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INTERNATIONAL STANDARD

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Automatic electrical controls – Part 1: General requirements

Dispositifs de commande électrique automatiques – Partie 1: Exigences générales



IEC 60730-1:2022-09(en-fr)

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Automatic electrical controls – Part 1: General requirements

Dispositifs de commande électrique automatiques – Partie 1: Exigences générales

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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AUTOMATIC ELECTRICAL CONTROLS –

Part 1: General requirements

FOREWORD

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IEC 60730-1 has been prepared by IEC technical committee 72: Automatic electrical controls. It is an International Standard.

This sixth edition cancels and replaces the fifth edition published in 2013, Amendment 1:2015 and Amendment 2:2020. This edition constitutes a technical revision.

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

a)	Structure of the main clauses	The clauses of the standard are grouped into two sections of requirements, where • the first section consists of the Clauses 5 to 13 that, in general, addresses the construction of the product. It is noted that certain construction requirements may have verification requirements integrated within the clause to facilitate usage of the standard, and • the second section consists of Clauses 14 to 26 that addresses the verification requirements;
b)	Scope	Relocated and deleted clauses to better reflect the products covered under the part 1 and for easier reading;
c)	Normative references	Updated references;
d)	Terms and definitions	Revised text in certain clauses and relocated relevant Clause H.3 subclauses into Clause 3;
e)	General requirements	General structure of the standard explained along with a figure to depict the intent;
f)	General notes on tests	Reduced sample size from 3 to 1, yet requiring analysis; order of tests more flexible; relocation of battery requirements from Annex V;
g)	Rating	Deleted – covered under the scope;
h)	Classification	Deleted – covered under information;
i)	Information	Updated Table 1 to reflect entries from the classification clause, and all cross-references;
j)	Protection against electric shock	Revised Clause 8 to include Clause H.8 and Clause V.8 subclauses, revised clauses as appropriate to distinguish between a live part and a hazardous live part;
k)	Provision for protective earthing	
l)	Construction requirements	One Y1 capacitor allowed; relocated relevant requirements of Clause H.11 and Clause V.11 into Subclause 9.2.5 and Subclause 9.13.4.4 respectively;
m)	Moisture and dust	Relocated IP table from classification to Clause 14; updated references;
n)	Manufacturing deviation and drift	All clauses moved to Annex H since the requirements pertain to functional safety of controls;
o)	EMC-Emissions	Moved Clause H.23 into Clause 23;
p)	EMC-Immunity	New EMC requirements (performance) for all controls except incorporated/integrated controls with Class A control functions. Products intended for HBES/BACS are also subjected to these requirements;
q)	Fault assessment on electronic circuits	Fault assessment moved from Annex H to Clause 13; deleted test abnormal voltage for electronic disconnection;

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r)	Annex H	Relocated all relevant requirements for electronics to the respective clauses within the body of the standard and retained requirements related to functional safety in this annex;
s)	Annex T	Revised clauses for clarity in Annex P;
t)	Annex U	Removed, the necessity of the annex was not seen anymore;
u)	Annex V	Included in the main part of the standard.

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

Draft	Report on voting
72/1307/FDIS	72/1320/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 https//www.iec.ch/publications.

A list of all parts of the IEC 60730 series, under the general title: *Automatic electrical controls*, can be found on the IEC website.

In the development of a fully international standard to cover automatic electrical controls, it has been necessary to take into consideration the differing requirements resulting from practical experience in various parts of the world and to recognize the variation in national electrical systems and wiring rules.

The "in some countries" clauses have been moved to the regional respectively national differences in Annex Q to Annex T.

It is envisaged that in the next edition of this document, it will be found possible to remove those differences that are covered by new IEC standards now being prepared by other technical committees.

This part 1 is to be used in conjunction with the appropriate part 2 for a particular type of control, or for controls for particular applications. This part 1 may also be applied, so far as reasonable, to controls not mentioned in a part 2, and to controls designed on new principles, in which cases additional requirements may be considered to be necessary.

Where, for a particular clause or subclause, the text of part 2 indicates:

Addition: the part 1 text applies with the additional requirement indicated in a part 2;

Modification: the part 1 text applies with a minor change as indicated in a part 2;

Replacement: the part 2 text contains a change which replaces the part 1 text in its entirety.

Where no change is necessary, the part 2 indicates that the relevant clause or subclause applies.

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NOTE In this document the following print types are used:

– Requirements proper: in roman type;

– *Test specifications: in italic type;*

– Explanatory matter: in smaller roman type;

– Defined terms: **bold type**.

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AUTOMATIC ELECTRICAL CONTROLS –

Part 1: General requirements

1 Scope

This document applies to automatic electrical controls

- for use in, on, or in association with equipment for household appliance and similar use;

NOTE 1 Throughout this document, the word "equipment" means "appliance and equipment".

- for building automation within the scope of ISO 16484 series and IEC 63044 series (HBES/BACS);

EXAMPLE 1 Independently mounted water valves, controls in smart grid systems and controls for building automation systems within the scope of ISO 16484-2.

- for equipment that is used by the public, such as equipment intended to be used in shops, offices, hospitals, farms and commercial and industrial applications;

EXAMPLE 2 Controls for commercial catering, heating and air-conditioning equipment.

- that are **smart enabled controls**;

EXAMPLE 3 Smart grid control, remote interfaces/control of energy-consuming equipment including computer or smart phone.

- that are AC or DC powered controls with a rated voltage not exceeding 690 V AC or 600 V DC where the DC source is provided by primary or secondary batteries;
- used in, on, or in association with equipment that use electricity, gas, oil, solid fuel, solar thermal energy, etc., or a combination thereof;
- utilized as part of a control system or controls which are mechanically integral with multifunctional controls having non-electrical outputs;
- using NTC or **PTC thermistors** and to discrete **thermistors**, requirements for which are contained in Annex J;
- that are mechanically or electrically operated, responsive to or controlling such characteristics as temperature, pressure, passage of time, humidity, light, electrostatic effects, flow, or liquid level, current, voltage, acceleration, or combinations thereof;
- as well as manual controls when such are electrically and/or mechanically integral with automatic controls.

NOTE 2 Requirements for manually actuated mechanical switches not forming part of an automatic control are contained in IEC 61058-1-1.

This document applies to

– the inherent safety of automatic electrical controls, and

– functional safety of automatic electrical controls and safety related systems,

– controls where the performance (for example the effect of EMC phenomena) of the product can impair the overall safety and performance of the controlled system,

– the operating values, operating times, and operating sequences where such are associated with equipment safety.

This document specifies the requirements for construction, operation and testing of automatic electrical controls used in, on, or in association with an equipment.

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This document does not

- apply to automatic **electronic controls** intended exclusively for industrial process applications unless explicitly mentioned in the relevant part 2 or the equipment standard. However, this document can be applied to evaluate automatic electrical controls intended specifically for industrial applications in cases where no relevant safety standard exists.
- take into account the response value of an automatic action of a control, if such a response value is dependent upon the method of mounting the control in the equipment. Where a response value is of significant purpose for the protection of the user, or surroundings, the value defined in the appropriate equipment standard or as determined by the manufacturer will apply.
- address the integrity of the output signal to the network devices, such as interoperability with other devices unless it has been evaluated as part of the control system.

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 60038, *IEC standard voltages*

IEC 60065:2014, *Audio, video and similar electronic apparatus – Safety requirements*

IEC 60068-2-75, *Environmental testing – Part 2-75: Tests – Test Eh: Hammer tests*

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

IEC 60099-1:1991, *Surge arresters – Part 1: Non-linear resistor type gapped surge arresters for a.c. systems*[1]

IEC 60112:2020, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60127 (all parts), *Miniature fuses*

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

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

IEC 60269 (all parts), *Low-voltage fuses*

IEC 60335-1:2020, *Household and similar electrical appliances – Safety – Part 1: General requirements*

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

[1] Withdrawn.

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IEC 60384-16, *Fixed capacitors for use in electronic equipment – Part 16: Sectional specification – Fixed metallized polypropylene film dielectric DC capacitors*

IEC 60384-17, *Fixed capacitors for use in electronic equipment – Part 17: Sectional specification – Fixed metallized polypropylene film dielectric AC and pulse capacitors*

IEC 60417, *Graphical symbols for use on equipment*

IEC 60423, *Conduit systems for cable management – Outside diameters of conduits for electrical installations and threads for conduits and fittings*

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

IEC 60539 (all parts), *Directly heated negative temperature coefficient thermistors*

IEC 60664-1:2007[2], *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC TR 60664-2 (all parts), *Insulation coordination for equipment within low-voltage systems*

IEC 60664-3:2016, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

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

IEC 60695-2-10, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60695-2-11:2021, *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 60738 (all parts), *Thermistors – Directly heated positive temperature coefficient*

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

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

IEC 60884-2-5:2017, *Plugs and socket-outlets for household and similar purposes – Part 2-5: Particular requirements for adaptors*

IEC 60998-2-2, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-2: Particular requirements for connecting devices as separate entities with screwless-type clamping units*

[2] Withdrawn.

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IEC 60998-2-3, *Connecting devices for low-voltage circuits for household and similar purposes – Part 2-3: Particular requirements for connecting devices as separate entities with insulation-piercing clamping units*

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

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤16 A per phase and not subject to conditional connection*

IEC 61000-3-11, *Electromagnetic compatibility (EMC) – Part 3-11: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems – Equipment with rated current ≤ 75 A and subject to conditional connection*

IEC 61000-3-12, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤ 75 A per phase*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*
IEC 61000-4-5:2014/AMD1:2017

IEC 61000-4-6, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

IEC 61000-4-8, *Electromagnetic compatibility (EMC) – Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test*

IEC 61000-4-11, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests for equipment with current up to 16 A per phase*

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*
IEC 61000-4-13:2002 /AMD1:2009
IEC 61000-4-13:2002 /AMD2:2015

IEC 61000-4-20, *Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides*

IEC 61000-4-21, *Electromagnetic compatibility (EMC) – Part 4-21: Testing and measurement techniques – Reverberation chamber test methods*

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IEC 61000-4-22, *Electromagnetic compatibility (EMC) – Part 4-22: Testing and measurement techniques – Radiated emissions and immunity measurements in fully anechoic rooms (FARs)*

IEC 61000-4-28, *Electromagnetic compatibility (EMC) – Part 4-28: Testing and measurement techniques – Variation of power frequency, immunity test for equipment with input current not exceeding 16A per phase*

IEC 61000-6-1:2016, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

IEC 61000-6-2:2016, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

IEC 61000-6-3:2020, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for equipment in residential environments*

IEC 61000-6-4:2018, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

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

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

IEC 61051-2-2, *Varistors for use in electronic equipment – Part 2: Blank detail specification for zinc oxide surge suppression varistors. Assessment level E*

IEC 61210, *Connecting devices – Flat quick-connect terminations for electrical copper conductors – Safety requirements*

IEC 61249 (all parts), *Materials for printed boards and other interconnecting structures*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and combinations thereof − Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers for general applications*

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 61810-3, *Electromechanical elementary relays – Part 3: Replays with forcibly guided (mechanically linked) contacts*

IEC 62151, *Safety of equipment electrically connected to a telecommunication network*

IEC 62319 (all parts), *Polymeric thermistors – Directly heated positive step function temperature coefficient*

IEC 62326 (all parts), *Printed boards*

IEC 62368-1, *Audio/video, information and communication technology equipment – Part 1: Safety requirements*

IEC 63044 (all parts), *Home and Building Electronic Systems (HBES) and Building Automation and Control Systems (BACS)*

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CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CISPR 14-1:2020, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment – Emission* requirements
CISPR 32:2015/AMD1:2019

ISO 4046-4:2016, *Paper, board, pulps and related terms − Vocabulary − Part 4: Paper and board grades and converted products*

ISO 7637-2:2011, *Road vehicles – Electrical disturbances from conduction and coupling – Part 2: Electrical transient conduction along supply lines only*

ISO 7637-3:2016, *Road vehicles – Electrical disturbances from conduction and coupling – Part 3: Electrical transient transmission by capacitive and inductive coupling via lines other than supply lines*

ISO 16484 (all parts), *Building automation and control systems (BACS)*

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

NOTE Where the terms "voltage" and "current" are used, they imply the RMS values, unless otherwise specified.

3.1 Definitions relating to ratings, voltages, currents, frequencies, and wattages

3.1.1
rated voltage, current, frequency or wattage
voltage, current, frequency or wattage assigned to a **control** by the manufacturer

Note 1 to entry: For three phase supply, the **rated voltage** is the line-to-line voltage.

3.1.2
rated voltage, current, frequency or wattage range
voltage, current, frequency or wattage ranges assigned to the **control** by the manufacturer and expressed by lower and upper values

3.1.3
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**

Note 1 to entry: **Transient overvoltages** are disregarded.

Note 2 to entry: Open-circuit conditions and normal operating conditions are taken into account.

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3.1.4
extra-low voltage
ELV
voltage not exceeding the maximum values of 50 V AC (RMS), 70,7 V AC (peak) or 120 V DC (ripple-free) between conductors and between conductors and earth which is permitted to be maintained indefinitely under normal and single-**fault** conditions

Note 1 to entry: Ripple-free is conventionally defined as an RMS ripple voltage of not more than 10 % of the DC component.

Note 2 to entry: The use of **ELV** other than in **SELV system** or **PELV system** is not a protective measure against electric shock, this is in line with IEC 61140:2016.

3.1.5
safety extra-low voltage
protective extra-low voltage
SELV/PELV
voltage for use in **SELV system** or **PELV system** between simultaneously **accessible part**(**s**) and between any **accessible part** and earth, not exceeding the limits of 30 V AC (RMS), 42,4 V AC (peak) or 60 V DC (ripple free) under normal and single-**fault** condition, which is provided by an independent source (such as motor generators, and batteries) or when obtained from higher voltage is obtained by a **safety isolating transformer** or a converter with separate windings providing equivalent insulation

Note 1 to entry: The voltage limits are based on the assumption that the **safety isolating transformer** is supplied at its rated voltage. For the purpose of the output test in 12.2.1, the secondary output voltage limit shall be increased as specified in 19.2.2.

Note 2 to entry: Transformers used in converters that have separate windings and provide equivalent insulation are covered under IEC 61558-2-6 and IEC 61558-2-16.

Note 3 to entry: **SELV/PELV** limits are defined regardless of any special condition which may occur in installation. Different requirements may be specified in the relevant electrical installation standards (e.g. IEC 60364 series) or in the applicable local regulations.

Note 4 to entry: Ripple-free is conventionally defined as an RMS ripple voltage of not more than 10 % of the DC component.

Note 5 to entry: **SELV/PELV** limits may be different in other product or system standards. In case a control is declared exclusively for use in applications governed by a different standard, the limits set by the application standard apply (e.g. controls to be used exclusively in household appliances according IEC 60335 set of standards or connected to HBES/BACS systems according to IEC 63044-3 accept different **SELV** voltage limits).

3.1.6
safety isolating transformer
transformer, the input winding of which is electrically separated from the output winding by an insulation at least equivalent to **double insulation** or **reinforced insulation**, and which is intended to supply **safety extra-low voltage** circuits

3.1.7
isolated limited secondary circuit
circuit from an isolated secondary winding of a transformer having a maximum capacity of 100 VA and an open-circuit secondary voltage rating not exceeding 1 000 V

3.1.8
pilot duty
class of **operation** in which the ultimate electrical load is controlled by an auxiliary means such as a relay or contactor

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3.1.9
transient overvoltage
overvoltage with a duration of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

Note 1 to entry: **Transient overvoltages** may be immediately followed by temporary overvoltages. In such cases the two overvoltages are considered as separate events.

Note 2 to entry: IEC 60071-1 defines three types of **transient overvoltages**, namely slow-front overvoltages, fast-front overvoltages and very fast-front overvoltages according to their time to peak, tail or total duration, and possible superimposed oscillations.

[SOURCE: IEC 60050-614:2016, 614-03-14]

3.1.10
rated impulse voltage
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 overvoltages

Note 1 to entry: The term rated impulse voltage is the same as impulse withstand voltage given in IEC 60664-1 overvoltage category.

3.1.11
overvoltage category
numeral defining a **transient overvoltage** condition

Note 1 to entry: Overvoltage categories I, II, III, and IV are used. See Annex D.

[SOURCE: IEC 60050-581:2008, 581-21-02, modified − Note 1 to entry has been added]

3.1.12
SELV system
electrical system in which the voltage cannot exceed the values in 3.1.5:

– under normal conditions, and
– under single **fault** conditions, including protective earth **faults** in other electric circuits

[SOURCE: IEC 60050-826:2004, 826-12-31; modified − "the value of extra-low voltage" has been changed to "the values in 3.1.5" and Note 1 to entry has been deleted]

3.1.13
PELV system
electrical system in which the voltage cannot exceed the values in 3.1.5:

– under normal conditions, and
– under single **fault** conditions, except protective earth **faults** in other electric circuits

[SOURCE: IEC 60050-826:2004, 826-12-32; modified − "the value of extra-low voltage" has been changed to "the values in 3.1.5" and Note 1 to entry has been deleted]

3.2 Definitions of types of control according to purpose

3.2.1
electrical control
device used in, on or in association with an equipment for the purpose of varying or modifying the output from such equipment, and which embodies the aspects of **initiation**, **transmission** and **operation**

Note 1 to entry: Hereinafter, electrical control is referred to as "**control**".

Note 2 to entry: At least one of these aspects shall be electrical or electronic.

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3.2.2
manual control
control in which the **initiation** is by **actuation** and in which the **transmission** and the **operation** are both direct and without any intentional time delay

3.2.3
automatic control
control in which at least one aspect is non-manual

3.2.4
sensing control
automatic control in which **initiation** is by an element sensitive to the particular **activating quantity** declared, for example, temperature, current, humidity, light, liquid level, position, pressure or velocity

3.2.5
thermostat
cycling temperature **sensing control**, which is intended to keep a temperature between two particular values under normal operating conditions and which can have provision for **setting by the user**

Note 1 to entry: A **thermostat** will provide a **type 1 action** or a **type 2 action** as declared.

3.2.6
temperature limiter
temperature **sensing control** which is intended to keep a temperature below or above one particular value during normal operating conditions and which can have provision for **setting by the user**

Note 1 to entry: A **temperature limiter** may be of the automatic or of the manual reset type. It does not make the reverse **operation** during the normal **duty cycle** of the appliance.

Note 2 to entry: A **temperature limiter** will provide a **type 1 action** or a **type 2 action** as declared.

3.2.7
thermal cut-out
temperature **sensing control** intended to keep a temperature below or above one particular value during abnormal operating conditions and which has no provision for **setting by the user**

Note 1 to entry: A **thermal cut-out** may be of the automatic or of the manual reset type.

Note 2 to entry: A **thermal cut-out** will provide a **type 2 action**.

3.2.8
energy regulator
self-cycling **control** which alters the energy to a load and which can incorporate means for **setting by the user** to change the average energy supplied

Note 1 to entry: The ratio of the on-time, to the on-plus-off-time, determines the average energy supplied.

3.2.9
time-based control
automated **control** in which the **transmission** is effected by a time-based **prime mover** or a time-based electrical circuit

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3.2.10
electrically operated control
automatic control in which the **transmission** is affected by an electrical **prime mover** and in which the **operation** controls an electric circuit, and is without intentional significant time-delay

Note 1 to entry: An example is a relay.

Note 2 to entry: A slugged-relay may be either an **electrically operated control**, or a **time-based control** by agreement between test house and manufacturer.

3.2.11
timer
time-based control which requires **actuation** before the next cycle can take place

Note 1 to entry: During a cycle, it may require an external electrical or mechanical signal before moving from a rest position to allow the cycle to continue. An example is a programmer.

3.2.12
time switch
time-based control which continues with a subsequent cycle when the preceding one has been completed

Note 1 to entry: An example is a 24 h **control** on a storage heater.

3.2.13
electrically operated valve
automatic control in which the **transmission** is effected by an electrical **prime mover** and in which the **operation** controls the flow of a liquid or a gas

3.2.14
electrically operated mechanism
automatic control in which the **transmission** is effected by an electrical **prime mover** in which the **operation** controls a mechanical device

Note 1 to entry: An example is an electrically operated interlock for a spin dryer lid.

Note 2 to entry: An electric motor is not included in this definition.

3.2.15
operating control
control which starts or regulates the equipment during normal operation

Note 1 to entry: This operating control can provide **class A**, **class B** or **class C control functions**.

3.2.16
protective control
control, the **operation** of which is intended to prevent a hazardous situation during abnormal operation of the equipment

3.2.17
multipurpose control
electrical control that can be classified and used for more than one purpose

Note 1 to entry: An example of a **multipurpose control** is a **thermostat** that can also be used as a **temperature limiter**.

3.2.18
multifunctional control
electrical control which incorporates more than one function

Note 1 to entry: An example of a **multifunctional control** is the combination of a **thermostat** and a humidistat.

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3.2.19
system
control and **control** sensors and actuators as applied to an application or processes

3.3 Definitions relating to the function of controls

3.3.1
initiation
alteration to that aspect of a **control** which is required to produce **transmission** and **operation**

3.3.2
transmission
essential coupling between **initiation** and **operation** which is required to enable the **control** to fulfil its purpose

Note 1 to entry: This includes, but is not limited to, the use of:

a) communication lines/protocols;

b) additional hardware and/or software;

c) IR/RF; or

all combinations of a) to c) via Internet using, for example, modems, portable telephones, etc.

