{cm}^2$);
- the contact time must be less than 1 s; at this short contact time, it is not reasonable to define different levels for various persons;
- This requirement applies to **accessible** circuits that can be contacted at both poles, including all grounded circuits isolated from the **mains** and any isolated circuits where both contacts are easily available to touch.

A simplified application of these requirements in the documents limits the accessibility of HF sinusoidal currents above a specified frequency. The 22 kHz and 36 kHz frequency limits are where the eBurn current crosses the 5 mA limit for the ES1 and ES2 measurement circuits. This will ensure that the person contacting the circuit will be able to remove themselves from the circuit under these conditions.

1 MHz limit

The effects of electric current on the human body are described in the IEC 60479 series and the requirements in IEC 62368-1 are drawn from there. The effects versus frequency are well laid out and properly accounted for in these requirements. The body effects move from conducted effects to surface radiofrequency burns at higher frequencies approaching 100 kHz. By long-term agreement, IEC safety documents are responsible for outlining the effects of current to 1 MHz, which are properly measured by the techniques given herein. Above the 1 MHz level, it becomes an EMC issue. Unless the current is provided as a principal action of the equipment operation, electric shock evaluation is not needed above the 1 MHz level. Where it is fundamental to the equipment's operation, the high-frequency current levels must be specially measured using proper high-frequency techniques, including classifying the circuits and, if necessary, appropriately protected to avoid any bodily injury.

5.2.1 Electrical energy source classifications

Source: IEC 60479-1:2018 and IEC TS 61201

Purpose: To define the line between hazardous and non-hazardous electrical energy sources for **normal operating conditions** and **abnormal operating conditions**.

Rationale: The effect on persons from an electric source depends on the current through the human body. The effects are described in IEC 60479-1.

IEC 60479-1:2018 (see Figures 20 and 22, Tables 11 and 13); zone AC-1 and zone DC-1; usually no reaction (Figure 8 and Figure 9, Table 2 and Table 3 in this document) are taken as values for ES1.

IEC 60479-1:2018 (see Figures 20 and 22; Tables 11 and 13); zone AC-2 and zone DC-2; usually no harmful physiological effects (see Figure 8 and Figure 9, Table 2 in this document) are taken as values for ES2.

IEC 60479-1:2018; zone AC-3 and zone DC-3; harmful physiological effects can occur (see Figure 8 and Figure 9, Table 2 and Table 3 in this document) are taken for the ES3 zone.

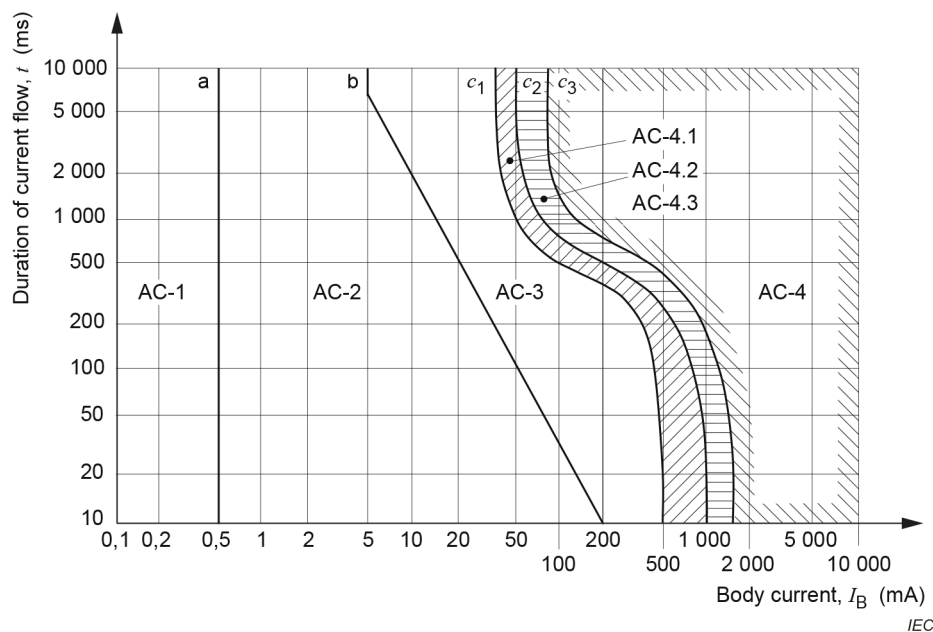


Figure 8 – Conventional time/current zones of effects of AC currents (15 Hz to 100 Hz) on persons for a current path corresponding to left hand to feet (see IEC 60479-1:2018, Figure 20)

**Table 2 – Time/current zones for AC 15 Hz to 100 Hz
for hand to feet pathway (see IEC 60479-1:2018, Table 11)**

Zones	Boundaries	Physiological effects
AC-1	up to 0,5 mA curve a	Perception possible but usually no startle reaction
AC-2	0,5 mA up to curve b	Perception and involuntary muscular contractions likely but usually no harmful electrical physiological effects
AC-3	Curve b and above	Strong involuntary muscular contractions. Difficulty in breathing. Reversible disturbances of heart function. Immobilisation can occur. Effects increasing with current magnitude. Usually, no organic damage to be expected.
AC-4 ^a	Above curve c_1 $c_1 - c_2$ $c_2 - c_3$ Beyond curve c_3	Pathophysiological effects can occur such as cardiac arrest, breathing arrest, and burns or other cellular damage. Probability of ventricular fibrillation increasing with current magnitude and time. AC-4.1 Probability of ventricular fibrillation increasing up to about 5 %. AC-4.2 Probability of ventricular fibrillation up to about 50 %. AC-4.3 Probability of ventricular fibrillation above 50 %.

^a For durations of current flow below 200 ms, ventricular fibrillation is only initiated within the vulnerable period if the relevant thresholds are surpassed. As regards ventricular fibrillation, this figure relates to the effects of current that flows in the path left hand to feet. For other current paths, the heart current factor must be considered.

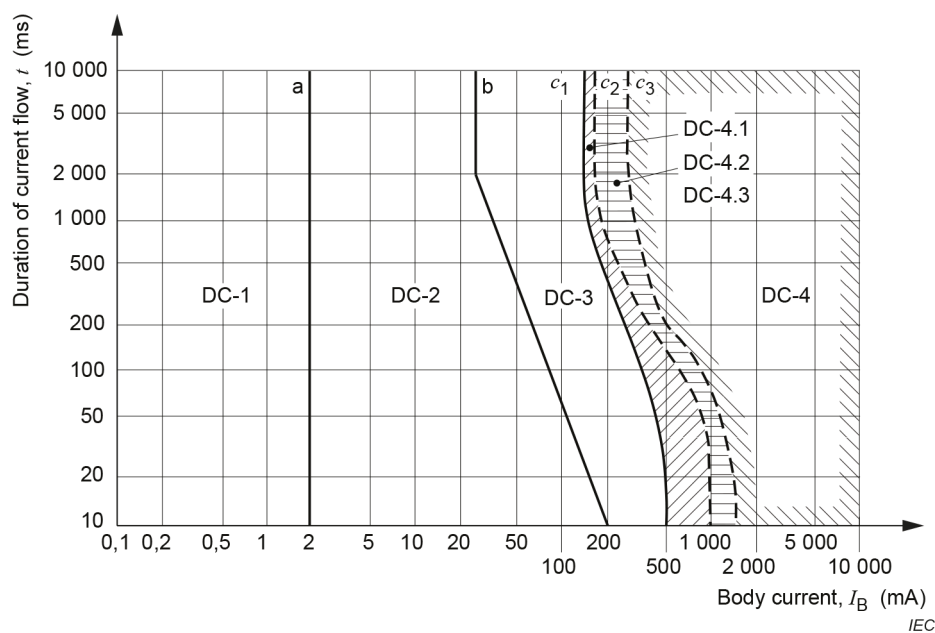


Figure 9 – Conventional time/current zones of effects of DC currents on persons for a longitudinal upward current path (see IEC 60479-1:2018, Figure 22)