3.3.3
operation
change in that aspect of a **control** which modifies the input to the equipment or part of the equipment

3.3.4
automatic action
that action of an **automatic control** in which the **transmission** and **operation** are produced by **initiation** which is not the result of **actuation**

3.3.5
slow-make slow-break automatic action
mode of **operation** where the rate of contact make and/or break is directly proportional to the rate of change of the **activating quantity**, or to the speed of movement of a **prime mover**

Note 1 to entry: This action may be applicable to either the make, or the break, or both.

3.3.6
manual action
that action of an **automatic control** or of a **manual control** in which the **transmission** and **operation** are produced by **initiation** which is the result of **actuation**

3.3.7
actuation
movement of the **actuating member** of the **control** by the **user**, by hand, by foot or by any other human activity

3.3.8
located position
position of the **actuating member** to which it will return if it is released after being moved slightly

3.3.9
intermediate position
any position of any **actuating member** which is adjacent to a **located position**, and in which the **actuating member** will remain and in which the **operation** of the **control** is intermediate

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3.3.10
activating quantity
physical characteristic of a medium, the variation or stability of which is being sensed

3.3.11
operating value
value of the relevant temperature, pressure, current, etc. at which a **sensing control** operates on a rise or fall of the **activating quantity**

3.3.12
operating time
duration of time, or the difference of time, between any two functions, electrical or mechanical, occurring during the **automatic action** of a **time-based control**

3.3.13
operating sequence
intended sequence, order or pattern in which the **operation** of the electrical or mechanical functions of a **control** are intended to occur as a result of either an **automatic** or a **manual action** of a **control**

Note 1 to entry: It includes the pattern of opened or closed contacts in any **located position**, **intermediate position** or position of **setting by the equipment manufacturer** or **setting by the user**.

3.3.14
response value
operating value, the **operating time** or the **operating sequence** which relates a **control** to a particular equipment

3.3.15
trip-free
automatic action, with a reset **actuating member**, in which the **automatic action** is independent of manipulation or position of the reset mechanism

3.3.16
setting
mechanical positioning of a part of a **control** in order to select an **operating value**

3.3.17
setting by the control manufacturer
any **setting** carried out by the **control manufacturer** which is not intended to be altered by the **equipment manufacturer**, the **installer** or the **user**

3.3.18
setting by the equipment manufacturer
any **setting** carried out by the **equipment manufacturer** which is not intended to be altered by the **installer** or the **user**

3.3.19
setting by the installer
any **setting** carried out by the **installer**, as instructed by the **equipment manufacturer** or the **control manufacturer**, and which is not intended to be altered by the **user**

3.3.20
setting by the user
any selection of an **operating value** by **actuation** performed by the **user**

3.3.21
set point
value selected by **setting**

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3.3.22
adjustable set point
multiple values, within a declared range of values, which can be selected by **setting**

3.3.23
duty cycle
all automatic and **manual actions** involved in one start-to-finish **operation** of the controlled equipment

3.3.24
cycle of contact operation
one contact make and one subsequent contact break action, or one contact break and one subsequent contact make action

3.3.25
operating differential
difference between the upper and lower values of the **operating value**

3.3.26
adjustable differential
ability to change or alter the **operating differential** within rated limits by **operation** of a manually actuated mechanism

3.3.27
fixed differential
operating differential which cannot be changed from the manufacturer's **setting**

3.3.28
maximum working pressure
declared maximum line or **system** working pressure to which the control or parts thereof can be subjected

3.3.29
maximum temperature
T_{max}
declared maximum continuous ambient temperature to which the **switch head** is intended to be exposed during normal operation

3.3.30
remotely actuated control function
function providing any **operation** by **control** devices through external means

Note 1 to entry: This includes, but is not limited to, the use of:

a) communication lines/protocols;

b) additional hardware and/or software;

c) IR/RF **transmission**; or

all combinations of a) to c) via Internet using, for example, modems, portable telephones, etc.

3.3.31
safety shut-down
change in the state of all electrical outputs so that all safety critical electrical outputs of the **control** will proceed to a safe condition including shut-down

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3.3.32
mounting surface temperature
$T_{s\ max}$
declared maximum temperature to which the mounting surface of the control is intended to be exposed including any likely overshoot once a control has operated

3.3.33
touch current
electric current passing through a human body or through livestock when it touches one or more accessible parts of an installation or of equipment

Note 1 to entry: Touch current is often referred to as "leakage current" in many safety standards such as IEC 60335 series of standards.

[SOURCE: IEC 60050-195:2021, 195-05-21, modified – Note 1 to entry has been added]

3.4 Definitions relating to disconnection and interruption

Some **controls** can incorporate more than one form of circuit disconnection or interruption.

3.4.1
all-pole disconnection
disconnection of all supply conductors, except the protective earthed (grounded) conductor, by a single switching action

Note 1 to entry: The protective earthing conductor is not considered to be a supply conductor.

3.4.2
full disconnection
contact separation in all supply poles other than protective earth so as to provide the equivalent of **basic insulation** between the supply mains and those parts intended to be disconnected

Note 1 to entry: There are electric strength and dimensional requirements.

Note 2 to entry: Where the number of poles on the **control** is equal to the number of supply poles of the appliance to which it is connected, **full disconnection** provides **all-pole disconnection**.

Note 3 to entry: An **electronic device** does not provide this disconnection.

3.4.3
micro-disconnection
adequate contact separation in at least one pole for functional disconnection

Note 1 to entry: There is a requirement for the electric strength of the contact gap but no dimensional requirement.

Note 2 to entry: **Micro-disconnection** denotes that for non-**sensing controls** the function controlled by the disconnection is secure, and that for **sensing controls** is secure between the limits of **activating quantity** declared in Table 1, requirement 30.

Note 3 to entry: An **electronic device** does not provide this disconnection.

3.4.4
micro-interruption
interruption of a circuit by contact separation, by a cycling action or by a non-cycling action which does not provide **full disconnection** or **micro-disconnection**

Note 1 to entry: There are no electric strength or dimensional requirements for the contact gap.

Note 2 to entry: An **electronic device** does not provide this disconnection.

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3.4.5
OFF position
position providing a visible or implied indication of a **full disconnection** or **micro-disconnection**

3.4.6
electronic disconnection
non-cycling interruption by an **electronic device** of a circuit for functional disconnection and which provides a disconnection other than by means of an air gap by satisfying certain electrical requirements in at least one pole

Note 1 to entry: **Electronic disconnection** ensures that, for all non-**sensing controls**, the function controlled by the disconnection is secure and that, for all **sensing controls**, the function controlled is secure between the limits of the **activating quantity** declared in Table 1, requirement 30.

The disconnection may be obtained by an **automatic action** or a **manual action**.

Some **controls** may incorporate circuit disconnections of more than one form.

3.5 Definitions of types of control according to construction

3.5.1
integrated control
control which is dependent on its correct mounting and fixing in an equipment, and which can only be tested in combination with the relevant parts of the equipment

Note 1 to entry: **Integrated control** also denotes a **control** which is part of a more complex **control** (electrical or non-electrical).

3.5.2
incorporated control
control intended to be mounted in, or on, an equipment, but which can be tested separately

Note 1 to entry: The fact that an **incorporated control** can be tested separately does not imply that it is not allowed to be tested in an equipment as specified in 4.3.4.1.1.

Note 2 to entry: **Incorporated control** also denotes a **control** intended for incorporation in or on a more complex **control** (electrical or non-electrical).

3.5.3
in-line cord control
separately cased **control** intended to be connected to the supply and to the equipment by means of flexible cords, equipment inlets or socket-outlets, and is intended to be manually actuated

Note 1 to entry: A fuse in the plug is not regarded as a part of the **control**.

3.5.4
free-standing control
in-line cord control intended to stand on a table or on the floor

Note 1 to entry: It may be actuated by hand, by foot or by other similar human activity.

3.5.5
independently mounted control
control intended for permanent connection to **fixed wiring**, but intended to be mounted separately from the controlled equipment

Note 1 to entry: It may be either:

– for surface mounting such as on to a wall;
– for flush mounting, such as into a wall cavity, when installation shall be possible from the front;
– for panel mounting, such as onto or into a **control** panel, when installation may be from the rear.

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3.5.6
pull-cord actuated control
control intended to be mounted in, or on, an equipment and actuated by means of a **pull-cord**

3.5.7
electronic control
control which incorporates at least one **electronic device**

3.5.8
electronic device
a device in which conduction is principally by electrons moving through a vacuum, gas or semi-conductor

[SOURCE: IEC 60050-531:1974, 531-11-01]

3.5.9
electronic assembly
group of components, at least one of which is an **electronic device**, but in which individual parts can be replaced without damage to the assembly

Note 1 to entry: An example of this is a group of components mounted on a printed circuit board.

3.5.10
integrated circuit
microcircuit in which all or some of the circuit elements are inseparably associated and electrically interconnected so that it is considered to be indivisible for the purpose of construction and commerce

[SOURCE: IEC 60050-521:2002, 521-10-03]

3.5.11
hybrid circuit
circuit produced on ceramic substrate by means of thick-film, thin-film or surface-mounted devices (SMD) technology, without accessible electrical connections except for I/O points, and with all internal connections constructed as part of a lead frame or other integral construction

3.5.12
two-step actuation
sequential performance of two distinct movements of the **actuating member**

3.6 Definitions of type of automatic action of a control

3.6.1
type 1 action
automatic action for which the **manufacturing deviation** and the **drift** of its **operating value**, **operating time** or **operating sequence** have not been declared and tested under this document

3.6.2
type 2 action
automatic action for which the **manufacturing deviation** and the **drift** of its **operating value**, **operating time** or **operating sequence** have been declared and tested under this document

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3.7 Definitions relating to protection against electric shock and type of insulation

3.7.1
live part
conductor or conductive part intended to be energized in **normal use**, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor

Note 1 to entry: Accessible parts complying with 6.1.1 are not considered to be **live parts**.

Note 2 to entry: Definitions for PEN, PEM and PEL can be found in IEC 61140:2016.

3.7.2
hazardous live part
live part that, under certain conditions, can give a harmful electric shock

[SOURCE: IEC 60050-195:2021, 195-06-05, modified – Note 1 to entry not included.]

3.7.3
class 0 control
control in which protection against electric shock relies upon **basic insulation**

Note 1 to entry: This implies that there are no means for the connection of accessible conductive parts, if any, to the **protective conductor** in the **fixed wiring** of the installation; reliance in the event of a **failure** of the **basic insulation** is placed upon the environment.

Note 2 to entry: An earthing terminal is only allowed if it is for continuity or functional (as distinct from protective) purposes.

3.7.4
class 0l control
in-line cord control having at least **basic insulation** throughout and provided with a protective earthing terminal but with a **non-detachable cord** without protective earthing conductor, and a plug without protective earthing contact which cannot be introduced into a socket-outlet with protective earthing contact

Note 1 to entry: An earthing terminal is only allowed if it is for continuity (as distinct from protective) purposes.

3.7.5
class I control
control in which protection against shock does not rely on **basic insulation** only, but which includes an additional safety precaution in such a way that means are provided for the connection of accessible conductive parts to the protective earthing conductor in the **fixed wiring** of the installation in such a way that accessible conductive parts cannot become live in the event of a **failure** of the **basic insulation**

Note 1 to entry: This provision includes a **protective conductor** as part of the flexible cord or cable. When **class I controls** are fitted with a two-core flexible cord or cable with a plug which cannot be introduced into a socket-outlet with earthing contact, the protection is then equivalent to that of class 0. However,the earthing provisions of the equipment in all other respects should fully comply with the requirements of class I.

Note 2 to entry: **Class I controls** may have parts with **double insulation** or parts that provide protection against electric shock by **SELV** or **PELV**.

3.7.6
class II control
control in which protection against electric shock does not rely on **basic insulation** only, but in which additional protective precautions, such as **double insulation** or **reinforced insulation**, are provided, there being no provision for protective earthing or reliance upon installation conditions

Note 1 to entry: Such a **control** may be one of the types defined in 3.7.6.1 to 3.7.6.3.

Note 2 to entry: **Class II controls** may have parts that provide protection against electric shock by use of **SELV**.

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Note 3 to entry: **Class II controls** cannot have parts that provide protection against electric shock by use of **PELV**, as such circuits require connection to an earthing terminal.

3.7.6.1
insulation-encased class II control
control having a durable and substantially continuous enclosure of insulation material which envelopes all metal parts, with the exception of small parts, such as name plates, screws and rivets, which are isolated from **live parts** by insulation at least equivalent to **reinforced insulation**

3.7.6.2
metal-encased class II control
control having a substantially continuous metal enclosure in which **double insulation** is used throughout, except for those parts where **reinforced insulation** is used, because the application of **double insulation** is manifestly impracticable

3.7.6.3
combination insulation-encased/metal-encased class II control
control which is a combination of the types described in 3.7.6.1 and 3.7.6.2

Note 1 to entry: The enclosure of an all-insulated **class II control** may form a part or the whole of the **supplementary insulation** or of the **reinforced insulation**. If a **control** with **double insulation** and/or **reinforced insulation** throughout has an earthing terminal or earthing contact, it is deemed to be of class 0I or class I construction.

3.7.7
class III control
control relying on limitation of voltage in 3.1.5 values as provision against electric shock for basic protection and

- with no provision for **fault** protection;
- which for supply are only connected to a **SELV system** or a **PELV system**, to form part of that **system**;
- where internal circuits do not operate at a higher level than **ELV**;
- where in case of a single **fault** within the **control** no steady state touch voltage can appear or be generated exceeding **ELV** level; and
- not provided with a means of connection for a **protective conductor**

3.7.8
detachable part
part that

- can be removed or opened without the aid of a tool, or
- can be removed or opened with a tool according to the **normal use** and user maintenance as declared by the control manufacturer, or
- does not fulfil the test of 9.11.1.3

3.7.9
accessible part or accessible surface
part or surface which can be touched by the test finger of Figure 5, when the **control** is mounted as in **normal use**, and after **detachable parts** have been removed

3.7.10 Definitions relating to type of insulation

NOTE In 3.7.10.1 through 3.7.10.5, the following abbreviations are used:

L **live part**;
A **accessible part** (either conductive or an insulating surface);
I intermediate part.

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3.7.10.1
functional insulation
insulation between **live parts** which have a potential difference between them, and which insulation is necessary for the correct **operation** of the **control** or controlled equipment (L-L)

3.7.10.2
basic insulation
insulation applied to **live parts** to provide basic protection against electric shock (L-A or L-I)

Note 1 to entry: **Basic insulation** includes insulation between **live parts** and

– intermediate conductive parts or metal foil over intermediate insulating surfaces (class II situation);
– accessible conductive parts (class 0, 0I, I situations);
– conductive parts connected to accessible conductive parts (class 0, 0I, I situations);
– metal foil over accessible insulating surfaces (class 0 situation).

3.7.10.3
supplementary insulation
independent insulation applied in addition to **basic insulation** in order to provide protection against electric shock in the event of a **failure** of **basic insulation** (I-A)

Note 1 to entry: It includes insulation between intermediate conductive parts, or metal foil over intermediate insulating surfaces and

– accessible conductive parts (class II situation);
– conductive parts connected to accessible conductive parts (class II situation);
– metal foil over accessible insulating surfaces (class II situation).

3.7.10.4
reinforced insulation
single insulation **system** applied to **live parts**, which provides a degree of protection against electric shock equivalent to **double insulation** under the conditions specified in this document (L-A)

Note 1 to entry: It includes insulation between **live parts** and

– accessible conductive parts;
– conductive parts connected to accessible conductive parts;
– metal foil over accessible insulating surfaces.

Note 2 to entry: The term "insulation system" does not imply that the insulation must be one homogeneous piece. It may comprise several layers which cannot be tested singly as **supplementary insulation** or **basic insulation**.

3.7.10.5
double insulation
insulation comprising both **basic insulation** and **supplementary insulation** (L-I-A)

[SOURCE: IEC 60050-195:2021, 195-06-08]

3.7.11
protective impedance
impedance connected between live parts and accessible conductive parts, of such value that the current, in normal use and under likely **fault** conditions in the equipment, is limited to a safe value

3.7.12
equipotential bonding
set of electric connections intended to achieve equipotentiality between conductive parts

[SOURCE: IEC 60050-195:2021, 195-01-10]

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3.7.12.1
protective equipotential bonding
equipotential bonding for the purposes of electrical safety

Note 1 to entry: Functional **equipotential bonding** is defined in IEC 60050-195:2021,195-01-16].

[SOURCE: IEC 60050-195:2021, 195-01-15, modified –Note 1 to entry has been added.]

3.7.13
exposed conductive part
conductive part of equipment that can be touched and that is not live under normal conditions, but that can become live when **basic insulation** fails

Note 1 to entry: A conductive part of a **control** which can only become live through contact with an **exposed conductive part** which has become live is not considered to be an **exposed conductive part** itself.

[SOURCE: IEC 60050-195:2021, 195-06-10, modified – Note 1 to entry has been added.]

3.7.14
conductive screen
screen of conductive material intended to reduce the penetration of an electric field

[SOURCE: IEC 60050-195:2021, 195-02-38]

3.7.15
protective screen, <electrically>
conductive screen used to separate an electric circuit and/or conductors from hazardous-live-parts

[SOURCE: IEC 60050-195:2021, 195-06-17]

3.7.16
protective screening, <electrically>
separation of electric circuits and/or conductors from **hazardous live parts** by an **electrically protective screen** connected to the **protective equipotential bonding system** and intended to provide protection against electric shock

[SOURCE: IEC 60050-195:2021, 195-06-18]

3.7.17
simple separation
separation between electric circuits or between an electric circuit and protective earth by means of **basic insulation**

[SOURCE: IEC 60050-826:2004, 826-12-28; modified by replacing "local" by "protective"]

3.7.18
protective separation, <electrically>
separation of one electric circuit from another by means of basic protection and fault protection

[SOURCE: IEC 60050-195:2021, 195-06-19]

3.7.19
protective earthing
earthing for purposes of electrical safety

[SOURCE: IEC 60050-195:2021, 195-01-11]

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3.7.20
functional earthing
earthing for purposes other than electrical safety

[SOURCE: IEC 60050-195:2021, 195-01-13]

3.8 Definitions relating to component parts of controls

3.8.1
sensing element
that part of the **control** which is intended to be exposed to the influences of the **activating quantity** to which the **automatic action** of a **sensing control** responds

3.8.2
switch head
complete **control**, except for any **sensing element**

Note 1 to entry: If by construction it is impossible to distinguish between the **switch head** and the **sensing element**, then the whole **control** is considered to be the **sensing element**.

3.8.3
actuating member
that part which is manually moved, pulled, pushed or turned to cause **initiation** of a **control** action, or for **setting by the user**

Note 1 to entry: The term "**actuating member**" does not include any device such as a set-screw used for **setting by the control manufacturer** if such a device is adequately locked against further movement, or if a **tool** is required for such **setting by the control manufacturer**.

3.8.4
actuating means
any part which connects the **actuating member** to the mechanism of the **control**

3.8.5
pull-cord
flexible **actuating member** which is pulled to cause **actuation**

3.8.6
prime mover
any device used to produce the mechanical energy required to provide the **transmission** for an **automatic control**, such as an **electrically operated control**, an **electrically operated valve**, an **electrically operated mechanism** or a **time-based control**

Note 1 to entry: It may be a mechanical storage device (for example, a clockwork spring), an electro-magnetic device (for example, an electric motor, or stepping solenoid), an electro-thermal device (for example, the heating element of an **energy regulator**) or any other mechanism producing mechanical energy.

3.8.7
clutch
mechanical device by which an **actuating member** can override either a **prime mover** or an **activating quantity**, causing or allowing the **initiation** or cancellation of an action

3.8.8
cover
cover plate
part which is accessible when the **control** is mounted as in **normal use** and which can be removed only with the aid of a **tool**

Note 1 to entry: It shall not require the use of a **special purpose tool** for its removal.

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3.8.9
screwless fixed part (or component)
accessible part (or component) which, after attachment, installation, mounting or assembly into or onto an equipment or another component, or to a specially prepared support, is retained in position by positive means which do not depend on screws

Note 1 to entry: Disassembly or removal may require the use of a **tool**, either applied directly to the part (or component), or to obtain access to the retaining means.

Note 2 to entry: The following are some examples of parts which are not regarded as **screwless fixed parts or components**:

– parts of components fixed permanently by rivets, glueing or similar means;
– flat, push-on connectors;
– **screwless terminals**;
– standard plugs and socket-outlets;
– standard appliance couplers, even if such have additional latching devices to prevent a single action uncoupling;
– the replacement of a lamp in a bayonet type lampholder;
– twist-lug construction;
– friction-fit construction.

3.9 Definitions of types of terminals and terminations of controls

3.9.1
pillar terminal
terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw or screws

Note 1 to entry: The clamping pressure may be applied directly by the shank of the screw, or through an intermediate clamping member to which pressure is applied by the shank of the screw (see Figure 12).