**Table 3 – Time/current zones for DC for hand to feet pathway
(see IEC 60479-1:2018, Table 13)**

Zones	Boundaries	Physiological effects
DC-1	Up to 2 mA curve a	Slight pricking sensation possible when making, breaking or rapidly altering current flow.
DC-2	2 mA up to curve b	Involuntary muscular contractions likely, especially when making, breaking or rapidly altering current flow, but usually no harmful electrical physiological effects
DC-3	curve b and above	Strong involuntary muscular reactions and reversible disturbances of formation and conduction of impulses in the heart can occur, increasing with current magnitude and time. Usually, no organic damage to be expected.
DC-4 ^a	Above curve c_1 $c_1 - c_2$ $c_2 - c_3$ Beyond curve c_3	Pathophysiological effects can occur such as cardiac arrest, breathing arrest, and burns or other cellular damage. Probability of ventricular fibrillation increasing with current magnitude and time. DC-4.1 Probability of ventricular fibrillation increasing up to about 5 %. DC-4.2 Probability of ventricular fibrillation up to about 50 %. DC-4.3 Probability of ventricular fibrillation above 50 %.
^a For durations of current flow below 200 ms, ventricular fibrillation is only initiated within the vulnerable period if the relevant thresholds are surpassed. As regards ventricular fibrillation, this figure relates to the effects of current which flows in the path left hand to feet and for upward current. For other current paths, the heart current factor must be considered.		

The seriousness of an injury increases continuously with the energy transferred to the body. To demonstrate this principle, Figure 8 and Figure 9 in this document (see IEC 60479-1:2018, Figures 20 and 22) are transferred into a graph: effects versus energy (see Figure 10 in this document).

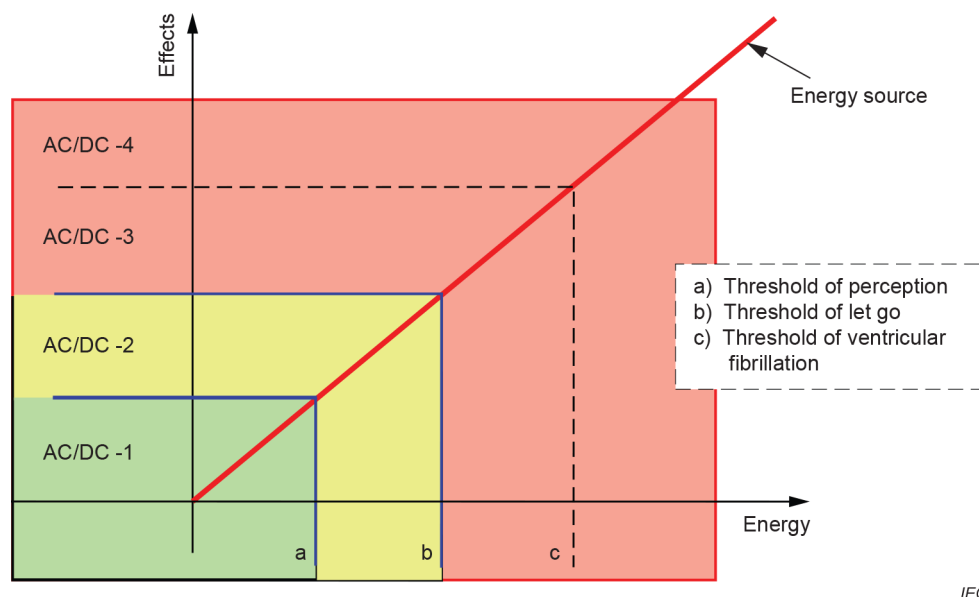


Figure 10 – Illustration that limits depend on both voltage and current

Within the document, only the limits for Zone 1 (green) and Zone 2 (yellow) will be specified.

Curve “a” (limit of Zone 1) will be the limit for parts **accessible** by an **ordinary person** during normal use.

Curve “b” (limit of Zone 2) will be the limit for parts **accessible** by an **ordinary person** during (or after) a single fault.

IEC TC 108 regarded it not to be acceptable to go to the limits of either Zone 3 or 4.

In the document three (3) zones are described as electrical energy sources.

This classification is as follows:

- electrical energy source 1 (ES1): levels are of such a value that they do not exceed curve “a” (threshold of perception) of Figure 8 and Figure 9 in this document (see IEC 60479-1:2018, Figures 20 and 22).
- electrical energy source 2 (ES2): levels are of such a value that they exceed curve “a”, but do not exceed curve “b” (threshold of let go) of Figure 8 and Figure 9 in this document (see IEC 60479-1:2018, Figures 20 and 22).
- electrical energy source 3 (ES3): levels are of such a value that they exceed curve “b” of Figure 8 and Figure 9 in this document (see IEC 60479-1:2018, Figures 20 and 22).

5.2.2.1 General

When classifying a circuit or part that is not **accessible**, that circuit or part must be regarded as being **accessible** when measuring **prospective touch voltage** and **touch current**.

Signals for communication or data circuits are generally low voltage, high impedance sources.

When combining these communication or data signals with a possible normal operating voltage (for example, DC feeding voltage), the communication or data signal voltage itself is disregarded and is not used for the classification of the circuits. If there is no normal operating voltage present, the signals are also disregarded for purposes of circuit classification.

Examples for communication or data signals:

- typically found on indoor ICT networks, like USB, HDMI, PoE, Ethernet, analogue voice, digital phone systems, G.fast, G.now, G.hn, ISDN-S Bus, A/V, etc.
- typically found on outdoor and/or indoor ICT networks, like analogue voice, T1/E1, SHDSL, xDSL, G.fast, G.now, G.hn, PoE, Ethernet, ISDN U interface, Primary rate ISDN, etc.

NOTE 1 In this context, the normal operating voltage is the powering voltage for the ICT line.

NOTE 2 See 5.2.2.6 for information regarding telephone ringing signals.

The typical application for classifying an **external circuit** is a remote feeding voltage with a superimposed communication or data signal.