3.9.2
screw terminal
terminal in which the conductor is clamped under the head of the screw

Note 1 to entry: The clamping pressure may be applied directly by the head of the screw, or through an intermediate part, such as a washer, a clamping plate or an anti-spread device (see Figure 11).

3.9.3
stud terminal
terminal in which the conductor is clamped under a nut

Note 1 to entry: The clamping pressure may be applied directly by a suitably shaped nut, or through an intermediate part, such as a washer, a clamping plate or an anti-spread device (see Figure 11).

3.9.4
screwless terminal
terminal in which the connection of the conductor is achieved directly or indirectly by means of springs, wedges, eccentrics, cones or the like

Note 1 to entry: The following are not regarded as **screwless terminals**:

– terminals requiring the fixing of special devices to the conductors before clamping them in the terminal, for example, **flat push-on connectors**;
– terminals requiring wrapping of the conductors, for example, those with wrapped joints;
– terminals providing direct contact to the conductors by means of edges or points penetrating the insulation.

3.9.5
flat push-on connector
assembly of a **tab** and a **receptacle** enabling the connection, at will, of a core or conductor to a **control** or to another core or conductor

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3.9.6
receptacle
female part of a **flat push-on connector** intended to be permanently attached to a core or conductor (see Figure 17)

3.9.7
tab
male part of a **flat push-on connector** (see Figure 15 and Figure 16)

3.9.8
in-line tab
tab intended to be permanently attached to a core or conductor

3.9.9
tab forming part of a control
tab permanently attached to, or an integral part of, a **control**

3.9.10
termination
part by which a conductor can be connected to a **control** in such a way that its replacement requires either a **special purpose tool**, a special process or a specially prepared end of the conductor

Note 1 to entry: Soldering requires a **special purpose tool**. Welding requires a special process. A cable lug attached to a conductor is a specially prepared end.

3.9.11
solder termination
termination in which the conductor is secured by a mechanical means, and the circuit continuity is assured by solder

3.9.12
saddle terminal
terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts (see Figure 14a)

3.9.13
lug terminal
screw terminal or **stud terminal**, intended to clamp a cable lug or bar by means of a screw or nut (see Figure 14b)

3.9.14
mantle terminal
terminal in which the conductor is clamped against the base of a slot in a threaded stud by means of a nut

Note 1 to entry: The conductor is clamped against the base of the slot by a suitably shaped washer under the nut, by a central peg if the nut is a cap nut or equally effective means for transmitting the pressure from the nut to the conductor within the slot (see Figure 13).

3.9.15
protective bonding terminal
terminal intended for **protective equipotential bonding** purposes

Note 1 to entry: Examples are a **protective screen**- or **PE**-terminal of a **control** or equipment.

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3.9.16
protective conductor
PE
conductor provided for purposes of electrical safety

[SOURCE: IEC 60050-195:2021, 195-02-09]

3.10 Definitions relating to the connections to controls

3.10.1
external conductor
any cable, flexible cord, core or conductor, a part of which is external to an **in-line cord control**, an **independently mounted control** or to an equipment in or on which a **control** is mounted

Note 1 to entry: Such a conductor may be a supply lead, a function cord or interconnecting cord between different parts of an equipment; or it may form part of the **fixed wiring**.

3.10.2
fixed wiring
any **external conductor** which is permanently secured to the fabric of the building such that, in **normal use** at the point at which the conductor enters the equipment or **control**, there is no likelihood of any strain being applied to the conductor

Note 1 to entry: Such securing to the fabric of the building may be, for example, by the enclosing of conductors in conduit, burying cables in walls, adequately fixing cables or cords to walls or other surfaces, etc.

3.10.3
internal conductor
any cable, flexible cord, core or conductor which is neither an **external conductor**, nor an **integrated conductor**

Note 1 to entry: An example is a conductor inside the equipment to interconnect the **control** and the equipment.

3.10.4
integrated conductor
conductor which is inside a **control**, or is used to permanently interconnect terminals or **terminations** of a **control**

3.10.5
detachable cord
flexible external cord connected to a **control** or equipment by means of an equipment inlet, or plug and socket arrangement

3.10.6
non-detachable cord
flexible **external conductor** connected to, or assembled to, a **control** according to one of the methods in 3.10.6.1 to 3.10.6.4

3.10.6.1
type X attachment
method of attachment such that the cord can be easily replaced without **special-purpose tools**, using standard cords without any special preparation

3.10.6.2
type M attachment
method of attachment such that the cord can be easily replaced without **special purpose tools**, but is intended to use only a special cord, such as one with a moulded-on cord guard, or one with special prepared ends

Note 1 to entry: This attachment method does not apply if it is possible to fit a standard cord during **servicing** unless such is permitted by a particular equipment standard.

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3.10.6.3
type Y attachment
method of attachment of the supply cord such that any replacement is intended to be made by the manufacturer, its service agent or a similar qualified person

3.10.6.4
type Z attachment
method of attachment such that the flexible cable or cord cannot be replaced without breaking or destroying a part of the **control**

3.10.7
primary battery
cell
any kind of electrochemical **cell** in which the electrochemical reaction of interest is not reversible

Note 1 to entry: An example is an alkaline battery.

3.10.8
secondary battery
rechargeable cell
any kind of electrochemical **cell** in which the electrochemical reaction of interest is reversible

Note 1 to entry: A rechargeable battery is a group of two or more secondary **cells**.

Note 2 to entry: Examples of rechargeable batteries are nickel metal hydride (NiMH), lithium ion (Li-ion) etc.

3.11 Definitions relating to the performance of type 2 actions

3.11.1
manufacturing deviation
maximum difference of **operating value**, **operating time** or **operating sequence** which is claimed between any two **controls**, supplied by the manufacturer to a **unique type reference**, when tested as submitted and in the same manner

Note 1 to entry: The difference may be related to an absolute value if permitted by the appropriate subclause of Clause 17.

3.11.2
drift
maximum alteration of **operating value**, **operating time** or **operating sequence** of any one sample which can occur when it is tested under the conditions specified in this document

Note 1 to entry: The alteration may be related to an absolute value, or combined with the **manufacturing deviation**, if permitted by the appropriate subclause of Clause 17.

3.12 Definitions relating to the requirements for creepage distances and clearances

3.12.1
clearance
shortest distance through air between two conductive parts, or between a conductive part and a metal foil in contact with a surface of insulating material

Note 1 to entry: The method of measurement is detailed in Annex B and Figure 18.

3.12.2
creepage distance
shortest distance along the surface of the insulating material between two conductive parts, or between a conductive part and a metal foil in contact with any **accessible surface** of insulating material

Note 1 to entry: The method of measurement is detailed in Annex B and Figure 18.

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3.12.3
pollution
any addition of foreign matter, solid, liquid, or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation

3.12.4 Definitions relating to the environment

3.12.4.1
macro-environment
environment of the room or other location in which the equipment is installed or used

3.12.4.2
micro-environment
environment in the immediate surrounding of an insulation, which particularly influences the dimensioning of clearances and **creepage distances**

3.12.4.3
pollution degree
numeral characterizing the expected **pollution** of the **micro-environment**

Note 1 to entry: **Pollution degrees** 1, 2, 3, and 4 are used. See Annex F.

3.13 Miscellaneous definitions

3.13.1
unique type reference
marking such that by quoting it in full to the manufacturer of the **control**, a replacement can be supplied which will be fully interchangeable with the original, electrically, mechanically, dimensionally and functionally

3.13.2
tool
screwdriver, a coin or any other object which can be used to operate a nut, a screw or similar part

3.13.3
special-purpose tool
tool which is unlikely to be readily available in a normal household, for example, a key for a hexagonal socket-headed screw

Note 1 to entry: **Tools** such as coins, screwdrivers and spanners intended to operate square, or hexagonal nuts, are not **special-purpose tools**.

3.13.4
normal use
use of the **control**, or its associated equipment, for the purpose for which it was made, and in the manner intended by the manufacturer

Note 1 to entry: **Normal use** includes any overload, or abnormal operating conditions specified in the equipment standard.

Note 2 to entry: **Normal use** does not include any process which is necessary to maintain the **control** or equipment in good order, even though this may be carried out by the **user** according to the manufacturer's instructions.

Note 3 to entry: **Normal use** may include standby mode and one or more operating modes.

3.13.5
user maintenance
any periodic process necessary to maintain the **control**, or equipment, in good order, for which details are given in the manufacturer's instructions to the **user**

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3.13.6
servicing
any process necessary to maintain a **control**, or equipment, in good order, that would be done by a competent person, such as in a workshop, by an electrician or by a service organization

Note 1 to entry: This includes replacing a flexible cord, thermal link or the like.

3.13.7
manufacturer servicing
servicing which can only be done by the manufacturer, or his accredited serviceman

Note 1 to entry: This may be due to the need for **special purpose tools**, or special instrumentation, and includes the **setting by the control manufacturer**.

3.13.8
failure
termination of the ability of an item to perform a required function

[SOURCE: IEC 60050-603:1986, 603-05-06]

3.13.9
fault
state of an item characterised by its inability to perform a required function, excluding the inability during preventive maintenance or other planned actions, or due to lack of external resources

Note 1 to entry: "**Failure**" is an event, as distinguished from "**fault**", which is a state.

Note 2 to entry: After **failure**, the item has a **fault**.

Note 3 to entry: This concept as defined does not apply to items consisting of software only.

Note 4 to entry: A **fault** is often the result of a **failure** of the item itself, but may exist without prior **failure**.

3.13.10
smart grid
intelligent grid
electric power **system** that utilizes information exchange and **control** technologies, distributed computing and associated sensors and actuators, for purposes such as:

– to integrate the behaviour and actions of the network **users** and other stakeholders,
– to efficiently deliver sustainable, economic and secure electricity supplies

[SOURCE: IEC 60050-617:2009+AMD1:2011, 617-04-13]

3.13.11
smart enabled control
control that integrates or uses one or more of the following functionalities:

– power demand response from the smart grid,
– demand signals from energy-consuming equipment,
– communications technology IoT,
– data analytics,
– control functions to optimize energy efficiency and deliver on operational requirements.

Note 1 to entry: For example, smart grid control, remote interfaces/control of energy-consuming equipment including computer or smart phone.

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3.13.12
intentionally weak trace
printed circuit board trace intended to rupture under conditions of abnormal operation to prevent the occurrence of a condition which could impair compliance with this document

Note 1 to entry: See 9.1.4.

3.14 Definitions relating to manufacturer and user

3.14.1
control manufacturer
manufacturer of the **control**

3.14.2
equipment manufacturer
manufacturer of equipment in which, on which, or together with which the **control** is used

3.14.3
installer
person qualified to install the **control** and possibly the associated equipment

3.14.4
user
one who uses the **control** with the aid of documentation (**user maintenance**) during its normal life

Note 1 to entry: The **user** is considered a layman.

3.15 Definitions pertaining to thermistors

See J.3.15.

3.16 Definitions relating to the structure of controls using software

See H.3.16.

3.17 Definitions relating to error avoidance in controls using software

See H.3.17.

3.18 Definitions relating to fault/error control techniques for controls using software

See H.3.18.

3.19 Definitions relating to memory tests for controls using software

See H.3.19.

3.20 Definitions of software terminology – General

See H.3.20.

3.21 Definitions relating to classes of control functions

See H.3.21.

3.22 Definitions relating to functional safety

See H.3.22.

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3.23 Definitions related to access to data exchange

See H.3.23.

3.24 Definitions related to EMC performance

3.24.1
port
particular interface of the equipment which couples this equipment with or is influenced by the external electromagnetic environment

Note 1 to entry: See Figure 1.

Note 2 to entry added: I/O ports are input, output or bi-directional, measurement, control, or data ports.

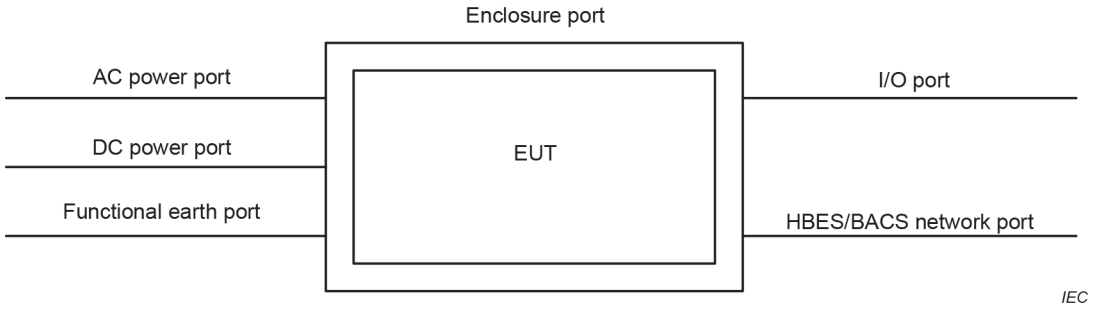


Figure 1 – Example of ports

[SOURCE: IEC 61000-6-1:2016: 3.1, modified − Note 1 to entry, modified Figure 1]

3.24.2
enclosure port
physical boundary of the equipment through which electromagnetic fields can radiate or impinge

[SOURCE: IEC 61000-6-1:2016: 3.2, modified – "may" changed to "can"]

3.24.3
I/O port
port at which a conductor or cable intended to carry signals is connected to the equipment

EXAMPLE Analog/digital inputs, outputs and control lines, data buses, communication networks other than HBES/BACS networks (3.24.10), etc

[SOURCE: IEC 61000-6-1:2016: 3.3; modified – "signal/control port" changed to "I/O port", example added with digital inputs/outputs and the exclusion for HBES/BACS networks]

3.24.4
DC power port
port used to connect to a low voltage DC power generating **system**, energy storage or DC distribution network to power the equipment

[SOURCE: IEC 61000-6-3:2020, 3.1.13, modified – Note 1 to entry is removed]

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3.24.5
DC distribution network
local DC electricity supply network in the infrastructure of a certain site or building intended for flexible use by one or more different types of equipment and ensuring continuous power supply independently from the conditions of the public mains network

Note 1 to entry: Connection to a remote local battery is not regarded as a DC distribution network, if such a link comprises only supply for a single piece of equipment

[SOURCE: IEC 61000-6-1:2016, 3.10]

3.24.6
EUT
equipment under test

3.24.7
residential electromagnetic environment
electromagnetic environment at a location including commercial, public and light-industrial locations where there is a level of electromagnetic interference normally expected in houses, shops, and business premises, cinemas, sports centres, workshops and laboratories for example

EXAMPLE 1 of residential locations are: houses, apartments, farm buildings used for living.

EXAMPLE 2 of commercial, public or light industrial are:

- retail outlets, for example shops, supermarkets;
- business premises, for example offices, banks, hotels, data centres;
- areas of public entertainment, for example cinemas, public bars, dance halls;
- places of worship;
- general public locations, for example parks, amusement facilities, public offices;
- hospitals, educational institutions, for example schools, universities, colleges;
- public traffic area, railway stations, and public areas of an airport;
- light-industrial locations, for example workshops, laboratories, service centres.

3.24.8
industrial electromagnetic environment
location where the totality of electromagnetic phenomena is characterized by a separate power network, supplied from a high- or medium-voltage transformer, dedicated for the supply of the installation

EXAMPLE Metalworking, pulp and paper, chemical plants, car production, farm building, high-voltage areas of airports.

Note 1 to entry: Industrial locations can generally be described by the existence of an installation with one or more of the following characteristics:

– items of equipment installed and connected together and working simultaneously;
– significant amount of electrical power generated, transmitted and/or consumed;
– frequent switching of heavy inductive or capacitive loads;
– high currents and associated magnetic fields;
– presence of industrial, high power scientific and medical (ISM) equipment (for example, welding machines).

The electromagnetic environment at an industrial location is predominantly produced by the equipment and installation present at the location. There are types of industrial locations where some of the electromagnetic phenomena appear in a more severe degree than in other installations.

Note 2 to entry: In general, the electromagnetic environment is time-dependent and its description may need a statistical approach.

Note 3 to entry: It is very important not to confuse the electromagnetic environment and the location itself.

[SOURCE: IEC 61000-6-2:2016, 3.7 and 3.8 combined and modified to one definition]

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3.24.9
long-distance lines
lines within a building which are longer than 30 m, or which leave the building (including lines of outdoor installations)

[SOURCE: IEC 61000-6-1:2016, 3.6, modified – definition extended to all lines instead of lines connected to signal/control ports]

3.24.10
HBES/BACS network port
port at which a conductor or cable intended to carry communication signals between the different devices of the HBES/BACS network is connected to the apparatus

Note 1 to entry: For test purposes, the HBES/BACS network port is equivalent to the telecommunications/network port according to IEC 61000-6-3.

Note 2 to entry: (HBES) Home and Building Electronic Systems and (BACS) Building Automation and Control Systems

[SOURCE: IEC 63044-5-1:2017, 3.1.5, modified – Note 2 to entry has been added]

4 General

4.1 General structure of the document

The clauses of this document are grouped into two sections of requirements, where

- the first section consists of Clauses 5 to 13 that, in general, addresses the construction of the product. It is noted that certain construction requirements have verification requirements integrated within the clause to facilitate usage of the document, and
- the second section consists of the of Clauses 14 to 26 that addresses the verification requirements.

NOTE For explanation of the word "Verification", see IEC 60050-192:2015,192-01-17.

The above structure is also applied to Annex H, Annex I and Annex J.

The requirements of this document have been structured based on two basic safety principles – inherent safety and functional safety.

Inherent safety is related to the potential risk of electric shock, fire and personal injury that exists within the design of the control, under normal and abnormal operation of the control and independent of any declaration to output functions. All controls, independent of their classification, shall comply with the requirements for inherent safety.

Requirements that relate to the inherent safety of all products covered under the scope of this document are located in the main body of the document.

Functional safety is related to the correct operation of the declared safety related function(s), failure or malfunction of which can cause a hazard. The hazard could result from a loss of protective function (output function) leading to a risk of explosion, excessive temperature, electric shock, fire and/or personal injury, etc. The requirements for functional safety, which are relevant for a control, depend on the classification of the output function.

Requirements that relate to functional safety are specified in Annex H of this document and shall be used in conjunction with the requirements of the main part, when applicable. Since some requirements are applicable for both inherent and functional safety, e.g. Table 14 showing the **fault** modes for electronic components used for the **fault** assessment, the place for those requirements were chosen as appropriate.

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A pictorial representation of the document structure and applicable requirements are noted below in Figure 2:

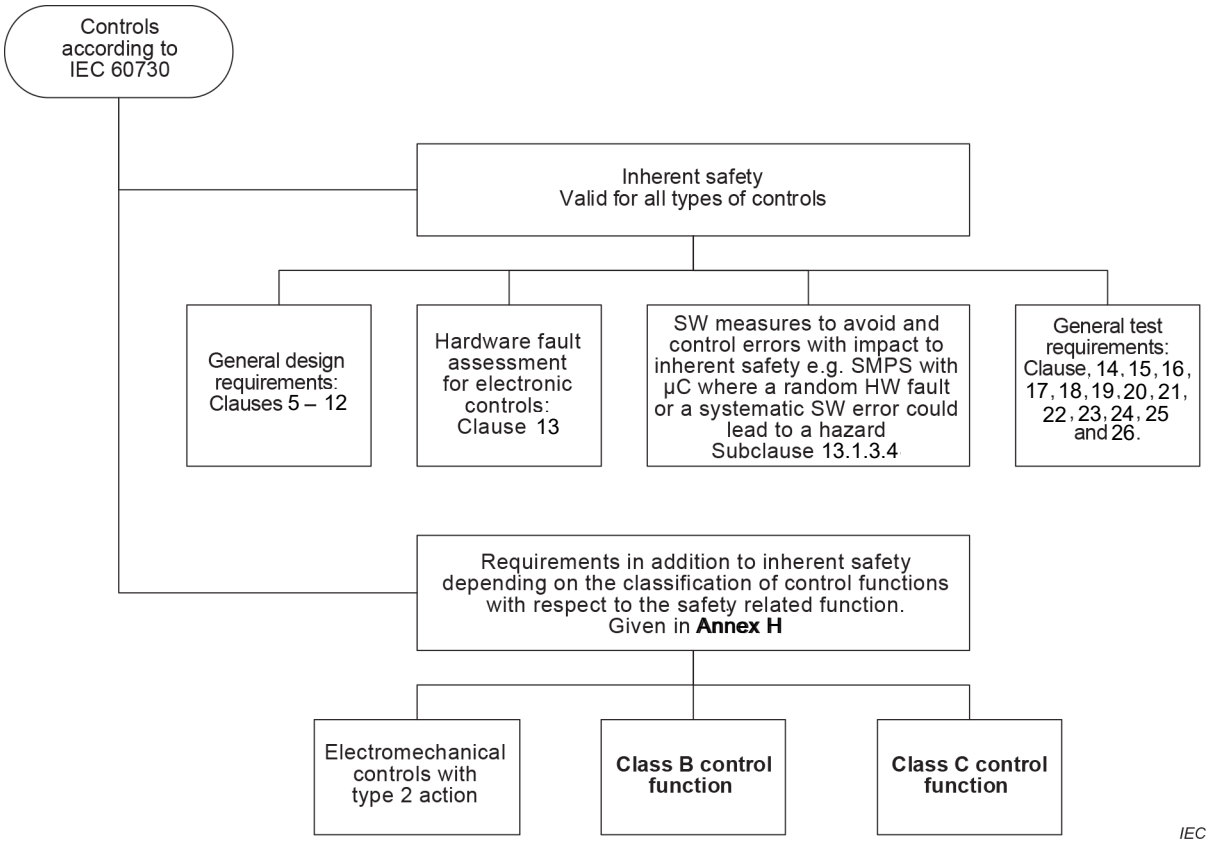


Figure 2 – Structure of the document with respect to inherent safety and functional safety

4.2 General requirements

Controls shall be so designed and constructed that in **normal use**, they function so as not to cause injury to persons or damage to surrounding property, even in the event of such carelessness as can occur in **normal use**.