5.2.2.2 Steady state voltage and current limits

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

Source: IEC 60479-1:2018, Dalziel, Effect of Wave Form on Let-Go Currents; AIEE Electrical Engineering Transactions, Dec 1943, Vol 62.

Rationale: The current limits of Table 4 line 1 and 2 are derived from curve a and b, Figure 8 and Figure 9 in this document (see IEC 60479-1:2018, Figures 20 and 22).

The basis for setting limits for combined AC and DC **touch current** is from the work of Dalziel which provides clear data for men, women and children. In the current diagram (Figure 22), the AC current is always the peak value (per Dalziel). In the voltage diagram (Figure 23), the 30 V AC and 50 V AC points on the baseline are recognized as AC RMS values as stated in Table 4. Since IEC TC 108 is working with consumer appliances, there is a need to provide protection for children, who are generally considered the most vulnerable category of people. The formulas of Table 4 address the Dalziel investigations.

Under **single fault conditions** of a relevant **basic safeguard** or **supplementary safeguard**, **touch current** is measured according to 5.1.2 of IEC 60990:2016. However, this IEC 60990 subclause references both the IEC 60990 perception/reaction network (Figure 4) and the let-go network (Figure 5), selection of which depends on several factors. Figure 5 applies to **touch current** limits above 2 mA RMS. IEC TC 108 has decided that parts under **single fault conditions** of relevant **basic safeguards** or **supplementary safeguards** must be measured per Figure 5 (let-go immobilization network). Therefore, since 5.1.2 makes reference to both Figure 4 and Figure 5, for clarification Table 4 is mentioned directly in 5.2.2.2.

Because there is usually no reaction of the human body when touching ES1, access is permitted by any person (IEC 60479-1:2018; zone AC-1 and zone DC-1).

Because there can be a reaction of the human body when touching ES2, protection is required for an **ordinary person**. One **safeguard** is sufficient because there are usually no harmful physiological effects when touching ES2 (IEC 60479-1:2018; zone AC-2 and zone DC-2).

Because harmful physiological effects can occur when touching ES3, (IEC 60479-1:2018; zone AC-3 and zone DC-3), protection is required for an **ordinary person** and an **instructed person**, including after a fault of one **safeguard**.

During the application of the electrical energy source limits for “combined AC and DC” in Table 4, if the AC component of a superimposed AC and DC energy source does not exceed 10 % of the DC energy, then the AC component can be disregarded for purposes of application of Table 4. This consideration is valid based on the definition of **DC voltage** in 3.3.14.1, which allows peak-to-peak ripple not exceeding 10 % of the average value to be integrated into **DC voltage** considerations. As a result, in such cases where AC does not exceed 10 % of DC, only the DC energy source limits in Table 4 need be applied.

When measuring combined AC and DC voltages and currents, both AC and DC measurements must be made between the same points of reference. Do not combine common-mode measurements with differential-mode measurements. They are assessed separately.

In using Table 4, ES1 touch current measurement specifies the startle-reaction circuit ‘a’ intended for limits less than 2 mA RMS / 2,8 mA peak and ES2 touch current specifies the let-go-immobilization circuit ‘b’ intended for limits > 2 mA RMS / 2,8 mA peak. These circuits are adopted from IEC 60990:2016, Clause 5.

Normal operating conditions of equipment for touch current testing are outlined in 5.7.2 and Clause B.2 and includes operation of all operator controls. **Abnormal operating conditions** are specified in Clause B.3. **Single fault conditions** (within the equipment), specified in Clause B.4, includes faults of a relevant **basic safeguard** or a **supplementary safeguard**.

5.2.2.3 Capacitance limits

Table 5 Electrical energy source limits for a charged capacitor

Source: IEC TS 61201:2007 (Annex A)

Rationale: Where the energy source is a capacitor, the energy source class is determined from both the charge voltage and the capacitance. The capacitance limits are derived from IEC TS 61201:2007, see Table 4 in this document.

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

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

Table 4 – Limit values of accessible capacitance (threshold of pain)

U V	C μF	U kV	C nF
70	42,4	1	8,0
78	10,0	2	4,0
80	3,8	5	1,6
90	1,2	10	0,8
100	0,58	20	0,4
150	0,17	40	0,2
200	0,091	60	0,133
250	0,061		
300	0,041		
400	0,028		
500	0,018		
700	0,012		

5.2.2.4 Single pulse limits**Table 6 Voltage limits for single pulses**

Rationale: The values are based on the DC current values of Table 4, assuming 25 mA gives a voltage of 120 V DC (body resistance of 4,8 kΩ). The lowest value is taken as 120 V because, under **single fault conditions**, the voltage of ES1 can be as high as 120 V DC without a time limit.

The table allows linear interpolation because the difference is considered to be very small. However, the following formula can be used for a more exact interpolation of the log-log based values in this table. The variable t or V is the desired unknown "in between value" and either can be determined when one is known:

$$V = \text{Antilog} \frac{\log V_2 + \log V_1 \times \frac{\log t_2 - \log t}{\log t - \log t_1}}{1 + \frac{\log t_2 - \log t}{\log t - \log t_1}}$$

and

$$t = \text{Antilog} \frac{\log t_2 + \log t_1 \times \frac{\log V_2 - \log V}{\log V - \log V_1}}{1 + \frac{\log V_2 - \log V}{\log V - \log V_1}}$$

where:

- t is the time duration that is required to be determined if U_{peak} voltage V is known (or t is known and V must be determined)
- t_1 is the time duration adjacent to t corresponding to the U_{peak} voltage V_1
- t_2 is the time duration adjacent to t corresponding to the U_{peak} voltage V_2
- V is the U_{peak} voltage value that is known if time duration t is to be determined (or V is required to be determined if time duration t is known)

V_1 is the value of the voltage U_{peak} adjacent to V corresponding to time duration t_1

V_2 is the value of the voltage U_{peak} adjacent to V corresponding to time duration t_2

Table 7 **Current limits for single pulses**

Source: IEC 60479-1:2018

Rationale: For ES1, the limit of a single pulse is not to exceed the ES1 steady-state voltage limits for **DC voltages**.

For ES2, the voltage limits have been calculated by using the DC current values of curve b Figure 9 in this document and the resistance values of Table 10 of IEC 60479-1:2018, column for 5 % of the population (see Table 5 in this document).

The current limits of single pulses in Table 7 for ES1 levels are from curve a and for ES2 are from curve b of Figure 9 in this document.

The table allows linear interpolation because the difference is considered to be very small. However, the following formula can be used for a more exact interpolation of the log-log based values in this table. The variable t or I is the desired unknown "in between value" and either can be determined when one is known:

$$I = \text{Antilog} \frac{\log I_2 + \log I_1 \times \frac{\log t_2 - \log t}{\log t - \log t_1}}{1 + \frac{\log t_2 - \log t}{\log t - \log t_1}}$$

and

$$t = \text{Antilog} \frac{\log t_2 + \log t_1 \times \frac{\log I_2 - \log I}{\log I - \log I_1}}{1 + \frac{\log I_2 - \log I}{\log I - \log I_1}}$$

where:

t is the time duration that is required to be determined if the electric current I is known (or t is known and I must be determined)

t_1 is the time duration adjacent to t corresponding to the electric current I_1

t_2 is the time duration adjacent to t corresponding to the electric current I_2

I is the value of the I_{peak} current that is known if time duration t is to be determined (or I is required to be determined if time duration t is known)

I_1 is the value of the I_{peak} adjacent to I corresponding to time duration t_1

I_2 is the value of the I_{peak} adjacent to I corresponding to time duration t_2

Table 5 – Total body resistances R_T for a current path hand to hand, DC, for large surface areas of contact in dry condition

Touch voltage V	Values for the total body resistance R_T (Ω) that are not exceeded for		
	5 % of the population	50 % of the population	95 % of the population
25	2 100	3 875	7 275
50	1 600	2 900	5 325
75	1 275	2 275	4 100
100	1 100	1 900	3 350
125	975	1 675	2 875
150	875	1 475	2 475
175	825	1 350	2 225
200	800	1 275	2 050
225	775	1 225	1 900
400	700	950	1 275
500	625	850	1 150
700	575	775	1 050
1 000	575	775	1 050
Asymptotic value	575	775	1 050
NOTE 1 Some measurements indicate that the total body resistance R_T for the current path hand to foot is somewhat lower than for a current path hand to hand (10 % to 30 %). NOTE 2 For living persons, the values of R_T correspond to a duration of current flow of about 0,1 s. For longer durations R_T values can decrease (about 10 % to 20 %) and after complete rupture of the skin R_T approaches the initial body resistance R_O. NOTE 3 Values of R_T are rounded to 25 Ω.			

5.2.2.5 Limits for repetitive pulses

Source: IEC 60479-1 and IEC 60479-2

Rationale: IEC 60950-1 typically used 1 s as the normal heartbeat interval time for which protection was provided – for example, impulse protection. The average heart rate for humans was considered to be 1 s (60 beats per minute).

However, people engaged in intense sport activities, such as marathon and triathlon competitors, sometimes have a rest heart rate going as low as around 20 bpm. IEC TC 64/WG 4 agreed that the protection time must be increased to 3 s to provide protection for the full population. This value is used in IEC 62368-1.

5.2.2.6 Ringing signals

Source: EN 41003

Purpose: To establish limits for analogue telephone network ringing signals.

Rationale: For details see rationale for Annex H. Where the energy source is an analogue telephone network ringing signal as defined in Annex H, the energy source class is taken as ES2 (as in IEC 60950-1:2005, Annex M).

5.2.2.7 Audio signals

Source: IEC 60065:2014

Purpose: To establish limits for touch voltages for audio signals.

Rationale: The proposed limits for touch voltages at terminals involving audio signals that can be contacted by persons have been extracted without deviation from IEC 60065. Reference: IEC 60065:2014, 9.1.1.2 a). Under **single fault conditions**, 10.2 of IEC 60065:2014 does not permit an increase in acceptable touch voltage limits.

The proposed limits are quantitatively larger than the accepted limits of Table 5 and Table 6, but are not considered dangerous for the following reasons:

- the output is measured with the load disconnected (worst case load);
- defining the contact area of connectors and wiring is very difficult due to complex shapes. The area of contact is considered small due to the construction of the connectors;
- normally, it is recommended to the user, in the instruction manual provided with the equipment, that all connections be made with the equipment in the “off” condition;
- in addition to being on, the equipment must be playing some programme at a high output with the load disconnected to achieve the proposed limits (although possible, highly unlikely). Historically, no known cases of injury are known for amplifiers with non-clipped output less than 71 V RMS;
- the National Electrical Code (USA) permits **accessible** terminals with maximum output voltage of 120 V RMS.

5.3.1 Protection against electrical energy sources – General

Source: IEC 60950-1

Rationale: IEC 60950-1:2005, subclause 2.3.2 “*Separation of TNV CIRCUITS from other circuits and from accessible parts*” requires protection either by subclause 2.3.2.2 “*Protection by basic insulation*”, or by subclause 2.3.2.3 “*Protection by earthing*”, or by subclause 2.3.2.4 “*Protection by other constructions*”.

In IEC 62368-1, in subclause 5.3 “*Protection against electrical energy sources*” – 5.3.1 “*General*”, protection requirements for **accessible** parts are given in subclause 4.3 “*Protection against energy sources*”.

For ES2/ES3 circuits having a **double safeguard** or a **reinforced safeguard** to any ES3 **main**s, and for ES2/ES3 circuits having a **basic safeguard** to any ES2 **main**s, under **single fault conditions** in the circuit between the ES2/ES3 circuits not directly connected to the **main**s and **accessible** ES1/ES2 circuits, the voltages/currents in ES1 circuits are not to exceed the ES1 limits, and the voltages/currents in ES2 circuits are not to exceed the ES2 limits.

For example, products such as internet residential gateways and similar products, powered by a class II power supply unit, frequently include an indoor foreign exchange station (FXS) telephone interface at ES2 levels (TNV-2 in IEC 60950-1) and other indoor ES1 interfaces (SELV for IEC 60950-1) and USB.

A very common characteristic of such internet residential gateways with indoor FXS telephone interface, and powered by a class II power supply unit, is that the protection between TNV-2 CIRCUITS and SELV CIRCUITS is not achieved by basic insulation or by earthing, but by compliance with subclause 2.3.2.4 “*Protection by other constructions*” of IEC 60950-1.

In subclause 2.3.2.4 “*Protection by other constructions*” of IEC 60950-1, other constructions are permitted if they ensure that the voltages of the SELV CIRCUITS and **accessible** conductive parts do not exceed the limits specified in 2.3.1 b) for TNV-2 CIRCUITS and TNV-3 CIRCUITS under **normal operating conditions**, and compliance is checked by simulation of failures of components and insulation such as are likely to occur in the equipment.

Even if the exception of 5.3.1 is applicable to ES2 (or ES3) circuits from which **accessible** ES1 (or ES2) circuits are derived, such a construction can be accommodated because it does not always require a clear demarcation (isolation) between indoor ES2 (FXS) and indoor ES1 (USB for example).

In the case of such internet residential gateways with indoor FXS (ES2) that are powered by a class II power supply unit, it is the indoor ES2 circuits (FXS) that are derived from the indoor ES1 circuits (powered by the output of the class II power supply unit).

Figure 11 of this document shows a typical example of a such a product.