In general, compliance is checked by carrying out the relevant tests specified in this document and the appropriate part 2, if any.

4.3 General notes on tests

4.3.1 General

Tests according to this document are type tests.

NOTE If the results of any of the prescribed tests can be determined beyond doubt by assessment, then the test or tests need not be performed.

4.3.2 Conditions of test

4.3.2.1 Unless otherwise specified in this document, the samples are tested as delivered, having been mounted as declared by the manufacturer, but, when significant, in the most unfavourable position.

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4.3.2.2 If the test results are influenced by the room temperature, this shall be maintained at (20 ± 5) °C, except that in cases of doubt, it shall be maintained at (23 ± 2) °C, unless otherwise specified in a particular clause.

4.3.2.3 **Actuating members** are placed in the most unfavourably **located position**, **intermediate position** or position of **setting by the user**, unless other instructions are given in a particular clause.

4.3.2.4 Unless otherwise specified in this document or evident from the construction of the control (in general for **electronic controls**), the tests are carried out in the order of the clauses of this document.

*For **electronic controls**, the tests of Clauses 24.1, 25 and 13.1 are carried out before the tests of Clause 21.*

4.3.2.5 During the tests of this document, actuation is performed by test equipment if so desired, except for the high-speed tests of 19.12.

4.3.2.6 During and for the purpose of the tests of this document, other than for the tests of 19.12, the actuating means can be used to actuate the control, if an actuating member is not supplied by the manufacturer.

4.3.2.7 The rates of temperature change declared in 5.2 and used in Clause 19 (that are α_1, β_1, α_2 and β_2) shall have test tolerances of ±12 K/h.

For other activating quantities, the minimum and/or maximum rates of change declared in Table 1, requirement 31 and used in Clause 19 (that is α_1, β_1, α_2 and β_2) shall have test tolerances as specified in the appropriate part 2.

4.3.2.8 In all tests, the measuring instruments or the measuring means shall be such as not to affect appreciably the value being measured.

NOTE Principles for uncertainty of measurements can be found in various sources, e.g. in OD-5014 under IECEE.

4.3.3 Samples required

4.3.3.1 Unless otherwise specified, one sample is used for the tests in Clauses 6 to 26, including the relevant annexes. For electromechanical controls, one sample shall be used for verification of Clauses 5 to 13 and another sample for Clauses 14 to 26, while for **electronic controls** different samples can be used unless tests are required to be carried out on the same sample.

If the sample does not comply with one or more of the tests, the cause of the non-compliance shall be identified and corrective action shall be taken. The test which caused the non-compliance, and those preceding which could have influenced the result of that test, are repeated on two other sets of identical samples, all of which shall then comply with the repeated tests. Also any tests where the corrective action has influence on the initial test result shall be repeated.

4.3.3.2 Additional samples can be required for some destructive tests of this document.

4.3.3.3 Controls which are intended to meet the requirements of more than one part 2 document shall, in general, be tested to each part 2 separately.

NOTE By agreement between manufacturer and test house, requirements and tests which are common to more than one part 2, need only be checked once, unless the common tests can influence the results of any specific tests.

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4.3.4 Instructions for test

4.3.4.1 According to submission

4.3.4.1.1 Controls for use in or with an equipment can either be tested with the equipment or separately. When tested in or with an equipment, the type of load controlled is classified as for declared specific load. When tested separately as an individual control, the type of load controlled is classified for the declared specific load, resistive load or resistive and inductive load. In both cases, the current in the appropriate circuit when the equipment is operating under normal load is regarded as the rated current of the circuit.

4.3.4.1.2 For all controls submitted, in, on or with an equipment, all other relevant information as required by 5.2 can be obtained by inspection and measurement of the submitted equipment.

4.3.4.1.3 Integrated controls are classified as for declared specific load and are tested in the equipment, or part thereof, for which they are intended.

4.3.4.1.4 Controls not submitted in or with an equipment are tested separately.

4.3.4.1.5 Controls for use with non-detachable cords are tested with the appropriate cord connected.

4.3.4.2 According to rating

4.3.4.2.1 Controls for AC only are tested with AC at rated frequency if declared; those for DC only are tested with DC and those for AC/DC at the more unfavourable supply.

4.3.4.2.2 Controls for AC only, which are not declared for a rated frequency, are tested at either 50 Hz or 60 Hz, whichever is the more unfavourable. Controls with a rated frequency within a declared range other than 50 Hz to 60 Hz are tested at the most unfavourable frequency within the marked or declared range.

4.3.4.2.3 When testing controls intended for DC only, the possible influence of polarity on the operation of the control is taken into consideration.

4.3.4.2.4 For controls with different AC and DC ratings, the tests for Clauses 14, 15, 16 and 19, are made on two sets of samples, one being tested according to the AC rating, and the other according to the DC rating.

NOTE At the option of the test house, a reduced number of tests can be made to cover the various ratings.

4.3.4.2.5 Unless otherwise specified, controls declared for one or more voltage ranges shall be tested at the most unfavourable voltage within the declared range, and this voltage being multiplied by the factor indicated in the appropriate clause (see 4.3.4.2.7).

4.3.4.2.6 For controls marked or declared for more than one rated voltage or rated current, the tests of Clause 19 are made on sets of samples for each combination of **rated voltage** and rated current.

NOTE At the option of the test house, a reduced number of tests can be made to cover the various ratings.

4.3.4.2.7 For controls declared for a voltage range, tests are made on one set of samples at each limit of the range, unless the difference between the limits does not exceed 10 % of the mean value of the range, in which case the tests are made on one set of samples at the upper limit of the range.

4.3.4.2.8 Controls intended to be operated from a specific supply are tested with that specific supply.

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4.3.4.2.9 A circuit for connection to the DC mains supply is classified as either a **SELV/PELV** circuit, ELV circuit or mains voltage circuit depending on the maximum operating voltage of the supply. This maximum operating voltage shall include consideration of the battery charging "float voltage" associated with the intended supply **system**, regardless of the marked voltage rating of the equipment.

NOTE Float voltage is the constant voltage that is applied continuously to a voltaic **cell** to maintain the **cell** in a fully charged condition. Float voltage varies significantly with the chemistry and construction of the battery and ambient temperature.

4.3.4.2.10 Operation of the control powered by secondary batteries (rechargeable) is under the following conditions:

– the **control**, supplied by its fully charged battery, is operated as specified in this document;
– if possible, the **control** is supplied from the supply mains through its battery charger, the battery being initially discharged to such an extent that the **control** cannot operate;
– if the **control** incorporates inductive coupling between two parts that are detachable from each other, the **control** is supplied from the supply mains with the **detachable part** removed.

4.3.4.2.11 See J.4.3.4.2.11.

4.3.4.3 According to protection against electric shock

4.3.4.3.1 If in class 0 control, class 0I control or class I control, or in controls for class 0, class 0I or class I equipment, it is necessary to have parts with double insulation or **reinforced insulation**, such parts are checked for compliance with the appropriate requirements specified for class II controls.

4.3.4.3.2 In any class I control, and in any control used in a class I equipment, unearthed accessible metal or accessible insulating surfaces shall be provided with insulation complying with the requirements for a class II control (see 7.1.1).

4.3.4.3.3 If in class 0 control, class 0I control, class I control or class II controls, or controls for class 0, class 0I, class I or class II equipment, it is necessary to have parts using **SELV**-circuits, such parts are also checked for compliance with the appropriate requirements specified for protection by use of **SELV** in 9.2.6.

*If in **class I controls** or **controls** for class I equipment it is necessary to have parts using **PELV**-circuits, such parts are also checked for compliance with the appropriate requirements specified for protection by use of **PELV** in 9.2.6.*

NOTE By definition (3.7.6) **class II controls** cannot use **PELV**-circuits.

4.3.4.4 According to manufacturing variants

4.3.4.4.1 Controls which are otherwise identical but which can produce varying operating values, operating times or operating sequences due to the setting by the manufacturer or inclusion of alternate components or parts at the manufacturing stage, are treated as a single submission. Normally, controls set to the most arduous condition will be sufficient. However, the test house may require extra samples, set to other values, where it can be clearly shown that these are necessary to allow approval of the whole range.

4.3.4.4.2 In these cases, due attention shall be paid to possible variations in manufacturing deviation and drift of any operating value, operating time or operating sequence, and, for sensing controls, to the minimum and maximum acceptable rates of rise and fall of the appropriate activating quantity which could be applicable to different parts of the range.

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4.3.4.5 According to purpose

4.3.4.5.1 Multi-purpose controls shall, in general be tested for each purpose separately. During the tests for any one purpose, the activating quantities and prime movers applicable to all other purposes, shall be maintained constant at the most arduous value or position within the declared range or ranges.

4.3.4.5.2 Such controls without an appropriate section of Clause 19 shall be tested in a manner agreed between the manufacturer and the test house so that the essential intended operating values, operating times and operating sequences are tested.

4.3.4.5.3 Any control with a purpose not defined in 3.2, or in the appropriate part 2, can be tested and approved to this document, except for Clause 19. A test schedule for Clause 19 shall be based, wherever possible, on the intent of that clause and shall be agreed between the manufacturer and the test house.

4.3.4.5.4 See J.4.3.4.5.

5 Required technical information

5.1 General requirements

The **control manufacturer** shall provide adequate information to confirm:

– that a suitable **control** can be selected;

– that the **control** can be mounted and used in a manner that will enable it to meet the requirements of this document; and

– that the relevant tests can be performed to determine compliance with this document.

5.2 Methods of providing technical information

5.2.1 Information shall be provided using one or more of the following methods. The information required for **controls** and the appropriate method for providing this information shall be as declared in Table 1.

NOTE It is not intended that Table 1 itself necessarily be the actual form used to communicate between manufacturer and test house.

– By marking (C) – this information shall be provided by marking on the **control** itself, except that, in the case of an **integrated control**, such marking can be on an adjacent part of the equipment, provided that it is clear that it refers to the **control**.

– By documentation on hard copy (D) – this information shall be provided for the **user** or **installer** of the **control**, and shall consist of legible instructions. Each **control** shall be accompanied by such instructions. Instruction sheets and other texts required by this document shall be written in the official language(s) of the country in which the **control** is to be sold.

– For **controls** intended to be exclusively delivered to the **equipment manufacturer**, the instruction sheet is replaced by a leaflet, letter or drawing, etc. It is not necessary for each **control** to be accompanied by such a document.

– By documentation on electronic media on internal or external memory or on web pages (e.g. by QR code) (E) – this information is as alternative to (D).

– By declaration (X) – this information shall be provided for the test house for purposes of test and in a manner agreed between test house and manufacturer. It can, for example, be provided by a marking on the **control**, by a leaflet, letter or drawing or, in the case of a **control** submitted in, on or with an equipment, by measurement or inspection of the submitted equipment. This information should also be provided to the **equipment manufacturer**, as appropriate.

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5.2.2 Information which is indicated as being required by marking (C) or by documentation (D,E) shall also be provided for the test house in an agreed manner if so requested by the test house.

5.2.3 For **controls** submitted in, on or with an equipment, the requirement for documentation (D,E) is replaced by declaration (X).

5.2.4 For an **integrated control** forming part of a more complex **control**, the marking relating to the **integrated control** can be included in the marking of the more complex **control**.

5.2.5 The requirement for documentation (D,E) is considered to be met if such information has been provided by marking (C).

5.2.6 The requirement for declaration (X) is considered to be met if such information has been provided by either documentation (D,E) or by marking (C).

5.2.7 Except as indicated in 5.4, for **integrated controls** all information is provided by means of declaration (X). Unless otherwise indicated in a part 2, for **incorporated controls**, the only marking required is the manufacturer's name or trade mark and the **unique type reference**, if other required marking is provided by documentation (D,E). For **incorporated controls** as declared in Table 1, requirement 45, see the explanation of documentation (D,E) contained in 5.2.1.

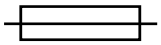
5.2.8 For **controls** that are neither integrated nor incorporated, where lack of space prevents legible marking as specified, the **control** shall be marked with the manufacturer's name (or trade mark) and the **unique type reference** only. The other marking required shall be included in documentation (D,E).

5.2.9 Additional marking or information is allowed, provided that it does not give rise to misunderstanding.

5.2.10 When symbols are used, they shall be as follows:

Amperes	A
Volts	V
Watts	W
Volts-amperes	VA
Alternating current (single-phase)	~ IEC 60417-5032 (2002-10)
Alternating current (three-phase)	3~ IEC 60417-5032-1 (2002-10)
Alternating current (three-phase with neutral)	3N~ IEC 60417-5032-2 (2002-10)
Direct current	⎓ IEC 60417-5031 (2002-10)
Class II control	⧈ IEC 60417-5172 (2003-02)
Class III control	Ⅲ IEC 60417-5180 (2003-02)

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Ambient temperature limits of **switch head**	T	(The letter T preceded by a minus sign and the numerical value of the lower temperature if T_{min} less than 0 °C, or followed by the numerical value of the higher temperature if $\boldsymbol{T_{max}}$ other than 55 °C.)
Rated current of the appropriate fuse in amperes		 IEC 60417-5016 (2002-10)
Frequency		Hz
Protective earth		 IEC 60417-5019 (2006-08)
**Functional earthing ..... **		 IEC 60417-5018 (2011-07)
Caution		 ISO 7000-0434B (2004-01)
Read operator's manual		 ISO 7000-0790 (2004-01)

For identification of the degree of protection provided by enclosures, the symbols shown in Table 1, requirement 9 shall be used.

NOTE 1 Information about rated current and rated voltage can be provided by using figures alone, the figure for the rated current preceding or above that for the rated voltage and separated from it by a line. For circuits for resistive load and inductive loads, the rated current for inductive load is placed between parentheses and immediately following the rated current for resistive load. The symbol for the nature of the supply is placed after the current and voltage.

Current, voltage and nature of supply can be indicated as follows:

$$16\ (3)\ \text{A}\ 240\ \text{V}\ \sim \quad \text{or} \quad 16\ (3)\ /\ 240\ \sim \quad \text{or} \quad \frac{16\ (3)}{240}\ \sim$$

NOTE 2 The following are examples of ways to provide information about the temperature limits of a **control**:

- 20T 30 (meaning minus 20 °C up to plus 30 °C);
- T85 (meaning 0 °C up to plus 85 °C).

NOTE 3 Information concerning declared specific loads can be given by reference to drawings or to types, for example:

"Electric motor, drawing No. ..., part list No. ..., made by..." or "5 × 80 W fluorescent".

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Table 1 – Required technical information and methods of providing these information

	Information	Clause or subclause	Method
1	Manufacturer's name or trade mark	5.2.7	C
2	**Unique type reference** [a]	3.13.1, 5.2.7	C
3	Rated voltage or rated voltage range in volts (V)	3.1.2, 4.3.4.2 16.4,	C
4	Nature of supply AC, DC, both AC and DC, battery powered, specific supplies or multiple supplies	4.3.4.2	C
5	Frequency if other than for range 50 Hz to 60 Hz inclusive	4.3.4.2	C
6	Purpose of **control**	3.2, 4.3.4.2, 4.3.4.5, 19.15	D or E
7	Type of **control** according to construction and whether the **control** is electronic	3.5, 3.5.7	X
8	The type of load controlled by each circuit[b] such as substantially resistive, resistive or inductive, declared specific load, 20 mA load, declared motor load and **pilot duty** load	16, 19, Table 18, Table 19, Table 20, 23.2.2 26.2.3	C
9	Degree of protection provided by enclosure [c] (IP classification according IEC 60529)	9.5, 14.1	C
10	Marking of terminals for external connections	5.4.2	C
11	Which of the terminals for **external conductors** are for a wider range of conductor sizes than those indicated in Table 2.	8.1	D or E
12	For **screwless terminals**, the method of connection and disconnection [d], if not readily identifiable	8	D
13	Details of any special conductors which are intended to be connected to the terminals for **internal conductors**	8.2.1	D or E
14	Maximum temperature of terminals for **internal conductors** and terminals for **external conductors** of **incorporated** and **integrated controls**, if higher than 85 °C	16	X
15	Temperature limits of the **switch head**, if the minimum value (T_{min}) lower than 0 °C or the maximum value ($\boldsymbol{T_{max}}$) other than 55 °C Preferred values of $\boldsymbol{T_{max}}$ are 30 °C, 55 °C, 70 °C, 85 °C, 105 °C, 125 °C, 150 °C. Preferred values of T_{min} are 0 °C, −10 °C, −20 °C, −30 °C, and −40 °C	16.5 16.7, 19.3	C
16	Temperature limits of mounting surfaces ($\boldsymbol{T_s}$) Maximum temperature of mounting surface ($\boldsymbol{T_{s\ max}}$) if it is more than 20K above $\boldsymbol{T_{max}}$	16.5 a), 19.3	C
17	Type of **control** according to protection against electric shock	3.7.3, 3.7.4, 3.7.5, 3.7.6, 3.7.7, 6, 7	X
18	For **class II controls**, the symbol for Class II construction	5.3	C
19	Number of cycles of **actuation** (M) for each **manual action** Preferred values are: 100 000 cycles; 30 000 cycles; 10 000 cycles; 6 000 cycles; 3 000 cycles [j]; 300 cycles [j]; 30 cycles [j] NOTE For controls with more than one manual action, a different value can be declared for each. If a control has more than one intended "OFF" position, then a cycle of actuation is regarded as a movement from one "OFF" position to the next "OFF" position.	19.10, 19.11	X

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	Information	Clause or subclause	Method
20	Number of automatic cycles (A) for each automatic action. Preferred values are: 300 000 cycles; 200 000 cycles; 100 000 cycles; 30 000 cycles; 20 000 cycles; 10 000 cycles; 6 000 cycles; 3 000 cycles[1)]; 1 000 cycles[1)]; 300 cycles[2)]; 30 cycles[2)4)]; 1 cycle[3)]. [1)] Not applicable to thermostats or to other fast cycling actions. [2)] Applicable only to manual reset. [3)] Applicable only to actions which require the replacement of a part after each operation. [4)] Can only be reset during manufacturer servicing. NOTE For controls having more than one automatic action, a different value can be declared for each.	13.1.3.3, Table 14, 19.7.6, 19.8.4,	X
21	Ageing period (Y) for **controls** with type 1.M or 2.M action Preferred values are: 60 000 h; 30 000 h; 10 000 h; 3 000 h; 300 h; 15 h	19.6	X
22	Type of disconnection or interruption provided by each circuit	3.4.1, 3.4.2, 3.4.3, 3.4.4	X
23	PTI of materials used for insulation	11.3.1, Table 12, Footnote [c], Table 13, Footnote [d], 21.2.9	X
24	Method of mounting **control** [d]	9.6, 9.11, 10.1, 16, 19 and 20	D
25	Marking and method of providing earthing of **control**	5.4.2.3, 7, 7.1.1, 7.1.2	D
26	Method of attachment for **non-detachable cords** [e]	8.1, 9.7	D or E
27	Range of allowed outer diameter for cords used in controls with type X attachment method when relevant for the compliance with Clause 14	14.1.4	D or E
28	Intended transportation condition of **control** [f]	18.1	X
29	Details of any limitation of **operating time** [g]	16, 19	D or E
30	Limits of **activating quantity** for any **sensing element** over which **micro-disconnection** or **electronic disconnection** is secure	9.3.2, 9.4.16, 19.14, 20.1.5, 13.1.1	X
31	Minimum and/or maximum rates of change of activating quantity, or minimum and/or maximum cycling rates for a **sensing control** [h]	4.3.2.7, H.17, 19	X
32	Values of overshoot of **activating quantity** for **sensing controls** which are necessary for correct action, or which can be used for test purposes	19	X
33	**Type 1 action** or **type 2 action**	3.6	D or E
34	Additional features of **type 1 action** or **type 2 actions**	9.4	D or E
35	**Manufacturing deviation** and condition of test (electrical, mechanical and thermal) appropriate to deviation	3.11.1, 9.4.3, H.17, 19.14	X
36	**Drift**	3.11.2, 9.4.3, H.17, 18.2.4	X
37	Reset characteristics for cut-out action [i]	9.4.11, 9.4.12,	D or E
38	If a **control** is either to be hand-held or is intended for a hand-held equipment	21, 9.12.4.4.1	X
39	Any limitation to the number or distribution of flat push-on **receptacles** which can be fitted	8.2.4.4	D or E