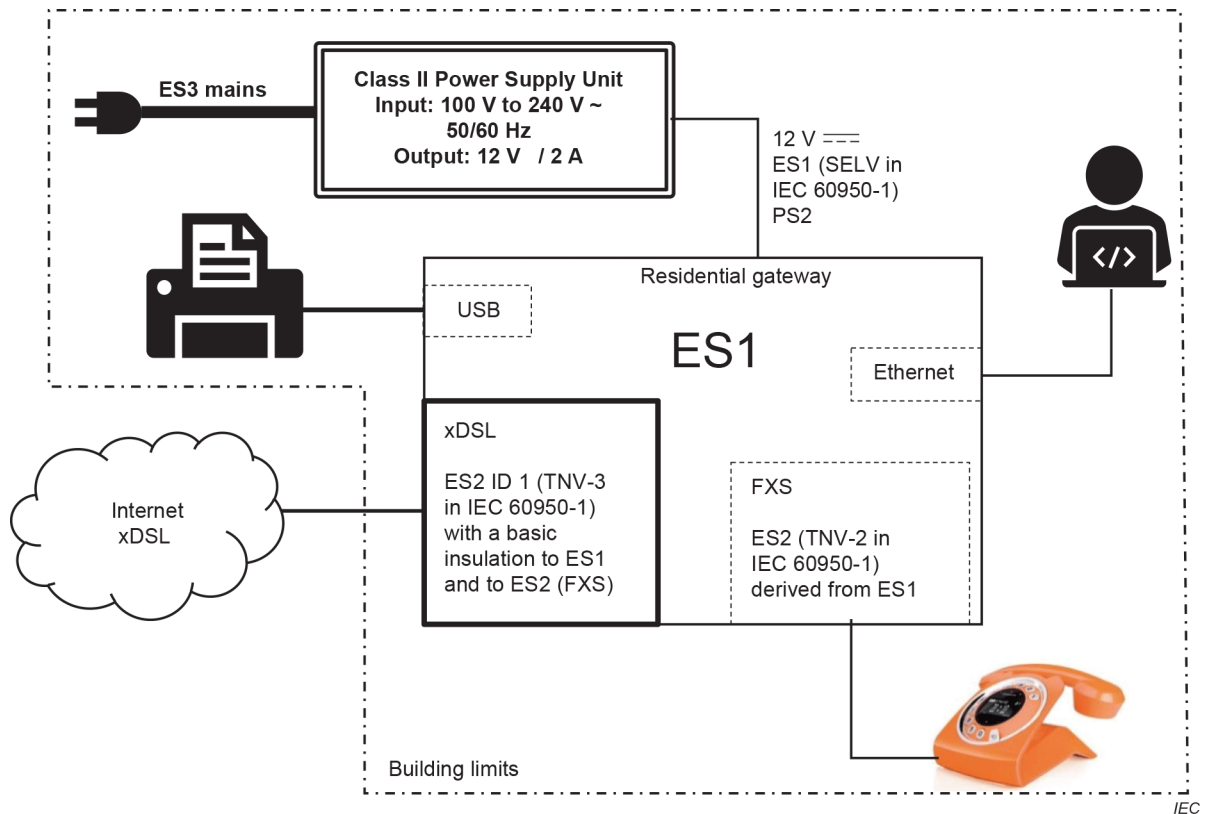
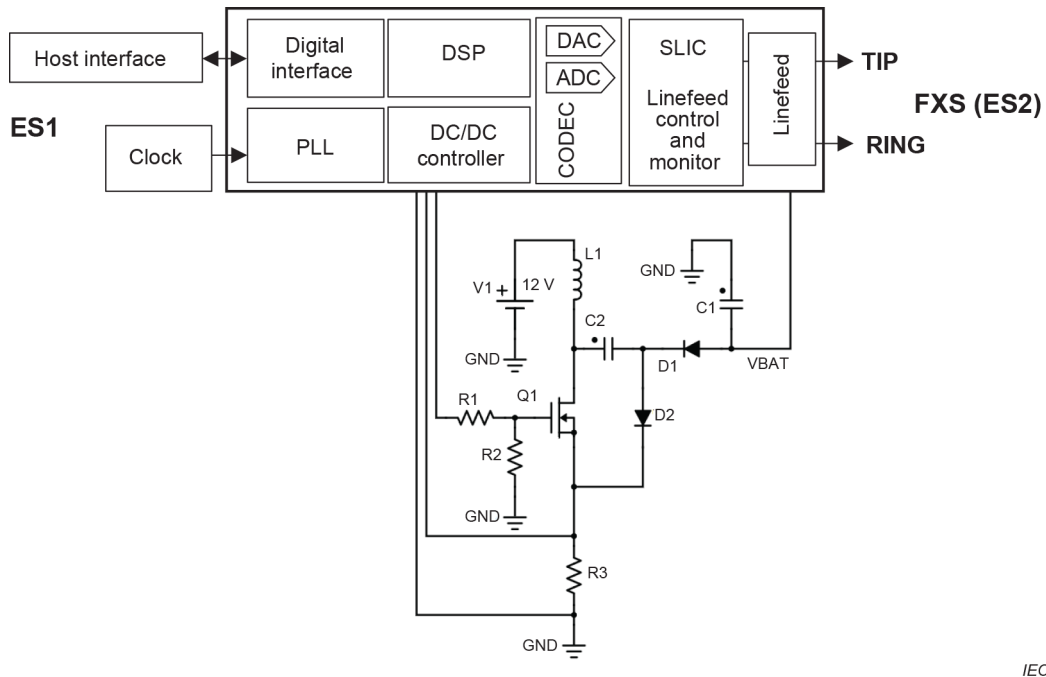


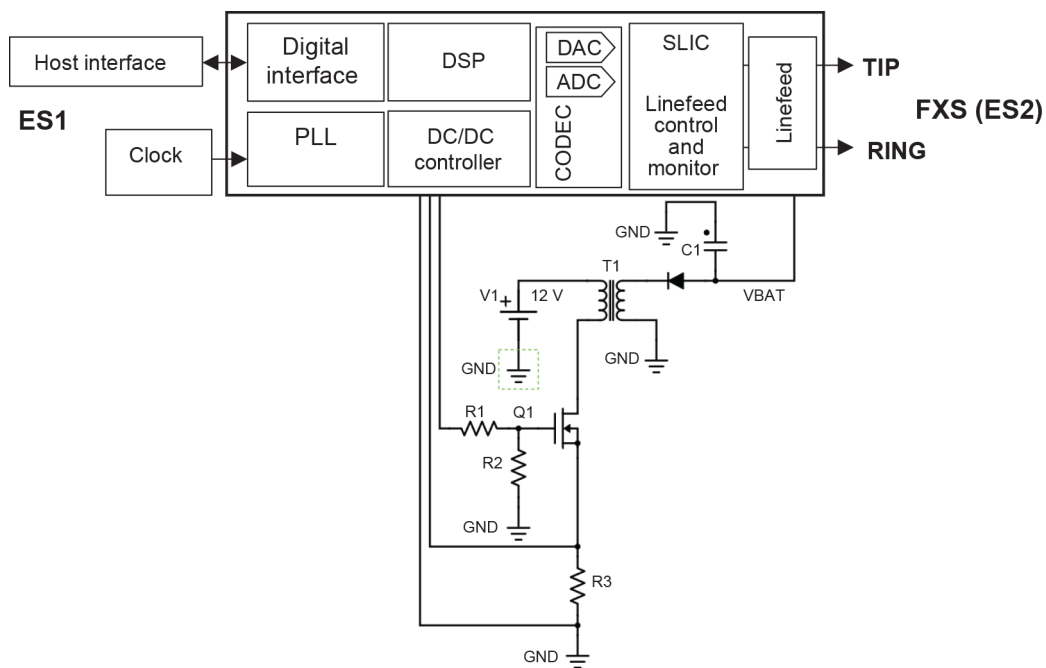
Figure 11 – Typical example

Figure 12 and Figure 13 show examples of typical circuits between ES1 and indoor ES2 of FXS.



IEC

Figure 12 – Example 1



IEC

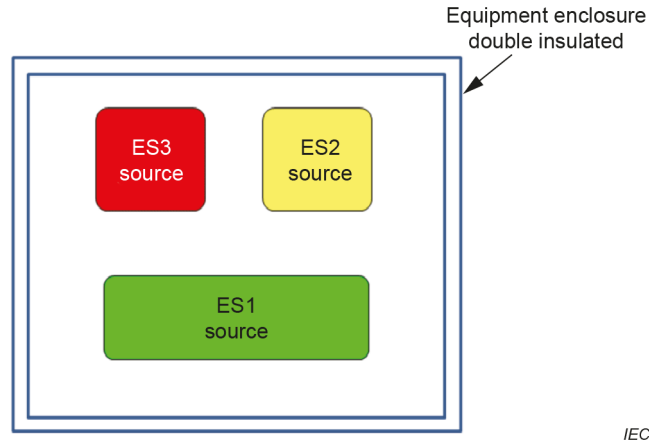
Figure 13 – Example 2

In the above examples, V1 (12 V DC) is the ES1 voltage source (output of class II power supply unit) and VBAT is the derived indoor ES2 voltage generated by the DC/DC converter function including DC/DC controller and the related components.

Multiple components are present and under **single fault conditions**, ES1 circuits must remain within ES1 limits, and ES2 circuits must remain within ES2 limits.

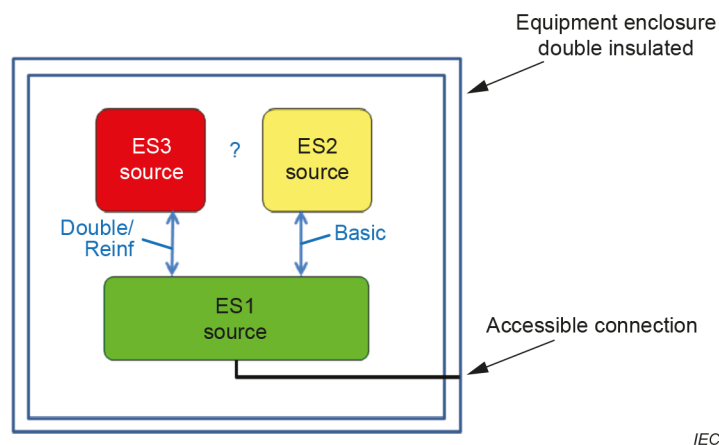
This approach is equivalent to subclause 2.3.2.4 “*Protection by other constructions*” of IEC 60950-1, is in compliance with the principle concept of IEC 62368-1 and is also common practice of most of the internet residential gateway constructions.

5.3.2 Accessibility to electrical energy sources and safeguards



What are the requirements between the non-**accessible** sources?

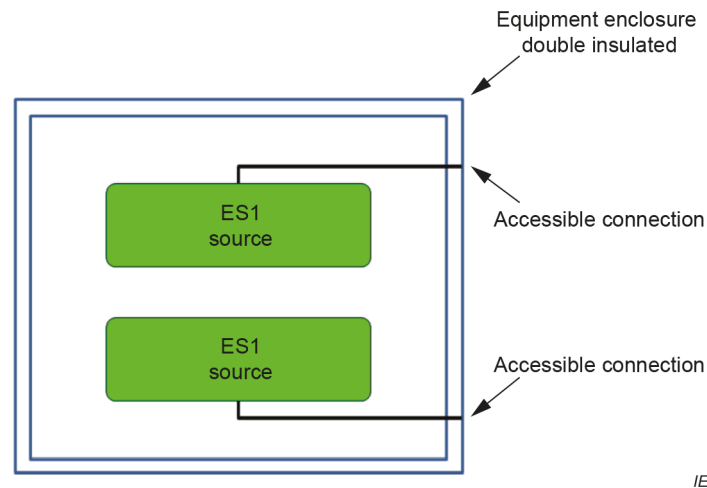
Answer: None. As the **enclosure** is double insulated, the sources are not **accessible**.



Now there is an **accessible** connection. What are the requirements between the sources in this case?

Answer:

- **Basic safeguard** between ES1 and ES2
- **Double safeguard** or **reinforced safeguard** between ES1 and ES3
- The **safeguard** between ES2 and ES3 depends on the **safeguard** between the ES1 and ES2



Now there are two **accessible** connections from independent sources. What are the requirements between the sources in this case?

Answer:

- According to Clause B.4, the insulation or any components between the sources must be shorted
- If one of the two ES1 sources would reach ES2 levels ⇒ **basic safeguard**
- If both ES1 sources stay within ES1 limits ⇒ no **safeguard (functional insulation)**

For **outdoor equipment**, lower voltage limits apply because the body impedance is reduced to half the value when subjected to wet conditions as described in IEC 60479-1:2018 and IEC TS 61201.

Where **Class III equipment** is acceptable in an indoor application, this outdoor application does not introduce additional **safeguard** requirements.

5.3.2.2 Contact requirements

Source: IEC 61140:2001, 8.1.1

Purpose: Determination of **accessible** parts for adults and children. Tests are specified in Annex V.

Rationale: According to Paschen's Law, air breakdown does not occur below 323 V peak or DC (at sea level). IEC 62368-1 uses 420 V peak (300 V RMS) to add an additional safety margin.

5.3.2.3 Compliance criteria

The reason for accepting different requirements for components is because you cannot expect your supplier to make different components for each end application.

5.3.2.4 Terminals for connecting stripped wire

Source: IEC 60065

Purpose: To prevent contact of ES2 or ES3 parts.

Rationale: Accepted constructions used in the audio/video industry for many years.

5.4 Insulation materials and requirements

Rationale: The requirements, test methods and compliance criteria are taken from the actual outputs from IEC TC 108 MT2 (formerly WG6) as well as from IEC TC 108 MT1.

- The choice and application of components is dependent on the need for electrical, thermal and mechanical strength, frequency of the **working voltage** and working environment (temperature, pressure, humidity and pollution).
- Components must have their electric strength, thermal strength, mechanical strength, dimensions, and other properties as specified in the document.
- Depending on the grade of **safeguard (basic safeguard, supplementary safeguard, reinforced safeguard)** the requirements differ.
- Components complying with their component documents (for example, IEC 60384-14 for capacitances) must be verified for their application.
- The components listed in this subclause of the new document have a separation function.