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	Information	Clause or subclause	Method
40	For any **type 2 action** the **manufacturing deviation** and **drift** of its **operating value**, **operating time** or **operating sequence** (declared in Table 1, requirement 35, and requirement 36)	9.4.3	D or E
41	Extent of any **sensing element**	3.8.1	X
42	**Operating value** (or values) or **operating time**	3.3.11, 3.3.12, 9, 16, H.17.6,19	D
43	Installation class (surge immunity) and operating modes	12.2 H.25.8.1 H.25.8.3 Annex N	X
44	Intended **pollution degree** of the **control**	Annex F	D or E
45	**Control** intended to be delivered exclusively to the **equipment manufacturer**	5.2.1, 5.2.7	X
46	Glow wire test temperatures	21.2.5, 21.2.6, 21.2.7, and 21.2.8	X
47	The minimum parameters of any heat dissipator (for example, heat sink) not provided with an **electronic control** but essential to its correct **operation**	16	D
48	Type of output waveform if other than sinusoidal	24.1	X
49	Details of the **touch current** waveform produced after **failure** of the **basic insulation**	13.1	X
50	The relevant parameters of those **electronic devices** or other circuit components considered as unlikely to fail (see paragraph 1 of 13.1.3.1)	13.1	X
51	Type of output waveform(s) produced after **failure** of an **electronic device** or other circuit component (see item g) of 13.1.3.8)	13.1	X
52	The effect on controlled output(s) after electronic circuit component **failure** if relevant (item c) of 13.1.3.8)	13.1	X
53	Any component on which reliance is placed for **electronic disconnection** which is disconnected as required by footnote n to Table 16	15.2 13.1	X
54	External load and emission control measures to be used for test purposes	23.3	X
55	**Rated impulse voltage**	3.1.10, 11.2	D or E
56	Type of printed circuit board protection	Annex L or Annex M	X
57	Temperature for the ball pressure test	21.2.5, 21.2.6 and 21.2.7	X
58	Maximum declared torque on single bush mounting using thermoplastic material	Table 9, Footnote [a]	D or E
59	**Pollution degree** in the **micro-environment** of the **creepage distance** or **clearance** if cleaner than that of the **control**, and how this is designed	Table 14	X
60	**Rated impulse voltage** for the **creepage distance** or **clearance** if different from that of the **control**, and how this is ensured	Table 14	D or E
61	The values designed for tolerances of distances for which the exclusion from **fault** mode "short" is claimed	13.1.3.3, Table 14, 13.1.3.5	X
62	For **class III controls**, the symbol for Class III construction	5.4.2.5	C
63	For **SELV** or **PELV** circuits, the **ELV** limits realized	3.1.5, 6.1.1, P.3.2	X
64	Value of accessible voltage of **SELV**/**PELV** circuit, if different from 6.1.1, and the product standard(s) referred to for the application of the **control**, in which the accessible **SELV**/**PELV** level(s) is (are) given	3.1.4, 6.1.1	X
65	Emission tests and groups as declared according to CISPR 11	23.2	X

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	Information	Clause or subclause	Method
66	Immunity tests for **protective controls** for use in accordance with IEC 60335 appliances	Table H.12	X
67	Maximum short circuit current as declared	9.3.5.2.1 b)	X
68	Overcurrent protective device external to the **control**	9.2.8, 26.2	D or E
69	Marking for the type of replaceable battery	5.4.3.3	C
70	For **incorporated controls** or **integrated controls**, whether the overload test shall be done at control level	26.2.2	X
71	Maximum altitude at which the **control** can be used if greater than 2 000 m	11.2	X
72	Maximum number of **reset** actions within a time period	9.12.4.4.5	D
73	Number of remote **reset** actions	19.1.6.5	X
74	Resistance to heat and fire for controls intended for use in IEC 60335 appliances	21.2.4	X
75	Type of electromagnetic environment of one of the two EMC emission limits **residential electromagnetic environment** or **industrial electromagnetic environment**	23, Table 23 or Table 24	D or E
76	Type of electromagnetic environment of one of the two EMC immunity levels	25.3.2	D or E
77	**Residential electromagnetic environment**	Table 26 or	
78	**Industrial electromagnetic environment**	Table 27	
79	Cable length up to or equal to 30 m (if not for **long-distance lines**)	25.3.2, Table 26 or Table 27	D or E
80	Cable length up to or equal to 3 m (if not for **long-distance lines**)	25.3.2, Table 26 or Table 27	D or E
81	Applicable of test and frequency	25.3.2, Table 26 or Table 27	D or E
82	Additional requirements for HBES/BACS [k] controls in **residential electromagnetic environment** according to IEC 63044-5-2 or **industrial electromagnetic environment** according to IEC 63044-5-3	25.3.2, Table 26 or Table 27	D or E
83	Control susceptible to magnetic fields (see footnote e in both tables)	25.3.2, Table 26 or Table 27	D or E
84	Controls declared for EMC performance	25.1, Table 25	D
85	Minimum and maximum battery voltage	24.2	X
86	**Electronic controls** of class A control function, which are additionally complying with 25.7 to 25.10	25.1, Table 25	D
87	Type of DC supply for non-stationary applications	Annex I, I.1	D

[a] The **unique type reference** shall be such that, when it is quoted in full, the manufacturer of the **control** can supply a replacement which will be fully interchangeable with the original electrically, mechanically, dimensionally, and functionally.

It may comprise a series type reference with other marking, such as voltage rating or an ambient temperature marking, which together provide a unique type reference.

[b] For **controls** with more than one circuit, the current applicable to each circuit and to each terminal. If these are different from each other, then it shall be made clear to which circuit or terminal the information applies. For circuits for resistive and inductive loads, the rated current, or the rated load in VA, at power factors as indicated in the appropriate table of 19.2.

[c] The marking (C) requirement does not apply to **controls** or parts thereof classified as IP00, IP10, IP20, IP30 and IP40.

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[d] If, for **independently mounted controls**, it is necessary to take special precautions when installing or using the **control**, these details shall be given in an instruction sheet accompanying the **control**.

Special precautions may be necessary, for example, for flush mounting **independently mounted controls**. In order to ensure that, after building-in, the conditions necessary to meet the requirements of this document are achieved, the instruction sheet for such **controls** shall include clear information concerning:

– the dimensions of the space to be provided for the **control**;

– the dimensions and position of the means for supporting and fixing the **control** within this space;

– a minimum clearance between the various parts of the **control** and the surrounding parts of the fitment;

– the minimum dimensions of ventilating openings and their correct arrangements;

– the connection of the **control** to the supply and the interconnection of separate components, if any.

If the supply conductors of a **control** can come into contact with parts of a terminal block or a compartment for **fixed wiring**, and these parts have, under conditions of **normal use**, a temperature exceeding that specified in Table 17, the instruction sheet shall also state that the **control** shall be connected by means of conductors having the appropriate T rating (see Footnote h of Table 17).

For **controls** with wiring between a sensor, sensing or actuating element and the rest of the **control** where part of this wiring is, or is intended to be, also part of the fixed installation, the manufacturer shall give in the documentation the relevant information for proper installation and the appropriate type of cable or cord required for that part of the fixed installation.

[e] **In-line cord**, **free-standing** and **independently mounted controls**, if fitted with **non-detachable cords** using **type Y attachments** or **type Z attachments**, shall have documentation (D) containing the substance of one of the following statements, whichever is appropriate:

– "The supply cord of this control cannot be replaced; if the cord is damaged, the control should be discarded" (Z)

or

– "The supply cord of this control can be replaced only by the manufacturer or his accredited service agent" (Y).

[f] The method of packaging does not have to be declared.

[g] For **in-line cord**, **free-standing** and **independently mounted controls**, this information shall be provided by method C.

[h] α_1 = minimum rising rate

β_1 = minimum falling rate

The rate of change (α_1 and $\beta_{1)}$ of the **activating quantity** are those applicable to **normal use**.

α_2 = maximum rising rate (for **type 2 actions** only)

β_2 = maximum falling rate (for **type 2 actions** only)

For test purposes, α_1 and β_1 shall be as declared but not lower than the limit(s) indicated in the appropriate part 2 standards for **type 1 actions** and/or **type 2 actions**. The values α_2 and β_2 are for test purposes only, and may alternatively be declared as a maximum cycling rate. The rates of change for the purpose of this document shall be expressed in the units as shown in the following table*:

Activating quantity	Unit for rate of change
Pressure	Pa/s
Temperature	K/h
Position	mm/s
Illumination	lux/s
Velocity	mm/s^2
Liquid level	mm/s
Current	A/s
Humidity	%/s
Air flow	m^3/s^2

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*	When using other activating quantities, the units shall be expressed in SI-units.
i	The manufacturer may declare a time before which, or a specific value of **activating quantity** above which, manual reset shall not occur.
j	Applicable only to actions of **controls** for specific equipment and applications such as voltage-tap **controls**, summer/winter **controls** for water heaters and where permitted by the appropriate equipment standard.
k	Home and Building Automation and Control (HBES/BACS) products.

5.3 Class II symbol

5.3.1 The symbol for class II construction shall be used only for **controls** of class II. The symbol for class II construction is not required for **incorporated controls** and **integrated controls**.

5.3.2 The dimension of the symbol for class II construction shall be such that the length of the sides of the outer square is about twice the length of the sides of the inner square.

5.3.2.1 The length of the sides of the outer square of the symbol shall be not less than 5 mm, unless the largest dimension of the **control** is 15 mm in length or less, in which case the dimension of the symbol can be reduced but the length of the sides of its outer square shall be not less than 3 mm.

5.3.2.2 **Controls** providing protection against electric shock as required for class II but that include terminals for earthing continuity for functional purposes shall not be marked with the symbol for class II construction, IEC 60417-5172 (2003-02), but shall be regarded as **class I controls**.

5.4 Additional requirements for marking

5.4.1 General

Required marking on a **control** shall not be placed on **detachable parts**.

Required markings shall be legible and durable.

Compliance is checked by inspection and by the tests of Annex A.

5.4.2 Marking of terminals for external connections

5.4.2.1 Terminals of **controls** intended for the connection of supply conductors shall be indicated by an arrow pointing towards the terminal, unless the method of connection to the supply mains is of no importance or is self-evident.

Compliance is checked by inspection.

5.4.2.2 Terminals intended exclusively for a neutral **external conductor** shall be indicated by the letter "N".

5.4.2.3 Earthing terminals for external protective earthing conductors or earthing continuity, and terminals for earthing for functional purposes (as opposed to purposes of protection against electric shock) shall be indicated

– for protective earth, by the earth symbol for protective earth, IEC 60417-5019 (2006-08);
– for functional earth, by the earth symbol for functional earthing, IEC 60417-5018 (2011-07).

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5.4.2.4 All other terminals shall be suitably identified, their purpose self-evident or the **control** circuitry visually apparent. The arrow, the letter "N" or the earth symbol shall not be used except as indicated above.

Compliance is checked by inspection.

5.4.2.5 In-line cord controls, free-standing controls and independently mounted controls intended to be connected only to **SELV systems** or **PELV systems** shall be marked with the graphic symbol IEC 60417-5180 (2003-02). This requirement does not apply where the means of connection to the supply is so shaped that it can only mate with a particularly designed **SELV** or **PELV** arrangement.

Controls providing protection against electric shock as required for **class III controls** but that carry terminals for functional earthing purposes or for external earthing continuity shall be marked with the symbol for class III construction.

NOTE The symbol for functional earth is IEC 60417-5018 (2011-07).

5.4.3 Markings for installation and servicing

5.4.3.1 **Controls** intended to be set by the **user** or by the **equipment manufacturer** during installation shall be provided with an indication of the direction to increase or decrease the **response value**.

NOTE An indication of "+" or "–" is sufficient.

Controls intended to be set by the **equipment manufacturer** or the **installer** shall be accompanied by documentation (D) indicating the proper method for securing the **setting**.

5.4.3.2 Parts destroyed during the normal **operation** of the **control** and which have to be replaced shall be marked so as to enable them to be identified from a catalogue or the like, even after they have operated, unless they are intended to be replaced only during **manufacturer servicing**.

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

– if the battery is intended to be replaced by the **user**, there shall be a marking close to the battery or a statement in both the instructions for use and the service instructions;
– if the battery is not intended to be replaced by the **user**, there shall be a marking close to the battery or a statement in the service instructions.

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

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

5.4.3.4 The battery compartment of **controls** incorporating batteries that are intended to be replaced by the **user** shall be marked with the battery voltage and the polarity of the terminals.

If colours are used, the positive terminal is to be identified in red and the negative terminal in black.

Colour is not to be used as the only indication of polarity.

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5.4.3.5 The instructions for **controls** incorporating batteries that are intended to be replaced by the **user** shall include the following:

– the type reference of the battery;
– the orientation of the battery with regard to polarity;
– the method of replacing batteries;
– warning against using incorrect type batteries;
– how to deal with leaking batteries.

The instructions for **controls** incorporating a battery that contains materials which are hazardous to the environment shall give details on how to remove the battery and shall state that:

– the battery must be removed from the **control** before it is scrapped;
– the **control** must be disconnected from the supply mains when removing the battery;
– the battery is to be disposed of safely.

5.4.3.6 For controls powered by secondary batteries (rechargeable), the instructions shall give information regarding charging of batteries.

5.5 Warning or cautionary markings

Warnings or cautions shall be written in the manufacturer's instructions (D or E) provided that the symbol ISO 7000-0434B (2004-01) is marked on the product.

6 Protection against electric shock

6.1 General requirements

6.1.1 **Controls** shall be so constructed that there is adequate protection against accidental contact with **live parts**, in any unfavourable position which can occur in **normal use**, and after any accessible **detachable parts**, other than lamps located behind a detachable **cover** have been removed. However, during the insertion and removal of lamps, protection against accidental contact with **live parts** of the lamp cap shall be ensured.

Unless otherwise specified, **accessible parts** connected to **SELV systems** or **PELV systems** where the voltage does not exceed the **SELV** limits of 3.1.5 are not considered to be **hazardous live parts**.

SELV/**PELV** circuits are not considered **hazardous live parts** if:

– the **control** is intended only to be used in an application governed by another product standard where the limit value of the voltage for accessible bare conductors of **SELV**/**PELV** is different

and

– the manufacturer declares the application, product standard governing the application and level of voltage for accessible **SELV**/**PELV** circuits considered to be non-hazardous by the application standard (declared in Table 1, requirement 64)

For accessible parts connected to a **SELV system** or a **PELV system** where the voltage exceeds the limits of 3.1.5, or is higher than the values declared in Table 1, requirement 64, the current between the simultaneously accessible parts and between the **accessible part**(**s**) and earth shall not exceed the limits in 6.1.10 under **fault**-free (normal) and single-**fault** conditions.

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6.1.2 The insulating properties of lacquer, enamel, paper, cotton, oxide film on metal parts, beads and sealing compounds shall not be relied upon to give the required protection against accidental contact with **hazardous live parts**. Sealing compounds of the self-hardening types can be touched, provided that the sealing compound fulfils requirements of Clauses 15 and 11.

6.1.3 For those **class II controls** and **controls** for class II equipment which are connected in **normal use** to the gas supply mains or to the water supply mains, any metal parts conductively connected to the gas pipes or in electrical contact with the water **system** shall be separated from **hazardous live parts** by **double insulation** or **reinforced insulation**.

6.1.4 Those **class II controls** and **controls** for class II equipment which are intended to be permanently connected to **fixed wiring** shall be so designed that the required degree of protection against electric shock is not impaired by the installation of the **control**.

NOTE The protection against electric shock of **class II independently mounted controls** can be affected, for example, by the installation of metal conduits or of cables provided with a metal sheath.

6.1.5 For **integrated** and **incorporated controls**, the tests of 6.1.8 are only applied to those parts of the **control** which are accessible when they are mounted in any position in accordance with the manufacturer's declarations and after removal of **detachable parts**.

6.1.6 For **in-line cord controls** and **free-standing controls**, the tests of 6.1.8 are made when the **control** is fitted with flexible cords either of the smallest, or of the largest nominal cross-sectional area used in 8.1.5, whichever is more unfavourable. **Detachable parts** are removed, and hinged **covers** which can be opened without the use of a **tool** are opened.

6.1.7 For **independently mounted controls**, the test is made when the **control** is mounted as in normal use, fitted with cable of the smallest or of the largest nominal cross-sectional area used in 8.1.5, whichever is more unfavourable, or with a rigid, pliable or flexible conduit. **Detachable parts** are removed, and hinged covers which can be opened without the use of a **tool** are opened.

6.1.8 *Compliance with 6.1.1 to 6.1.7 inclusive is checked by inspection and by the following tests:*

a) *The test finger shown in Figure 5 is applied without force in every possible position. Apertures preventing the entry of the finger are further tested by means of a straight unjointed test finger of the same dimensions which is applied with a force of 20 N; if this finger enters, the test with the test finger shown in Figure 5 is repeated, the finger being pushed through the aperture if necessary. If the unjointed test finger does not enter, the force applied is increased to 30 N. If then the guard is so displaced or the aperture so distorted that the test finger shown in Figure 5 can be inserted without force, the test with the latter finger is repeated. An electrical contact indicator is used to show contact.*

NOTE A lamp can be used for the indication of contact, with the voltage not less than 40 V.

b) *The test finger shown in Figure 5 shall be so designed that each of the jointed sections can be turned through an angle of 90° with respect to the axis of the finger in the same direction only.*

c) *In addition, openings in insulating material and in unearthed metal shall be tested by applying the test pin shown in Figure 4 without force in every possible position.*

d) It shall not be possible, with either the standard test finger or the test pin, to touch **hazardous live parts**.

e) For **controls** which have any parts of **double insulation** construction, it shall not be possible to touch metal parts with the test finger shown in Figure 5 which are only separated from **hazardous live parts** by **basic insulation**.

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f) *If there is an instruction to remove a part during **normal use** or **user maintenance** and if there is no warning on the part which indicates: "Disconnect from supply before removing", that part is regarded as a **detachable part** for compliance with 6.1.5, 6.1.6 and 6.1.7 only, even if a **tool** has to be used for its removal. If there is such a warning on the part, it is permissible, after removal, to touch parts separated from **hazardous live parts** by **basic insulation**.*

6.1.9 Accessible conductive parts shall not be considered as hazardous live parts if separated from the supply by protective impedance.

6.1.10 For **protective impedance**, the current between the part or parts and either pole of the supply source shall not exceed 0,7 mA (peak value) AC or 2 mA DC:

– for frequencies exceeding 1 kHz, the limit of 0,7 mA (peak value) is multiplied by the value of the frequency in kHz but shall not exceed 70 mA (peak value);
– for voltages over 42,4 V (peak value) and up to and including 450 V (peak value), the capacitance shall not exceed 0,1 µF;
– for voltages over 450 V (peak value) and up to and including 15 kV (peak value), the product of the capacitance in farads times the potential in volts shall not exceed 45 µC;
– for voltages over 15 kV (peak value), the product of the capacitance in farads times the square of the potential in volts shall not exceed 350 mJ.

Compliance is checked by measurement.

Voltages and currents are measured between a single accessible conductive part (or any combination of such parts) and the protective earth conductor. Measurements shall be taken in normal supply configuration, and with supply poles interchanged.

Details of the measuring circuit are shown in Figure K.1 of Annex K.

6.1.11 Between class III circuits and circuits connected to the mains or earth, insulation external to the **safety isolating transformer** shall comply with all requirements for class II insulation.

NOTE Where a circuit is not specifically required to be class III, class II requirements are not applicable between the class III circuit and earth.

Compliance is checked by inspection and measurement.

6.1.12 **Controls** having battery compartments that can be opened without the aid of a **tool**, or that according to the instructions for use can be replaced by the **user** need only have **basic insulation** between **live parts** and the inner surface of the battery compartment. If the **control** can be energized without the batteries, **double insulation** or **reinforced insulation** is required.

NOTE If a part has to be removed in order to discard the battery before scrapping the **control**, this part is not considered to be detachable even if the instructions state that it is to be removed.

Compliance is checked by inspection and measurement.

6.2 Actuating members and actuating means

6.2.1 An actuating member shall not be a **live part**.

6.2.2 An **actuating means** shall not be a **live part**, unless either it is provided with an insulated **actuating member** which is adequately fixed or the **actuating means** is not accessible when the **actuating member** is removed.

Compliance with 6.2.1 and 6.2.2 is checked by inspection and by the tests of 6.1.

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NOTE An insulated **actuating member** is considered to be adequately fixed if it can be removed only by breaking, cutting, or after being seriously damaged.

6.2.3 For **controls** other than class III or **controls** for equipment other than those of class III, **actuating members** and handles held in **normal use** shall be either of insulating material, or adequately covered by insulating material, or, if of metal, their **accessible parts** shall be separated from their **actuating means**, or from their fixings by **supplementary insulation**, if such parts would be likely to become live in the event of an insulation **fault**.

For **controls** for connection to **fixed wiring**, or for **controls** for stationary equipment, this requirement does not apply provided that such parts are either:

– reliably connected to a **protective earthing** terminal or a protective earthing contact of a plug; or

– shielded from hazardous live parts by **protective screening**.

Compliance is checked by inspection.

NOTE Parts separated from **hazardous live parts** by **double insulation** or **reinforced insulation** are not regarded as likely to become live in the event of an insulation **fault**.

6.3 Capacitors

6.3.1 For class II **in-line cord controls** and **independently mounted controls**, capacitors shall not be connected to accessible metal parts, unless they comply with 6.1.10 and 9.2.5. For **incorporated controls** and **integrated controls** used in class II equipment, capacitors shall not be connected to metal likely to be connected to accessible metal when the **control** is mounted in accordance with the manufacturer's declarations.

Compliance is checked by inspection.

6.3.2 **Controls** intended to be connected to the supply by means of a plug shall be so designed that in **normal use**, there is no **risk** of electric shock from charged capacitors when touching the pins of the plug after disconnecting from the supply.

Compliance is checked by the following tests, which are made 10 times.

a) The **control** is supplied at rated voltage or at the upper limit of the rated voltage range.

b) The **actuating member**, if any, is then moved to the "OFF" position if one exists and the **control** is disconnected from the supply by removing the plug from the socket-outlet.

c) One second after disconnection, the voltage between the pins of the plug is measured.

d) *The voltage shall not exceed 42,4 V peak. The test is only performed if the capacitor exceeds 0,1 µF.*

6.4 Covers and uninsulated live or hazardous parts

Controls provided with a **cover** or **cover plate** of non-metallic material shall be so designed that the **cover** fixing screws are not accessible, unless they are either protective earthed or separated from **hazardous live parts** by **double insulation** or **reinforced insulation** or not accessible after mounting in the equipment.

Compliance is checked by inspection.

6.5 Battery operated controls provided with a user accessible mains supply input connector

Battery operated **controls** provided with a **user** accessible mains supply input connector shall be so designed that 1 s after disconnection of the mains supply connector, the voltage between any two accessible mains supply input terminals is less than or equal to the limits given in 6.1.1. The test shall be conducted using a fully charged battery or batteries.

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7 Provision for protective earthing

7.1 Class 0I and Class I controls

7.1.1 Accessible metal parts, other than **actuating members**, of

– **in-line cord**, **free-standing** and **independently mounted controls** of class 0I and class I which can become live in the event of an insulation **fault**, shall be permanently and reliably connected to an earthing terminal or **termination** within the **control**, or to the earthing contact of an equipment inlet.

– **integrated controls** and **incorporated controls** for class 0I and class I equipment which can become live in the event of an insulation **fault** shall have provision for earthing.

NOTE 1 Parts separated from **live parts** by **double insulation** or **reinforced insulation** and parts screened from **live parts** by metal parts connected to an earthing terminal, earthing **termination** or earthing contact are not regarded as likely to become live in the event of an insulation **fault**.

NOTE 2 Requirements for **actuating members** are specified in 6.2.3.

Integrated controls and **incorporated controls** can be connected to earth through their fixing means, provided that provision is made for clean metallic surfaces. This also applies, for example, to **controls** with metallic **sensing elements** which are connected reliably to the metal parts of the equipment if the manufacturer has declared this to be a method of earthing.

7.1.2 Earthing terminals, earthing **terminations** and earthing contacts shall not be electrically connected to any neutral terminal.

Compliance with 7.1.1 and 7.1.2 inclusive is checked by inspection.

7.2 Class II and class III controls

Class II and class III controls shall have no provision for protective earthing.

Compliance is checked by inspection.

7.3 Adequacy of earth connections

7.3.1 General requirements

The connection between an earthing terminal or **termination** or earthing contact, and parts required to be connected thereto, shall be of low resistance.

Compliance is checked by the following test:

– *A current of 1,5 times the rated current, but not less than 25 A, and derived from an AC or DC source with a no-load voltage not exceeding 12 V, is passed between the earthing terminal, earthing **termination** or earthing contact, and each of the parts, in turn.*

– *The voltage drop between the earthing terminal, earthing **termination** or earthing contact and the part is measured, and the resistance calculated from the current and this voltage drop. In no case shall the resistance exceed 0,1 Ω. The test is continued until steady conditions have been established.*

NOTE 1 The contact resistance between the tip of the measuring probe and the metal part under test is such that it does not influence the test results.

NOTE 2 The resistance of any **external conductor** or **internal conductor** is not included in the resistance measurement, but the resistance of any **integrated conductor** is included.

7.3.2 Fixed wiring and methods X and M

Earthing terminals for the connection of **fixed wiring** or for **non-detachable cords** shall comply using methods X and M

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Compliance is checked by requirements of 8.1.

7.3.3 External conductors

Earthing connections for **external conductors** shall not be made using **screwless terminals**, however for **type Y attachment** and **type Z attachment**, screwless-type clamping units complying with IEC 60998-2-2 or 60998-2-3 or screwless-type clamping units according to IEC 60999-1 are allowed.

7.3.4 Size of accessible earthing terminals

Earthing terminals which are accessible in **normal use** shall allow the connection of conductors having nominal cross-sectional areas of 2,5 mm^2 to 6 mm^2 inclusive and it shall not be possible to loosen them without the aid of a **tool**.

7.3.5 Size of non-accessible earthing terminals

Earthing terminals which are not accessible in **normal use** for **external conductors** shall be of a size equal to or larger than that required for the corresponding current-carrying terminal.

7.3.6 Locking of earthing terminals

Clamping means of earthing terminals for **external conductors** shall be adequately locked against accidental loosening.

Compliance with 7.3.2 to 7.3.6 inclusive is checked by inspection, by manual test and by the appropriate tests of 8.1.

NOTE In general, the designs commonly used for current-carrying terminals provide sufficient resilience to comply with the requirement for adequate locking against accidental loosening, provided that there is no excessive vibration or temperature cycling. If the terminal is subjected to excessive vibration or temperature cycling, special provision such as the use of an adequately resilient part, for example, a pressure plate which is not likely to be removed inadvertently, can be necessary when **pillar terminals** are used.

Screwless clamping units for **type Y attachment** and **type Z attachment** in accordance with 7.3.3 are considered to provide adequate resilience against vibrations and thermal cycling.

7.4 Corrosion resistance

7.4.1 General

All parts of an earthing terminal shall be resistant to corrosion resulting from contact between those parts and the copper of the earthing conductor or any other metal that is in contact with those parts.

7.4.2 Materials

The body of an earthing terminal shall be of brass, or other metal no less resistant to corrosion, unless it is a part of the metal frame or enclosure. Then any screws or nuts shall be of brass, plated steel or other metal complying with Clause 22, or other metal no less resistant to corrosion.

7.4.3 Frames or enclosures of aluminium

If the body of an earthing terminal is a part of a frame or enclosure of aluminium or aluminium alloy, precautions shall be taken to avoid the **risk** of corrosion due to electrochemical action resulting from contact between copper and aluminium or its alloys.

Compliance with 7.4, 7.4.2, and 7.4.3 is checked by inspection, and in cases of doubt by an analysis of the materials and their coatings.

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NOTE Corrosion resistance can be achieved by plating or similar process.

7.5 Other requirements

7.5.1 Detachable parts

If a **detachable part** of a **control** has an earth connection, this connection shall be made before any current-carrying connections are established when placing the part in position, and any current-carrying connections shall be separated before the earth connection is broken when removing the part.

Compliance is checked by inspection.

7.5.2 Incorporated control

If an **incorporated control** is likely to be separated from its normal earthing means after mounting in the equipment for purposes of testing, **setting** or **servicing** while the equipment is energized, it shall be provided with an earthing connection or with an earthing conductor which does not require removal from the **control** for such testing, **setting** or **servicing**.

Compliance is checked by inspection.

NOTE Refrigerator temperature **sensing controls** and defrost **controls** are examples.

7.6 Protective equipotential bonding

The requirements for **protective equipotential bonding** are those for **protective earthing** as given in 7.1 to 7.5.

For the installation of controls which consist of several component parts (sensing component, transmitters, central control unit, receivers, actuators, interface units) and where such component parts are parts of the fixed electrical installation of a building, the requirements for protective bonding in IEC standards for installation of buildings apply.

8 Terminals and terminations

8.1 Terminals and terminations for external copper conductors

8.1.1 Terminals for **fixed wiring** and for **non-detachable cords** using **type X attachment** and **type M attachment**, except as specified in 8.1.3, shall be such that connection is made by means of screws, nuts or equally effective devices or methods, but without requiring a **special purpose tool** for connection or disconnection.

8.1.2 Terminals or **terminations** for **non-detachable cords** using **type Y attachment** and **type Z attachment** shall satisfy the appropriate requirements for terminals and **terminations** for **internal conductors** and can require the use of **special purpose tools** for connection or disconnection.

Compliance with 8.1.1 and 8.1.2 is checked by inspection and test.

NOTE 1 Screw type terminals in accordance with IEC 60998-2-1, **screwless terminals** in accordance with IEC 60998-2-2 or IEC 60998-2-3 and clamping units in accordance with IEC 60999-1 are considered to be effective devices.

NOTE 2 Flat push-on terminals are deemed to require a **special purpose tool** for effecting the crimp.

8.1.3 Screws and nuts which clamp **external conductors** shall have a metric ISO thread or a thread of equivalent effectiveness. They shall not serve to fix any other component, except that they can also clamp **internal conductors** if these are so arranged that they are unlikely to be displaced when fitting the **external conductors**.

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Compliance is checked by inspection.

NOTE SI, BA and Unified threads are deemed to be of equal effectiveness to metric ISO thread.

8.1.4 Soldered, welded, crimped or similar **terminations** shall not be used for the connection of **non-detachable cords** using **type X attachment** and **type M attachment** unless such is permitted by the appropriate equipment standard. When such **terminations** are used for **external conductors**, they shall also comply with the requirements of 8.2.2 and 8.2.3.

Compliance is checked by inspection.

NOTE The application standards restrict the use of such connections.

8.1.5 Terminals for **fixed wiring** or **non-detachable cords** using **type X attachment** or **type M attachment** shall allow at least the connection of conductors having nominal cross-sectional areas as shown in Table 2.

Compliance is checked by inspection, by measurement and by fitting conductors of the smallest and largest cross-sectional areas specified or declared.

Table 2 – Cross-sectional area of conductors

Current carried by terminal [a] A	**Nominal cross-sectional area** mm^2	
	Flexible cord conductor	**Fixed wiring conductors**
Up to 6 and including [b]	0,5 to 1	1 to 1,5
Over 6 up to and including 10	0,75 to 1,5	1 to 2,5
Over 10 up to and including 16	1 to 2,5	1,5 to 4
Over 16 up to and including 25	1,5 to 4	2,5 to 6
Over 25 up to and including 32	2,5 to 6	4 to 10
Over 32 up to and including 40	4 to 10	6 to 16
Over 40 up to and including 63	6 to 16	10 to 25

[a] Requirements for applications greater than 63 A are under consideration.

[b] The nominal cross-sectional areas specified do not apply to terminals in **SELV**-circuits or **PELV**-circuits carrying a current not exceeding 3 A.

If a terminal is designed to accommodate a wider range of **fixed wiring** or flexible cord conductor sizes than those indicated in columns 2 and 3 of Table 2, then this shall be declared in Table 1, requirement 11.

8.1.6 Terminals for **fixed wiring** or **non-detachable cords** using **type X attachment** or **type M attachment** shall be so fixed that, when the clamping means is tightened or loosened, the terminal does not work loose, **internal conductors** are not subjected to stress, and **creepage distances** and **clearances** are not reduced below the values specified in Clause 11.

Compliance is checked by inspection and by measurement after fastening and loosening a conductor of the largest cross-sectional area used in 8.1.5 10 times, the conductor being moved each time it is loosened. For threaded parts, the full torque applied is either that shown in Table 9, or the torque specified in the relevant figure (see Figure 11 to Figure 14), whichever is greater.

During the test, terminals shall not work loose and there shall be no damage, such as breakage of screws or damage to the head slots, threads, washers, stirrups or other parts, that will impair the further use of the terminal.

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NOTE 1 This requirement does not imply that the terminal must be so designed that rotation or displacement is prevented, provided that its movement does not bring about non-compliance with the other requirements of this document.

NOTE 2 Terminals can be prevented from working loose by fixing with two screws, by fixing with one screw in a recess or by other suitable means.

NOTE 3 Covering with sealing compound, or with resins, is only considered to be a sufficient means for preventing a terminal from working loose if

– the seal is not subject to mechanical strain as a result of connection or disconnection of the conductor or use of the equipment; and

– the effectiveness of the sealing compound is not impaired by the temperature which is attained by the terminal under the most unfavourable conditions required by this document.

8.1.7 Terminals for **fixed wiring** or **non-detachable cords** using **type X attachment** or **type M attachment** shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without undue damage to the conductor, except that for **screwless terminals** intended for circuits carrying a current not exceeding 2 A, one of the surfaces can be of non-metallic material.

Compliance is checked by inspection of the terminal and of the conductors after the test of 8.1.6.

NOTE Conductors are considered to be unduly damaged if they show sharp or deep indentations.

8.1.8 Terminals for **fixed wiring** and **non-detachable cords** using **type X attachment** shall not require special preparation of the conductor in order to effect correct connection.

Terminals for **type X attachment** can also have alternative means of connection if at least one of the means conforms to this requirement, even if the original factory-made connection uses another means. In this case, the original factory-made connection shall comply with the requirements for terminals and **terminations** for **internal conductors**.

Compliance is checked by inspection.

NOTE The term "special preparation of the conductor" covers soldering of the strands, use of cable lugs, formation of eyelets, etc., but not the reshaping of the conductor before its introduction into the terminal or the twisting of a stranded conductor to consolidate its end.

8.1.9 Terminals for **fixed wiring** and **non-detachable cords** using **type X attachment** or **type M attachment** shall be so designed or placed that neither the conductor nor a wire of a stranded conductor can slip out while any clamping screws or nuts are being tightened, or while any equally effective device is being operated.

Compliance is checked by the following tests.

a) Terminals are fitted with conductors according to the use of the terminal, in accordance with Table 3. The wires of fixed wiring conductors are straightened before inserting into the terminal.

b) The wires of flexible cables and cords are twisted so that there is an even twist of one complete turn in 20 mm. The conductor is inserted into the terminal for the minimum distance prescribed, or where no distance is prescribed, until it just projects from the far side of the terminal. The conductor is inserted into the terminal in the position most likely to assist a wire to escape and then the screw is tightened with a torque equal to two-thirds of the torque specified in Table 9.

c) For flexible cords, the test is repeated using a new conductor which is twisted as before, but in the opposite direction. After the test, no wire of the conductor shall have escaped into the gap between the clamping means and the retaining device.

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Table 3 – Terminal conductors

Current carried by terminal [a] A		Conductor to be fitted (number of wires and nominal diameter of each wire in millimetres)	
Flexible cord conductors	**Fixed wiring conductors**	**For flexible cord conductors**	**For fixed wiring conductors**
0 to 6	–	32 × 0,20	–
6 to 10	0 to 6	40 × 0,25	7 × 0,52
10 to 16	6 to 10	50 × 0,25	7 × 0,67
16 to 25	10 to 16	56 × 0,30	7 × 0,85
25 to 32	16 to 25	84 × 0,30	7 × 1,04
–	25 to 32	94 × 0,30	7 × 1,35
32 to 40	32 to 40	80 × 0,40	7 × 1,70
40 to 63	40 to 63	126 × 0,40	7 × 2,14
[a] Requirements for applications greater than 63 A are under consideration.			

8.1.10 Terminals shall be so designed that they clamp the conductor reliably.

Compliance is checked by the following tests.

a) The terminals are fitted with conductors of the smallest and largest nominal cross-sectional areas used in 8.1.5, fixed or flexible, whichever is appropriate, or the more unfavourable and the terminal screws are tightened, the torque applied being equal to two-thirds of the torque specified in Table 9. Each conductor is subjected to a pull of the value shown in Table 4. The pull is applied without jerks for 1 min, in the direction of the axis of the conductor space.

b) This pull test is normally applied directly to the conductor adjacent to where it enters the terminal. If, however, an additional crimping or clamping device holding the conductor or the insulation around the conductor exists not more than 30 mm from the entry point for the conductor into the terminal and measured along the length of the conductor, this test should apply to the crimping or clamping device, and not to the actual terminal.

c) During the test, the conductor shall not move by more than 1,6 mm in the terminal.

Table 4 – Conductor pull test values

Current carried by terminal A	Pull N	
	Terminals for flexible cord conductors	**Terminals for fixed wiring conductors**
Up to and including 3	20	20
Over 3 up to and including 6	30	30
Over 6 up to and including 10	30	50
Over 10 up to and including 16	50	50
Over 16 up to and including 25	50	60
Over 25 up to and including 32	60	80
Over 32 up to and including 40	90	90
Over 40 up to and including 63	100	100

8.1.11 Terminals shall be so designed that they do not attain temperature in **normal use**, so as to damage the material of the supporting insulation, or the insulating covering of the clamped conductors.

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Compliance is checked during the heating tests of Clause 16.

8.1.12 Terminals shall be so located that each core contained within any **fixed wiring** sheath or flexible cord sheath can be terminated in reasonable proximity to the other cores within the same sheath, unless there is a good technical reason for the contrary.

Compliance is checked by inspection.

8.1.13 Terminals for **non-detachable cords** using **type X attachment** or **type M attachment** shall be so located or shielded, that should a wire escape when the conductors are fitted, there is no **risk** of accidental contact between **live parts** and accessible metal parts, and for **class II controls** and **controls** for class II equipment, between **live parts** and metal parts separated from accessible metal parts by **supplementary insulation** only. Furthermore, there shall be no **risk** of short-circuiting a declared action providing a **full disconnection** or a **micro-disconnection**.

Compliance is checked by inspection and by the following test:

– *An 8 mm length of insulation is removed from the end of a stranded conductor having a nominal cross-sectional area equal to the minimum size used during the test of 8.1.5. One wire of the stranded conductor is left free, and the other wires are fully inserted into and clamped in the terminal. The free wire is bent, without tearing the insulation back, in every direction, but without making sharp bends around barriers.*

– *The free wire of a conductor connected to a live terminal shall not touch any metal part which is accessible or is connected to an accessible metal part, or for **class II controls** and **controls** of class II equipment, any metal part which is separated from accessible metal parts by **supplementary insulation** only.*

– *The free wire of a conductor connected to an earthing terminal shall not touch any **live part**.*

– *The free wire of a conductor connected to a live terminal shall not become accessible, nor shall it short-circuit a declared action providing a **full disconnection** or a **micro-disconnection**.*

8.1.14 Terminals shall be so designed that circuit continuity is not maintained by pressure transmitted through insulating material other than ceramic, or other insulating material with characteristics no less suitable, unless there is sufficient resilience in the appropriate metal parts to compensate for any shrinkage or distortion.

Compliance is checked by initial inspection and by further examination of the terminals when the samples have completed the test of Clause 19.

NOTE The suitability of the material is considered in respect to the stability of the dimensions within the temperature range applicable to the **control**.

8.1.15 Screws and threaded parts of terminals shall be of metal.

Compliance is checked by inspection.

8.1.16 **Terminals** of the pillar type and the mantle type shall be so designed as to allow an adequate length of conductor to be introduced into, and pass beyond the edge of the screw, to ensure that the conductor does not fall out.

*Compliance is checked for **pillar terminals** by measurement of dimension "g" in Figure 12 and for **mantle terminals** by the minimum distance specified in Figure 13.*

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8.2 Terminals and terminations for internal conductors

8.2.1 Connection of conductors

Terminals and **terminations** shall allow the connection of conductors having nominal cross-sectional areas as shown in Table 5.

Table 5 – Nominal cross-sectional areas of conductors

Current carried by terminal or terminations [a] A	**Minimum nominal cross-sectional area of conductor** mm^2
Up to and including 3	– [b]
Over 3 up to and including 6	0,75
Over 6 up to and including 10	1
Over 10 up to and including 16	1,5
Over 16 up to and including 25	2,5
Over 25 up to and including 32	4
Over 32 up to and including 40	6
Over 40 up to and including 63	10

[a] Requirements for applications greater than 63 A are under consideration.

[b] No minimum specified, but the manufacturer shall declare the conductor size for test purposes.

The requirements of 8.2.1 do not apply to terminals which are not intended to accept standard conductors without special preparation, or which, by their design and application, cannot accept standard conductors; or which are deliberately designed to accept conductors of a different size and which are for use only in particular types of equipment.

NOTE An example is a thermostat intended for use within the fabric of an electric blanket.

8.2.2 Suitability for purpose

Terminals and **terminations** shall be suitable for their purpose. **Terminations** for making soldered, crimped and welded connections shall be capable of withstanding the stresses which occur in normal service.

Compliance is checked by inspection.

8.2.3 Soldered terminals

When soldered terminals are used, the conductor shall be so positioned or fixed that reliance is not placed upon the soldering alone to maintain the conductor in position, unless barriers are provided such that **creepage distances** and **clearances** between **live parts** and other metal parts cannot be reduced to less than 50 % of the values specified in Clause 11 should the conductor break away at the soldered joint.

Compliance is checked by inspection.

NOTE In general, "hooking-in" before soldering is considered to be a suitable means for maintaining a conductor in position, provided the hole through which the conductor is passed is not unduly large, and provided that the conductor is not part of a flat-twin tinsel cord.

Other methods of maintaining a conductor in position, such as waisting the sides of a solder tag, are also considered acceptable.

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8.2.4 Flat push-on connectors

8.2.4.1 **Tabs** forming part of a **control** shall comply with the dimensional requirements of Figure 15 or Figure 16.

Compliance is checked by measurement.

Tabs with dimensions other than those shown in Figure 15 or Figure 16 can be used, if the dimensions and shapes are so different as to prevent any possible mismating with a standard **receptacle** (see Figure 17).