5.4.1.1 Insulation

Source: IEC 60664-1

Purpose: Provide a reliable **safeguard**

Rationale: Solid **basic insulation, supplementary insulation, and reinforced insulation** must be capable of durably withstanding electrical, mechanical, thermal, and environmental stress that can occur during the anticipated lifetime of the equipment.

Clearances and **creepage distances** can be divided by intervening unconnected (floating) conductive parts, such as unused contacts of a connector, provided that the sum of the individual distances meets the specified minimum requirements (see Figure O.4).

5.4.1.4 Maximum operating temperatures for materials, components and systems

Source: IEC 60085, IEC 60364-4-43, ISO 306, IEC 60695-10-2

Rationale: Temperature limits given in Table 9:

- limits for insulation materials including electrical insulation systems, including winding insulation (Classes A, E, B, F, H, N, R and 250) are taken from IEC 60085;
- limits for insulation of internal and external wiring, including power supply cords with temperature marking are those indicated by the marking or the rating assigned by the (component) manufacturer;
- limits for insulation of internal and external wiring, including power supply cords without temperature marking of 70 °C, are referenced in IEC 60364-4-43 for an ambient temperature of 25 °C;
- limits for thermoplastic insulation are based on:
 - data from Vicat test B50 of ISO 306;
 - ball pressure test according to IEC 60695-10-2;
 - when it is clear from the examination of the physical characteristics of the material that it will meet the requirements of the ball pressure test;
 - experience with 125 °C value for parts in a circuit supplied from the **mains**.

5.4.1.4.3 Compliance criteria

Table 9 Temperature limits for materials, components and systems

Rationale	Regarding condition “a”, it has been assumed by the technical committee for many years that the thermal gradient between outer surface and inner windings will be limited to 10 °C differential as an average. As a result, the temperature limits for outer surface insulation measured via thermocouple is 10 °C lower than similar measurement with a thermocouple embedded in the winding(s), with both limits at least 5 °C less than the hot-spot temperature allowed per IEC 60085 as an additional safety factor. However, some modern transformer constructions with larger power densities can have larger thermal gradients, as well as some outer surface transformer insulation thermal measurements in the equipment/system be influenced by forced cooling or similar effects. Therefore, if thermal imaging, computer modeling, or actual measurement shows a thermal gradient greater than 10 °C average between transformer surface temperature and transformer winding(s), the rise of resistance temperature measurement method and limits for an embedded thermocouple must be used (for example, 100 °C maximum temperature for Class 105 (A)) for determining compliance of a transformer with Table 9 since the original assumptions do not hold true. As an example, a material rated for 124 °C using the rise of resistance method is considered suitable for classes whose temperature is lower (class with letter codes E and A) and not for classes whose temperature is higher (class with letter codes B, F, H, N, R and 250).
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5.4.1.5 Pollution degrees

Source: IEC 60664-1

Rationale: No values for PD 4 (pollution generates persistent conductivity) are included, as it is unlikely that such conditions are present when using products in the scope of the document.

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

The compliance check made by visual inspection applies both to single layer and multi-layer boards without the need for sectioning to check for voids, gaps, etc.

5.4.1.6 Insulation in transformers with varying dimensions

Source: IEC 60950-1

Purpose: To consider actual **working voltage** along the winding of a transformer.

Rationale: Description of a method to determine adequacy of **solid insulation** along the length of a transformer winding.

5.4.1.7 Insulation in circuits generating starting pulses

Source: IEC 60950-1, IEC 60664-1

Purpose: To avoid insulation breakdown due to starting pulses.

Rationale: This method has been successfully used for products in the scope of IEC 62368-1 for many years.

5.4.1.8 Determination of working voltage

Source: IEC 60664-1:2020, 3.1.7; IEC 60950-1

Rationale: The **working voltage** does not include short duration signals, such as transients. Recurring peak voltages are not included. Transient overvoltages are covered in the **required withstand voltage**. Ringing signals do not carry external transients.

5.4.1.8.1 General

Rationale: **Functional insulation** is not addressed in Clause 5, as it does not provide protection against electric shock. Requirements for **functional insulation** are covered in Clause 6, which addresses protection against electrically caused fire.

Source: IEC 60664-1:2020, 3.1.14

Rationale: In IEC 62368-1, "Circuit supplied from the **mains**" is used for a "primary circuit". "Circuit isolated from the **mains**" is used for a "secondary circuit".

"**External circuit**" is defined as external to the equipment. ES1 can be external to the equipment.

For an **external circuit** operating at ES2 level and not exiting the building, the transient is 0 V. Therefore, in this case, ringing peak voltage must be taken into account.

5.4.1.8.2 RMS working voltage

Source: IEC 60664-1:2020, 3.1.7

Rationale: RMS **working voltage** is used when determining minimum **creepage distance**. Unless otherwise specified, working voltage is the RMS value.

5.4.1.10 Thermoplastic parts on which conductive metallic parts are directly mounted

Source: ISO 306 and IEC 60695-2 series

Rationale: The temperature of the thermoplastic parts under **normal operating conditions** must be 15 K less than the softening temperature of a non-metallic part. Supporting parts in a circuit supplied from the **mains** must not be less than 125 °C.

5.4.2 Clearances**5.4.2.1 General requirements**

Source: IEC 60664-1:2020

Rationale: The dimension for a **clearance** is determined from the required impulse withstand voltage for that **clearance**. This concept is taken from IEC 60664-1:2020, 5.2. In addition, **clearances** are affected by the largest of the determined transients. The likelihood of simultaneous occurrence of transients is very low and is not taken into account.

Overvoltages and transients that can enter the equipment, and peak voltages that can be generated within the equipment, do not break down the **clearance** (see IEC 60664-1:2020, 5.2.4 and 5.2.5).