For the dimensions of Figure 15, Figure 16 and Figure 17, the physical dimensions of IEC 61210 can alternatively be used. The performance requirements of IEC 61210 do not apply.

Tabs allowing the polarized acceptance of **receptacles** can be used (see Figure 17).

8.2.4.2 **Tabs** forming part of a control shall consist of material and plating having electrical, thermal and mechanical characteristics appropriate for the application; particularly, with regard to resistance to corrosion and mechanical strength. The maximum temperature of the **tabs** shall be within the manufacturer's specifications.

Compliance is checked by tests of this document.

8.2.4.3 **Tabs** forming part of a **control** shall have adequate strength to allow the insertion and withdrawal of **receptacles** without damage to the **control** such as to impair compliance with this document.

Compliance is checked by applying, without jerks, axial forces equal to those shown in Table 6. No significant displacement or damage shall occur.

Table 6 – Axial force values for tab insertion and withdrawal

Tab size (see Figure 17)	**Push** [a] N	**Pull** [a] N
2,8	50	40
4,8	60	50
6,3	80	70
9,5	100	100

[a] The values in the table are the maximum allowed for the insertion and the withdrawal of a **receptacle** from a **tab**.

8.2.4.4 **Tabs** forming part of a **control** shall be adequately spaced to allow the connection of the appropriate **receptacles**.

For the dimensions of Figure 15, Figure 16 and Figure 17, the physical dimensions of IEC 61210 can alternatively be used. The performance requirements of IEC 61210 do not apply.

*Compliance is checked by applying an appropriate receptacle on each **tab** unless otherwise declared in 7.2. During this application, no strain nor distortion shall occur to any of the tabs nor to their adjacent parts, nor shall the creepage distance or clearance values be reduced below those specified in Clause 11.*

NOTE For **tabs** complying with Figure 15 or Figure 16, the appropriate **receptacle** is shown in Figure 17.

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8.3 Terminals and terminations for integrated conductors

There are no specific requirements or tests for terminals or terminations for **integrated conductors** under Clause 8, but the relevant requirements of the other clauses can apply.

9 Constructional requirements

9.1 Materials

9.1.1 Insulating materials – Impregnated

Wood, cotton, silk, ordinary paper and similar fibrous or hygroscopic material shall not be used as insulation unless impregnated.

Compliance is checked by inspection.

NOTE Insulating material is considered to be impregnated if the interstices between the fibres of the materials are substantially filled with a suitable insulant.

9.1.2 Current-carrying parts

If brass is used for current carrying parts other than threaded parts of terminals, it shall contain at least 50 % copper if the part is cast or made from bar, or at least 58 % if the part is made from rolled sheet.

Compliance is checked by inspection, comparing the requirement with the manufacturer's specification or by analysis of the material

9.1.3 Non-detachable cords

9.1.3.1 **Non-detachable cords** of **class I controls** shall have a green/yellow insulated conductor which is connected to the earthing terminal or **termination** of the **control**, or to the earthing contact of any equipment inlet or socket-outlet, if provided.

9.1.3.2 Conductor with insulation identified by the colour combination green/yellow shall not be connected to terminals or **terminations** other than earthing terminals or **terminations**.

Compliance with 9.1.3.1 and 9.1.3.2 is checked by inspection.

9.1.4 Intentionally weak traces

Intentionally weak traces shall be used only to protect against hazards caused by failure of components included in Table 14.

9.2 Protection against electric shock

9.2.1 Double insulation

When **double insulation** is employed, the design shall be such that the **basic insulation** and the **supplementary insulation** can be tested separately unless satisfaction with regard to the properties of both insulations is provided in another way.

If the **basic insulation** and the **supplementary insulation** cannot be tested separately, or if satisfaction with regard to the properties of both insulations cannot be obtained in another way, the insulation is regarded as **reinforced insulation**.

Compliance is checked by inspection and by test.

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NOTE Specially prepared samples, or samples of the insulating parts, are regarded as ways of providing satisfaction.

9.2.2 Infringement of double insulation or reinforced insulation

Class II controls and **controls** for use in class II equipment shall be so designed that **creepage distances** and **clearances** over **supplementary insulation** or **reinforced insulation** cannot, as a result of wear, be reduced below the values specified in Clause 11. They shall be so constructed that if any wire, screw, nut, washer, spring, flat push-on **receptacle** or similar part becomes loose and falls out of position, it cannot in **normal use** become so disposed that **creepage distances** or **clearances** over **supplementary insulation** or **reinforced insulation** are reduced to less than 50 % of the value specified in Clause 11.

For the purpose of this requirement:

– *it is not to be expected that two independent fixings will become loose at the same time;*

– *parts fixed by screws or nuts provided with a locking washer are regarded as not liable to become loose, provided these screws or nuts are not required to be removed during **user maintenance** or **servicing**;*

– *springs and spring parts that do not become loose or fall out of position during the tests of Clauses 19 and 20 are deemed to comply;*

– *wires connected by soldering are considered to be not adequately fixed unless they are mechanically fixed in place near to the **termination**, independently of the solder;*

– *wires connected to terminals are considered to be not adequately secured unless an additional fixing is provided near to the terminal. This additional fixing, in the case of stranded conductors, shall clamp the insulation and not the conductor;*

– *short rigid wires are regarded as not liable to come away from a terminal if they remain in position when any one terminal screw or nut is loosened.*

Compliance is checked by inspection, by measurement and/or by manual test.

9.2.3 Integrated conductors

9.2.3.1 **Integrated conductors** shall be so rigid, so fixed or so insulated that in **normal use creepage distances** and **clearances** cannot be reduced below the values specified in Clause 11.

9.2.3.2 Insulation, if any, shall be such that it cannot be damaged during mounting or in **normal use**.

Compliance with 9.2.3.1 and 9.2.3.2 is checked by inspection, by measurement and by manual test.

NOTE If the insulation on a conductor is not at least electrically equivalent to that of cables and flexible cords complying with the appropriate IEC standard, or alternatively does not comply with the electric strength test made between the conductor and metal foil wrapped around the insulation under the conditions specified in Clause 15, the conductor is considered to be a bare conductor.

9.2.4 Flexible cord sheaths

Inside a **control**, the sheath (jacket) of a flexible cable or cord shall be used as **supplementary insulation** only where it is not subject to undue mechanical or thermal stresses, and if its insulating properties are not less than those specified in IEC 60227-1 or IEC 60245-1.

Compliance is checked by inspection, and, if necessary, by testing the sheaths of the flexible cords according to IEC 60227-1 or IEC 60245-1.

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9.2.5 Protective impedance

Protective impedance shall consist of two or more impedance components of equivalent resistance values in series, which are connected between **live parts** and **accessible parts**. It shall consist of components in which the probability of a reduction in impedance during life can be ignored and the possibility of a short circuit is negligible.

Such components are

– *Resistors detailed in Table 14, footnote c.*

Alternatively, the resistors shall comply with the requirements of IEC 60065:2014, 14.2.

– *Capacitors.*

Capacitors shall comply with IEC 60384-14, class Y.

The use of only one Y1 capacitor is permitted where the capacitor complies with IEC 60384-14 appropriate to the **working voltage** of application where it is used.

Compliance is checked by

a) *open-circuiting each impedance component in turn;*
b) *short-circuiting of those impedance components which are likely to fail by a short circuit (according to 13.1);*
c) *applying a **fault** condition according to 13.1 to any part of the circuit which might influence the maximum **touch current** with the **protective impedance** intact.*

   *Operation of a protective device or loss of one pole of the supply shall also be considered as **faults**.*

Under these conditions, the equipment shall still comply with the requirements of 6.1.9.

9.2.6 Protection against electric shock by use of SELV or PELV

See Annex P.

9.2.7 Connections between internal and external SELV/PELV circuits

Adequate measures shall be provided to prevent the interconnection of an integrated **SELV** circuit to an external **PELV** circuit and vice versa.

The supply of a **class III control** from an external **SELV** source by means of a separable connection shall only be possible by means of a dedicated plug and socket **system** which cannot be fitted or interconnected with other connecting **systems**.

Compliance is checked by inspection.

9.2.8 Overcurrent protection

Controls shall be capable of carrying the currents likely to flow in abnormal conditions for such periods of time as are determined by the characteristics of the overcurrent protective device. For **integrated controls** or **incorporated controls**, if the overcurrent protective device is external to the control, it shall be declared in Table 1, requirement 68.

Compliance is checked by the test of 26.2.

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9.3 Actuation and operation

9.3.1 Full disconnection

Controls with positions declared as **full disconnection** shall be so designed that in the declared positions there is contact separation in all supply poles other than earth, at least equal to the relevant values specified in Clause 11. The contact separation can be obtained by automatic action or by manual action, but any subsequent automatic action shall not cause any contact separation to be reduced below the specified minimum.

If the disconnection is also declared to provide **all-pole disconnection**, the contact **operation** in each supply pole shall be practically simultaneous.

Compliance is checked by inspection and by the tests of Clauses 15 and 11, where necessary.

9.3.2 Micro-disconnection

Controls with positions declared as **micro-disconnection** shall be so designed that in the declared positions there is contact separation in at least one supply pole to meet the electric strength requirements of Clause 15 but no **clearance** dimension is specified. The contact separation can be obtained by **automatic action** or by **manual action**, but any subsequent change of **activating quantity** between the limits declared in Table 1, requirement 30, or at any **switch head** temperature between the limits declared in Table 1, requirement 15, shall not cause an **operation** which would reduce the contact separation such that the requirements of Clause 15 are no longer met.

Compliance is checked by inspection and, where necessary, by the tests of Clause 15 carried out at the temperature limits declared.

9.3.3 Reset buttons

Reset buttons of **controls** shall be so located or protected that they are not likely to be accidentally reset.

This requirement does not apply to manual reset **controls** with **trip-free** actions.

Compliance is checked by inspection.

NOTE This requirement precludes, for example, reset buttons mounted in such a position that they can be reset by pushing the **control** against a wall, or by pushing a piece of furniture against the **control**.

9.3.4 Setting by the manufacturer

Parts used for the **setting** of **controls** by the manufacturer shall be secured to prevent accidental shifting after **setting**.

Compliance is checked by inspection.

9.3.5 Contacts

9.3.5.1 General

Contacts with a DC rating greater than 0,1 A, which can be operated by **actuation**, shall be so designed that the speeds of approach and separation of the contact surfaces are independent of the speed of **actuation**.

Compliance is checked by inspection.

NOTE This requirement does not apply to contacts excluded by 9.3.7.

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9.3.5.2 Systems of class C control functions

9.3.5.2.1 **Systems** of **class C control functions** shall include at least two switching elements to directly de-energize the safety relevant terminals.

NOTE A single relay operating two independent contacts is considered to be only one switching element.

– To prevent common cause errors, measures shall be taken to protect against **failure** of two (or more) switching elements, due to a common cause, by an external short circuit that would prevent the **control** from performing a **safety shut-down**.

Acceptable methods are, for example,

– overcurrent protection device,

– current limitation or

– internal **fault** detecting means.

The suitability of measures to maintain the capability to interrupt the energization of the safety related output terminals by means of at least one switching element or the interruption of an overcurrent protection device shall be verified by the following test.

The safety related output terminals of the control are connected to a switch that is intended to switch the short-circuit current. With this switch opened, the control is connected as described in 13.1.3 with the outputs energized to simulate normal operation (contacts of the internal switching elements closed).

The test equipment shall have the following characteristics:

a) when overcurrent protection devices are used as the protective measure, the power supply to the **control** shall have the capability of supplying a short-circuit current of at least 500 A.

b) when current limitation techniques are used as the protective measure (for example, transformer), the power supply to the **control** shall not limit the declared (Table 1*,* requirement 67) short-circuit current.

9.3.5.2.2 A short-circuit is applied between the safety related output terminals of the **control** by closing the switch.

The test is operated for 1 h or until there is no current flow through the switch, whichever occurs first.

*If an overcurrent protection device is replaceable and has operated during the test, it shall be replaced and the test is repeated a further two times by attempting to restart the **control** keeping the switch closed.*

The test is repeated using either the same or a separate sample with the switch maintained in the closed position prior to the first start-up sequence.

9.3.5.2.3 If an internal **fault** detecting function of the **control** either opens the switching elements or initiates a **safety shut-down**, the test is repeated two times by attempting to restart the **control** while maintaining the external short circuit.

Compliance is checked in accordance with 13.1.3.8 and Clause H.17.

*After the test, at least one switching element of the **control** shall be able to de-energize the safety related output terminals, or a non-replaceable overcurrent protection device has permanently interrupted the supply to the safety related output terminals.*

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9.3.6 Contacts for full disconnection and micro-disconnection

Contacts for **full disconnection** and contacts for **micro-disconnection**, having either a DC rating not greater than 0,1 A, or an AC rating, and which can be operated by **actuation**, shall be so designed that they can come to rest only in a closed position or in an open position.

*Compliance is checked by inspection, and for a closed position by the temperature requirements of Clause 16, and for open position by the requirements of Clause 15, as specified for **micro-disconnection**. However, where an **intermediate position** of the **actuating member** occurs adjacent to a **located position** declared as **full disconnection**, then the tests of Clauses 15 and 11, as specified for **full disconnection**, are made for this **intermediate position**.*

9.3.7 Exclusions for 9.3.5.1 and 9.3.6

9.3.7.1 The requirements of 9.3.5.1 and 9.3.6 shall not apply to contacts where inspection shows they cannot be operated on-load or are not intended to be operated on-load, nor to contacts which do not arc under conditions of **normal use**.

Compliance is checked by inspection, and if necessary by the test of 9.3.7.2.

9.3.7.2 *A DC voltage equal to the maximum **working voltage** is applied to the contacts in series with a resistor such that the current occurring in **normal use** is obtained. It shall not be possible to maintain an arc by slowly opening the contacts.*

9.3.8 Contacts rest position

Contacts shall, in any rest position of the **actuating member**, be either open or closed as intended, or such that no **hazard** can occur within the control or equipment.

Compliance is checked by inspection.

NOTE 1 The term "rest position of the **actuating member**" includes located, intermediate and position of **setting by the user**.

NOTE 2 For the purposes of trying to obtain an **intermediate position** of an **actuating member**, between any indexed, marked, or intended rest positions, the **actuating member** can be actuated as in **normal use**. Holding the **actuating member** in position is not **actuation**.

9.3.9 Pull-cord actuated control

A **pull-cord actuated control** shall be so designed that when the **pull-cord** is released after actuating the **control**, the relevant parts of the mechanism normally cannot fail to return to a position from which they allow the immediate performance of the next movement in the cycle of **actuation** of the **control**.

Compliance is checked by inspection and by the following test.

***Pull-cord actuated controls** can be actuated from any **located position** to the next **located position** by the application and removal of a steady pull not exceeding 45 N vertically downwards, or 70 N at 45° to the vertical, with the **control** mounted in any declared manner.*

NOTE The actuating forces for **controls** actuated by other than **pull-cords**, are not specified. Attention is drawn to the relevant equipment standard where such requirements are given.

9.3.10 See J.9.3.10.

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9.4 Actions

9.4.1 Combined actions

A **control** having more than one action, with one of the actions designed to operate after the **failure** of the other action(s), shall be so constructed that this action remains operative after **failure** of any portion unique to the other action(s).

Compliance is checked by inspection and, if necessary, by tests after making all of the other action(s) inoperative.

9.4.2 Setting by the manufacturer

Type 2 action which has provision for setting by the manufacturer of its operating value, operating time or operating sequence, shall be designed such that it is clearly discernible if any subsequent interference with the setting has been made.

Compliance is checked by inspection.

9.4.3 Type 2 action

Any **type 2 action** shall be so designed that the **manufacturing deviation** and **drift** of its **operating value**, **operating time** or **operating sequence** is within the limit declared in Table 1, requirements 35 and requirement 36.

Compliance is checked by the tests of Clauses 17 to 19 inclusive.

9.4.4 Type 1.A or 2.A action (Full disconnection on operation)

Type 1.A or 2.A action shall operate to provide the **clearances** and electric strength requirements specified for **full disconnection**.

Compliance is checked by the tests of Clause 15 and the relevant requirements of Clause 11.

9.4.5 Type 1.B or 2.B action (Micro-disconnection on operation)

A Type 1.B or 2.B action shall operate to provide the electric strength requirements specified for **micro-disconnection**.

Compliance is checked by the test of Clause 15 and the relevant requirements of Clause 11.

9.4.6 Type 1.C or 2.C action (Micro-interruption on operation)

A Type 1.C or 2.C action shall operate to provide circuit interruption by **micro-interruption**.

Compliance is checked by the relevant requirements of Clause 11.

9.4.7 Type 1.D or 2.D action (a trip-free mechanism which cannot even momentarily be reclosed against the fault)

A Type 1.D or 2.D action shall be so designed that disconnection can neither be prevented nor inhibited, by any reset mechanism and so that after disconnection, it is not possible to reclose the circuit even momentarily while the excess or **fault** condition persists.

Compliance is checked by inspection and by test.

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9.4.8 Type 1.E or 2.E action (a trip-free mechanism in which the contacts cannot be prevented from opening or maintained closed against a continuation of the fault)

A Type 1.E or 2.E action shall be designed so that disconnection can neither be prevented, nor inhibited by any reset mechanism and so that the contacts can neither be prevented from opening nor be maintained closed against a continuation of the excess or **fault** condition.

EXAMPLE A current-**sensing control** which has to be reclosed or can be reclosed momentarily to detect that the excess current **fault** still exists.

Compliance is checked by inspection and by test.

9.4.9 Type 1.F or 2.F action (an action which can only be reset by the use of a tool)

A Type 1.F or 2.F action shall be designed so that after the **control** has been mounted in accordance with the manufacturer's instructions, it can only be reset with the aid of a **tool**.

Compliance is checked by inspection.

NOTE Mounting within an equipment such that a **tool** is required to gain access to the **control** is deemed to satisfy this requirement.

9.4.10 Type 1.G or 2.G action (an action which is not intended to be reset under electrically loaded conditions)

A Type 1.G or 2.G action shall be designed so that after the **control** has operated, it is possible to reset the **control** (although not intended) under electrically loaded conditions.

Compliance is checked by inspection and by resetting once at rated voltage and rated current.

9.4.11 Type 1.H or 2.H action (a trip-free mechanism in which the contacts cannot be prevented from opening and which can automatically be reset to the "closed" position after normal operation conditions have been restored if the reset means is held in the "reset" position)

A Type 1.H or 2.H action shall be so designed that the contacts cannot be prevented from opening and which can automatically reset to the closed position if the reset means is held in the reset position. The **control** shall not reset automatically at any temperature above –35 °C with the reset mechanism in the normal position.

Compliance is checked by inspection and by test.

NOTE The test is given in the relevant part 2.

9.4.12 Type 1.J or 2.J action (a trip-free mechanism in which the contacts cannot be prevented from opening and the control is not permitted to function as an automatic reset device if the reset means is held in the "reset" or "on" position)

A Type 1.J or 2.J action shall be so designed that the contacts cannot be prevented from opening, and the **control** is not permitted to function as an automatic reset device if the reset means is held in the reset position. The **control** shall not reset automatically at any temperature above 0 °C or –35 °C.

Compliance is checked by inspection and by test.

NOTE The test is given in the relevant part 2.

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9.4.13 Type 1.K or 2.K action (for sensing actions, no increase in the operating value as the result of a breakage in the sensing element, or in parts connecting the sensing element to the switch head)

A Type 1.K or 2.K action shall be so designed that in the event of a break in the **sensing element**, or in any other part between the **sensing element** and the **switch head**, the declared disconnection is provided before the declared **operating value**, **operating time** or **operating sequence** is exceeded.

NOTE The test is given in the relevant part 2.

9.4.14 Type 1.L or 2.L action (an action that does not require any external auxiliary energy source of electrical supply for its intended operation)

A Type 1.L or 2.L action shall be so designed that in the case of **failure** of the electrical supply, it performs its intended function independently of any external auxiliary energy source or electrical supply.

Compliance is checked by inspection.

NOTE A simple direct acting spring or weight is not regarded as an auxiliary energy source or electrical supply.

9.4.15 Type 1.M or 2.M action (an action which operates after a declared ageing period)

A Type 1.M or 2.M action shall be so designed that it operates in its intended manner after the declared ageing procedure.

Compliance is checked by the test of 19.6.

9.4.16 Type 1.Y or 2.Y (electronic disconnection on operation)

9.4.16.1 Type 1.Y or 2.Y action shall operate to provide **electronic disconnection**.

Compliance is checked according to 9.4.16.2 and 9.4.16.3.

9.4.16.2 The test is carried out with the **control** connected to its declared maximum load, supplied with rated voltage, and at temperature T_{max}.

9.4.16.3 The current through the **electronic disconnection** shall not exceed 5 mA or 10 % of the rated current, whichever is the lower.

9.4.17 See J.9.4.17.

9.5 Openings in enclosures

Drain holes, if any, shall have a minimum area of 20 mm^2, a maximum area of 40 mm^2 and minimum dimension of 3 mm.

Compliance is checked by inspection.

NOTE 1 Additional requirements for moisture resistance are contained in Clause 14.

NOTE 2 **Controls** classified as IPX7 can have a facility for opening a drain hole.