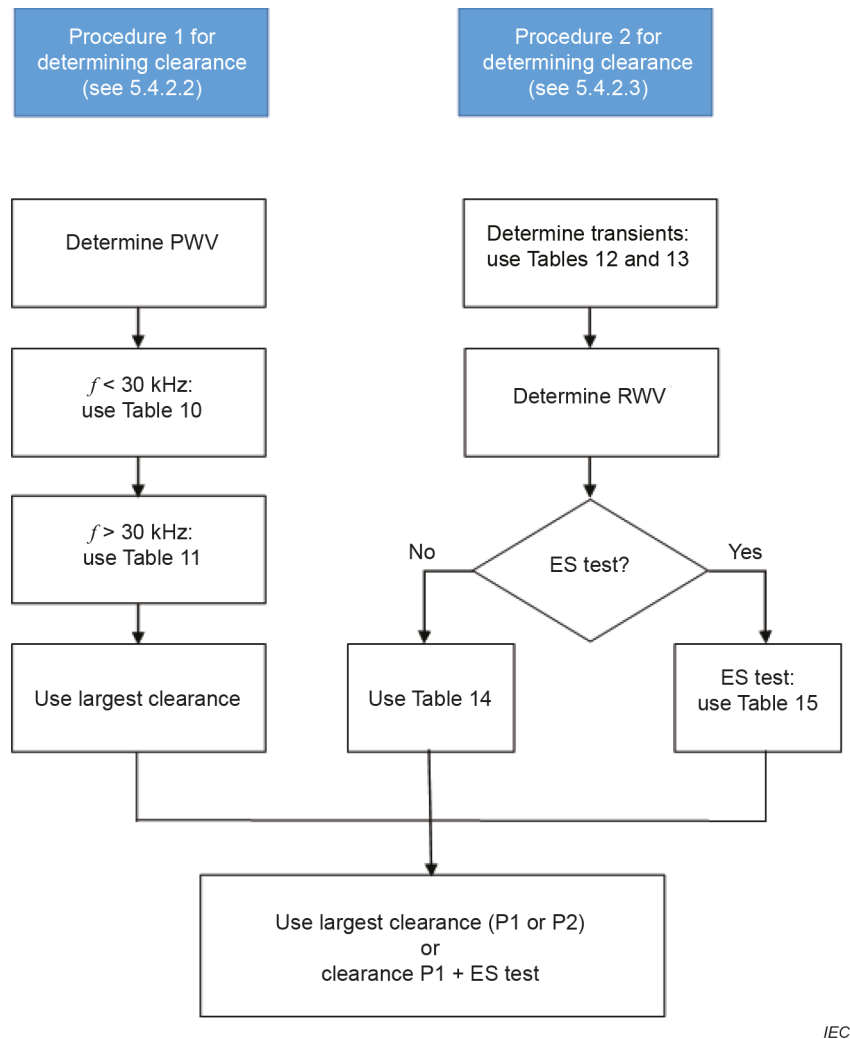
Minimum **clearances** of safety components must comply with the requirements of their applicable component safety document.

Clearances between the outer insulating surface of a connector and conductive parts at ES3 voltage level must comply with the requirements of **basic insulation** only, if the connectors are fixed to the equipment, located internal to the outer **electrical enclosure** of the equipment, and are **accessible** only after removal of a sub-assembly that is required to be in place during normal operation.

It is assumed that the occurrence of both factors, the **sub-assembly** being removed and the occurrence of a transient overvoltage, have a reduced likelihood and hazard potential.

Source: IEC 60664-2 series, *Application guide*

Rationale: The method is derived from the IEC 60664-2 series, *Application guide*. The principles of the requirements of IEC 62368-1 are explained in Figure 14 of this document.



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Example:

Assuming:

- an SMPS power supply,
- connection to the AC **mains**,
- a peak of the working voltage (PWV) of 800 V,
- frequencies above and below 30 kHz,
- reinforced **clearances** required,
- **temporary overvoltages**: 2 000 V

Procedure 1:

Table 10 requires 2,54 mm

Table 11 requires 0,44 mm

Result is 2,54 mm

NOTE All PWV below 1 200 V have **clearance** requirements less than 3 mm for both Table 10 and Table 11.

Final result:

- 3,0 mm or
- ES test at 4,67 kV and 2,54 mm

ATTENTION:

For a product with connection to coaxial cable, different values must be used since a different transient and **required withstand voltage** are required.

Procedure 2:

Transients (OVC 2): 2 500 V

RWV = 2 500 V

Table 14 requires 3,0 mm

The required ES test voltage according to Table 15 is 4,67 kV

Result is 3,0 mm or ES test at 4,67 kV

Figure 14 – Flow chart for determining clearances

5.4.2.2 Procedure 1 for determining clearance

Rationale: Related to the first dash of 5.4.2.2, it is noted that an example of a cause of determination of the peak value of steady state voltages that are below the peak voltage of the **mains** includes, for example, a determination in accordance with the 2nd and 3rd dash of 5.4.2.3.3 where filtering is in place to lower expected peak voltages.

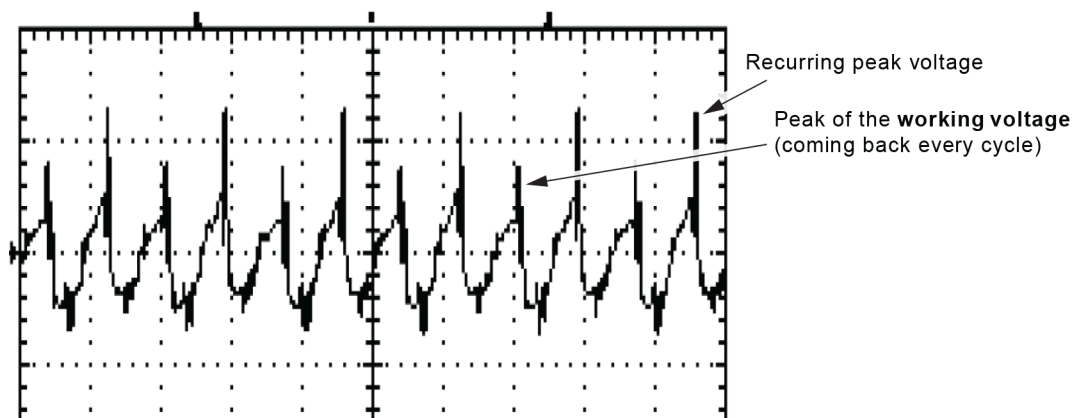
Similarly, related to the second dash of 5.4.2.2, an example of this case where the recurring peak voltage is limited to 1,1 times the **mains** voltage is the use of certain forms of surge protection **devices** that reduce overvoltage category.

Peak of the working voltage versus recurring peak voltage.

There has been some discussion between the two terms. The peak of the **working voltage** is the peak value of the waveform that occurs each cycle, and therefore is considered to be a part of the **working voltage**.

A recurring peak voltage is a peak that does not occur at each cycle of the waveform, but that reoccurs at a certain interval, usually at a lower frequency than the waveform frequency.

Figure 15 in this document gives an example of a waveform where the recurring peak voltage occurs every two cycles of the main waveform.



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Figure 15 – Illustration of working voltage

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

Rationale: IEC TC 108 noted that, if the rules of IEC 60664-1 are followed, for reinforced **clearance**, some values were more than double the requirements for **basic insulation**. IEC TC 108 felt that this is not to be the case and decided to limit the requirement for **reinforced insulation** to twice the value of **basic insulation**, thereby deviating from IEC 60664-1.

In addition, normal rounding rules were applied to the values in the table.

5.4.2.3.2.2 Determining AC mains transient voltages

Source: IEC 60664-1:2020, 4.3.2

Rationale: Table 12 is derived from Table F.1 of IEC 60664-1:2020.

The term used in IEC 60664-1 is 'rated impulse voltage'. Products covered by IEC 62368-1 are also exposed to transients from **external circuits**, and therefore another term is needed, to show the different source.

Outdoor equipment that is part of the building installation, or that can be subject to transient overvoltages exceeding those for Overvoltage Category II, must be designed for Overvoltage Category III or IV, unless additional protection is provided internally or externally to the equipment. In this case, the installation instructions are required to state the need for such additional protection.