9.6 Mounting of controls

9.6.1 **Controls** shall be so designed that the methods of mounting in accordance with the manufacturer's declaration do not adversely affect compliance with this document.

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9.6.2 Declared methods of mounting shall be such that the **control** cannot rotate or be otherwise displaced, and cannot be removed from an equipment without the aid of a **tool**, if such movement or removal could adversely affect compliance with this document. If removal or partial removal is necessary for correct use of the **control**, then the requirements of Clauses 6, 15 and 11 shall be satisfied before and after removal.

Compliance with 9.6.1 and 9.6.2 is checked by inspection and by manual test.

NOTE **Controls**, other than those with rotary **actuation**, fixed by a nut and single bushing concentric with the **actuating means**, are deemed to comply with this requirement, provided that the tightening of the nut requires the use of a **tool**, and that the parts have adequate mechanical strength. An **incorporated control** mounted by screwless fixing is deemed to comply with this requirement if the use of a **tool** is required before the **control** can be removed from the equipment.

9.6.3 Mounting of independently mounted controls

9.6.3.1 **Independently mounted controls** other than those declared for panel mounting shall either:

– fit a standard box as declared;

– be supplied with a conduit box if a special conduit box is required; or

– be suitable for surface mounting on a plane surface.

9.6.3.2 If a special conduit box is required, it shall be delivered together with the **control** and the box shall be provided with the entries for conduit specified in IEC 60423.

9.6.3.3 **Independently mounted controls** for surface mounting used with buried installation (concealed wiring) not using an outlet box shall be provided with suitable holes on the back of the **control** allowing easy installation and connection to the terminals.

9.6.3.4 **Independently mounted controls** for surface mounting used with exposed wiring shall be provided with cable or conduit entries, knock-outs, or glands, which allow connection of the appropriate type of cable or conduit complying with the relevant IEC standard.

9.6.3.5 **Independently mounted controls** for surface mounting or the sub-bases for such **controls** shall be constructed in such a manner that the terminals for **external conductors** are accessible and can be used when the **control** or the sub-base is correctly fixed to its support and its **cover** (or the **control**) is removed.

9.6.3.6 **Controls** intended for mounting on an outlet box or similar enclosure shall have wiring terminals, other **live parts** and sharp-edged metal parts, earthed or not, located or protected so that they will not be forced against wiring in the box or enclosure during installation of the **control**.

9.6.3.7 Where back wiring terminals are used, they shall be recessed or be protected by close-fitting barriers or insulating materials or the equivalent that will prevent contact with wiring installed in the box.

9.6.3.8 *Compliance with 9.6.3.1 to 9.6.3.7, inclusive is checked by inspection.*

Terminals that do not project into the box beyond the plane of the front edge of the box are acceptable.

Guards provided alongside terminals and extending at least 6,5 mm beyond the terminals before wiring, with a corresponding guard between double pole mechanism, are acceptable.

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9.7 Attachment of cords

9.7.1 Flexible cords

9.7.1.1 The flexible cords of **in-line cord** and **free-standing controls** shall be capable of withstanding the flexing likely to occur in **normal use**. If a cord-guard is provided to meet this requirement, it shall not be integral with the flexible cord if **type X attachment** is used.

9.7.1.2 *Compliance is checked by subjecting the **control**, fitted with the flexible cord or range of flexible cords for which it is designed, to the test of 20.8.*

9.7.2 Cord anchorages

9.7.2.1 **Controls** other than those **integrated** and **incorporated**, intended to be connected by means of a **non-detachable cord**, shall have cord anchorages such that the conductors are relieved from strain, including twisting, where they are connected to the terminals, and that their covering is protected from abrasion. It shall be clear how the relief from strain and the prevention of twisting is intended to be effected.

9.7.2.2 Cord anchorages of **class II controls** shall be of insulating material or, if of metal, be insulated from accessible metal parts or metal foil over accessible non-metallic surfaces by insulation complying with the requirements for **supplementary insulation**.

9.7.2.3 Cord anchorages of **controls** other than those of class II shall be of insulating material or be provided with an insulating lining, if otherwise an insulation **fault** on the cord could make accessible metal parts live. This lining, if any, shall be fixed to the cord anchorage, unless it is a bushing which forms part of a cord guard provided to meet the requirements of 9.7.1.

9.7.2.4 Cord anchorages shall be so designed that:

– the cord cannot touch clamping screws of the cord anchorage, if these screws are accessible metal parts;

– the cord is not clamped by a metal screw which bears directly on the cord;

– for **type X attachment** or **type M attachment**, at least one part is securely fixed to the **control**;

– for **type X attachment** or **type M attachment**, replacement of the flexible cord does not require the use of a **special purpose tool**;

– for **type X attachment**, they are suitable for the different types of flexible cord which can be connected;

– for **type X attachment**, the design and location make replacement of the flexible cord easily possible.

9.7.2.5 For other than **type Z attachment**, makeshift methods such as tying the cord into a knot, or tying the ends with string, shall not be used.

9.7.2.6 Glands shall not be used as cord anchorages in **in-line cord controls** using **type X attachment** unless they make provision for clamping all types and sizes of cords used in 10.1.4.

9.7.2.7 Screws, if any, which have to be operated when replacing the cord, shall not serve to fix any other component, unless either the **control** is rendered inoperable or manifestly incomplete if they are omitted or incorrectly replaced, or the component intended to be fixed cannot be removed without the aid of a **tool** when replacing the flexible cord.

9.7.2.8 *Compliance with 9.7.2.1 to 9.7.2.7 inclusive is checked by inspection and by the tests of 20.9 inclusive. Integrated and **incorporated controls**, intended for the connection of flexible cords, are tested according to the relevant standard for the equipment in which they are integrated or incorporated.*

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9.8 Size of cords – non-detachable

9.8.1 **Non-detachable cords** shall be at least those of ordinary tough rubber sheathed flexible cord, designated 60245 IEC 53, or ordinary polyvinyl chloride sheathed flexible cord, designated 60227 IEC 53. The use of a flexible cord other than specified above is permissible if allowed in a particular equipment standard or for connection to external **SELV** devices (sensors/units).

Compliance is checked by inspection.

9.8.2 **Controls** fitted with **non-detachable cords** shall have a cord with conductors of a size not less than that shown in Table 7.

Table 7 – Minimum cord conductor sizes

Current in relevant circuit [a] A	**Nominal cross-sectional area** mm^2
Up to and including 6 [b]	0,75
Over 6 up to and including 10	1
Over 10 up to and including 16	1,5
Over 16 up to and including 25	2,5
Over 25 up to and including 32	4
Over 32 up to and including 40	6
Over 40 up to and including 63	10

[a] Requirements for applications greater than 63 A are under consideration.

[b] Lower values than 0,75 mm^2 are permitted for **class III controls** or if permitted in a particular equipment or installation standard.

Compliance is checked by inspection.

9.8.3 The space for the flexible cord inside the **control** shall be adequate to allow the conductors to be easily introduced and connected, and the **cover**, if any, fitted without **risk** of damage to the conductors or their insulation. It shall be possible to check that the conductors are correctly connected and positioned before the **cover** is fitted.

Compliance is checked by inspection and by connecting cords of the largest cross-sectional area used in 8.1.5.

9.9 Inlet openings

9.9.1 Inlet openings for flexible external cords shall be so designed and shaped, or shall be provided with an inlet bushing, so that the covering of the cord can be introduced without **risk** of damage.

Compliance is checked by inspection.

9.9.2 Conduit entries and knock-outs of **independently mounted controls** shall be so designed or located that introduction of the conduit or conduit fitting does not affect the protection against electric shock or reduce **creepage distances** and **clearances** below the values specified in Clause 11.

Compliance is checked by inspection.

9.9.3 If an inlet bushing is not provided, then the inlet opening shall be of insulating material.

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9.9.4 If an inlet bushing is provided, then it shall be of insulating material, and

– shall be so shaped as to prevent damage to the cord,

– shall be reliably fixed,

– shall not be removable without the aid of a **tool**,

– shall, if **type X attachment** is used, not be integral with the cord.

9.9.5 An inlet bushing shall not be of rubber, with the exception that for **type M attachment**, **type Y attachment** and **type Z attachment** for **class 0 control**, **class 0l control** or **class I control**, rubber is allowed if the bushing is integral with the sheath of a cord of rubber.

Compliance with 9.9.1 to 9.9.5 inclusive is checked by inspection and manual test.

9.9.6 Enclosures of **independently mounted controls** intended to be permanently connected to **fixed wiring** shall have cable entries, conduit entries, knockouts or glands which permit the connection of the appropriate conduit, cable or cord, as applicable.

Compliance is checked by inspection.

9.10 Equipment inlets and socket-outlets

9.10.1 The design of equipment inlets and socket-outlets intended for use by the **user** for the interconnection of **controls** and equipment shall be such as to render unlikely their engagement with each other or with equipment inlets or socket-outlets intended for other **systems** if such engagement could result in fire, or injury or electric shock to persons or damage to equipment or surroundings.

Compliance is checked by inspection.

9.10.2 **In-line cord controls** provided with an equipment inlet or socket-outlet shall be so rated, or so protected, that unintentional overloading of either the **control**, equipment inlet or socket-outlet cannot occur in **normal use**.

Compliance is checked by inspection and test of 26.2.1.

9.10.3 **Controls** provided with pins, blades, or other connecting/adapting means, in order to be introduced into fixed socket outlets shall comply with the requirements of the appropriate socket-outlet **system**.

In **in-line cord controls** provided with a plug and a socket outlet, where the plug can be connected to a socket outlet rated for a higher load current than the **control**, the **control** shall be provided with an incorporated fuse or a protective device to limit the current to the **control**'s rating. The testing of the protective function is done in the sequence of tests according to 26.2.

The plug and socket outlet part of the **control** shall comply with IEC 60884-1 and IEC 60884-2-5 or the appropriate standard for the plug and socket **system**. In addition, the **control** part shall comply with this document.

*Compliance is checked by inspection and by carrying out tests based on those prescribed for the socket-outlet **system**.*

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9.11 Requirements during mounting, use, maintenance and servicing

9.11.1 Covers and their fixing

9.11.1.1 For other than **integrated controls**, the removal of a **cover** or **cover plate**, including battery compartment **cover**, which is intended to be removed during mounting, **user maintenance** or **servicing** of the **control** or equipment, shall not affect the **setting** of the **control** if this might impair compliance with this document.

9.11.1.2 The fixing of **covers** shall be such that they cannot be displaced, nor replaced incorrectly if this could mislead the **user** or would impair compliance with this document. The fixing of **covers** which need to be removed for mounting shall not serve to fix any parts, other than **actuating members** or gaskets.

Compliance with 9.11.1.1 and 9.11.1.2 is checked by inspection.

9.11.1.3 Non-detachable parts

9.11.1.3.1 Non-detachable parts which provide the necessary degree of protection against electric shock, moisture or contact with moving parts shall be fixed in a reliable manner and shall withstand the mechanical stress occurring in **normal use**.

Snap-in devices used for fixing non-detachable parts shall have an obvious locked position. The fixing properties of snap-in devices used in parts which are likely to be removed for installation or during **servicing** shall not deteriorate.

Compliance is checked by the tests of 9.11.1.3.2 to 9.11.1.3.4.

9.11.1.3.2 Parts which are likely to be removed for installation or during **servicing** are disassembled and assembled 10 times before the test is carried out.

NOTE **Servicing** includes replacement of the supply cord.

9.11.1.3.3 For the tests of 9.11.1.3.4, the **control** shall be at room temperature. However, in cases where compliance can be affected by temperature, the test is also carried out immediately after the **control** has been operated under the conditions specified in Clause 16.

9.11.1.3.4 A force is applied for 10 s, without jerks, in the most unfavourable direction, to those areas of the **cover** or part which are likely to be weak. The force to be used shall be as follows:

– *Push force* *50 N*

– *Pull force, as follows:*

  a) *If the shape of the part is such that the fingertips cannot easily slip off* *50 N*

  b) *If the projection of the part which is gripped is less than 10 mm in the direction of removal* *30 N*

The push force is applied by means of a rigid test finger similar in dimensions to the standard test finger shown in Figure 5.

The pull force is applied by any suitable means (for example, a suction cup) so that the test results are not affected.

While the pull test of a) or b) is being applied, the test fingernail shown in Figure 6 is inserted in any aperture or joint with a force of 10 N. The fingernail is then slid sideways with a force of 10 N; it is not twisted or used as a lever.

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If the shape of the part is such that an axial pull is unlikely, no pull force is applied but the test fingernail shown in Figure 6 is inserted in any aperture or joint with a force of 10 N and is then pulled for 10 s by means of the loop with a force of 30 N in the direction or removal.

*If the **cover** or part is likely to be subjected to a twisting force, a torque as detailed below shall be applied at the same time as the pull or push force:*

– *for major dimensions up to and including 50 mm 2 Nm*
– *for major dimensions over 50 mm 4 Nm*

This torque is also applied when the test fingernail is pulled by means of the loop.

If the projection of the part which is gripped is less than 10 mm, the above torque is reduced to 50 % of the value.

9.11.1.3.5 During and after the tests of 9.11.1.3.4, parts shall not become detached and they shall remain in the locked position, otherwise they are deemed to be **detachable parts**.

9.11.1.4 A **cover**, which can be removed with one hand, shall not be released when a squeezing force of up to 45 N combined with up to 15 N for the pull test is applied at any two points, the distance between which does not exceed 125 mm, as measured by a tape stretched tightly over that portion of the surface of the **cover** which would be encompassed by the palm of the hand. The test is performed before and after 10 removal and replacement **operations**.

9.11.2 Cover fixing means

Fixing screws of **covers** or **cover plates** which need to be removed during mounting, **user maintenance** or **servicing** shall be captive.

Compliance is checked by inspection.

NOTE The use of tight-fitting washers of cardboard or similar material is deemed to meet this requirement. See 10.1.5.

9.11.3 Actuating member

9.11.3.1 A **control** shall not be damaged when its **actuating member** is mounted or removed in the intended manner.

9.11.3.2 If the maximum or minimum **setting** by the manufacturer or **setting by the user** of a **type 2 action** is limited by mechanical means associated with an **actuating member**, such **actuating member** shall not be removable without the use of a **tool**.

9.11.3.3 If an **actuating member** of a **control** with a **type 1 action** providing an "OFF" position or the **actuating member** of any **control** with a **type 2 action** is used to indicate the condition of the **control**, it shall not be possible to fix the **actuating member** in an incorrect position.

*Compliance with 9.11.3.1 to 9.11.3.3 inclusive is checked by inspection and, for **actuating members** which do not require a **tool** for their removal, by the test of 20.7.*

NOTE In certain equipment standards, an **actuating member** that is used to indicate the condition of a **control** is not permitted to have the capability of being fixed in an incorrect position.

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9.11.4 Parts forming supplementary insulation or reinforced insulation

Parts of **controls** which serve as **supplementary insulation** or **reinforced insulation** and which might be omitted during reassembly after **user maintenance** or **servicing**, shall either be fixed in such a way that they cannot be removed without being seriously damaged, or be so designed that they cannot be replaced in an incorrect position, and that, if they are omitted, the **control** is rendered inoperable or manifestly incomplete.

Compliance is checked by inspection.

NOTE Lining metal enclosures with a coating of lacquer, or with other material in the form of a coating which can be easily removed by scraping, is not deemed to meet this requirement.

9.11.5 Sleeving as supplementary insulation

Sleeving used as **supplementary insulation** on **integrated conductors** shall be retained in position by a positive means.

Compliance is checked by inspection and by manual test.

NOTE A sleeve is considered to be fixed by a positive means if it can only be removed by breaking or cutting, or if it is clamped.

9.11.6 Pull-cords

Pull-cords shall be insulated from **live parts** and the **control** shall be so designed that it is possible to fit or to replace the **pull-cord** without **live parts** becoming accessible.

Compliance is checked by inspection.

9.11.7 Insulating linings

Insulating linings, barriers and the like shall have adequate mechanical strength and shall be secured in a reliable manner.

Compliance is checked by inspection.

9.12 Controls using software

See H.9.12.

9.12.1 Requirements for the architecture

See H.9.12.1.

9.12.2 Measures to control faults/error

See H.9.12.2.

9.12.3 Measures to avoid errors

See H.9.12.3.

9.12.4 Remotely actuated control functions

9.12.4.1 Remotely actuated control functions can be connected to separate, independent devices, which can themselves contain control functions or provide other information. Remotely actuated control functions can either be safety critical or non-safety critical based on the application as listed below.

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a) The following conditions are considered safety critical since they can impair the safety of the control or appliance:

   1) If software is downloaded or data exchanged that are part of a **class B** or **class C control function**.

   2) If software is downloaded or data exchanged, that includes parametric changes (e.g. constants, algorithms, timing used for normal operation) that can impair the compliance criteria of the document due to unauthorized modification or transmission errors.

      EXAMPLE A downloaded software or parameter set which regulates or limits the maximum normal temperature rises in Clause 16.

   3) If software is downloaded, which only affects that part of the software which is not covered by the above cases 1) or 2), but where compliance with the document can be impaired due to improper separation or partitioning from the software or data as it relates to conditions 1) or 2).

b) Any downloaded software or data that meets the criteria of any item in a) shall comply with H.9.12.4.

c) Types of remote communication (software download or data exchange) not listed in a) are considered not to impair compliance with the document, therefore no additional requirements are specified. Examples are lised below:

   – controls providing **remote communication** and/or **remote operation,** where all measures to comply with the document are independent of software,

   – controls using **remote communication** through **public networks** for the send only transmission of data,

   – controls which only provide event driven or push remote monitoring.

9.12.4.2 Data exchange

9.12.4.2.1 General

Remotely actuated control functions can be connected to separate, independent devices, which can themselves contain **control** functions or provide other information. Any data exchange between these devices shall not compromise the integrity of **class B control function** or **class C control function**.

9.12.4.2.2 Type of data

Message types for data exchange in a **control** function or functions shall be allocated to **class A control function**, **class B control function** or **class C control function**. Regarding the safety or protective relevance or influence, message types or data exchange shall be allocated only to **class B control function** or **class C control functions**, see Table 8.

Table 8 – Data exchange

Data	Safety relevant	Non safety relevant
Operating data	Messages such as "RESET from safe state"	Messages such as on/off instructions, room temperature information
Configuration parameters	Messages modifying parameters that determine related **class B control function** or **class C control function**	Messages modifying parameters that determine performance related functions
Software modules	Modules downloaded into a **system**, that determine related **class B control function** or **class C control function**	Modules downloaded into a **system**, that determine performance related functions

9.12.4.2.3 Communication of safety related data

See H.9.12.4.2.3.

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9.12.4.2.4 Duration or limits of operation

For the operation of **remotely actuated control function**, the duration or limits of operation shall be set before switching on, unless an automatic switching off is realized at the end of a cycle or the **system** is designed for permanent operation (operation for longer than 24 h without interruption or new cycle).

*Compliance is checked by software **inspection**.*

9.12.4.3 Priority of control functions

Care shall be taken that priority over **control** functions shall not lead to a hazardous condition.

*Compliance is checked by **inspection**.*

9.12.4.4 Remote reset action

9.12.4.4.1 The remote reset action shall be manually initiated. When the reset function is initiated by a hand-held device, at least two manual actions are required to activate a reset.

NOTE The two **manual actions** are considered to be discrete and separate.

9.12.4.4.2 **Reset** functions shall be capable of resetting the **system** as intended.

9.12.4.4.3 Unintended resets from safe state shall not occur.

9.12.4.4.4 Any **fault** of the **reset** function shall not cause the **control** or controlled function to result in a hazardous condition. In such a case, the **reset** function shall comply with the class B requirements, see H.13.2.2.

9.12.4.4.5 For **reset** functions initiated by manual action not in visible sight of the appliance, the following additional requirements apply:

- the actual status and relevant information of the process under control shall be visible to the **user** before, during and after the reset action;
- the maximum number of reset actions within a time period shall be declared (for example, 5 actions within a time span of 15 min). Following this, any further reset shall be denied unless the appliance is physically checked.

9.12.4.4.6 For **integrated controls** and **incorporated controls**, the reset function shall be evaluated in the final application.

NOTE 1 Remote **reset** requirements are dictated by the end product requirements (example – the boiler standard).

NOTE 2 Not all types of remote **reset** functions will be suitable for some applications.

If the reset is activated by manual switching of a device, this function shall be specified by the manufacturer and be suitable in the final application.

9.12.4.4.7 **Independently mounted controls** performing remote **reset** functions shall be tested for a minimum 1 000 reset actions. For integrated and incorporated devices, unless otherwise specified, the minimum reset cycles shall be declared by the manufacturer. After the test, the reset device shall be capable to reset the **system** as intended. Unintended **resets** shall not occur.

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9.13 Protective controls and components of protective control systems

9.13.1 Protective controls

Protective controls shall

– be so designed and constructed as to be reliable and suitable for their intended duty and take into account the maintenance and testing requirements of the devices, where applicable,

– be independent of other functions, unless their safety function cannot be affected by such other functions,

– comply with appropriate design principles in order to obtain suitable and reliable protection.

These principles include, in particular, fail-safe modes, redundancy, diversity, and self-diagnosis.

Compliance is checked by carrying out the relevant tests specified in this document and the appropriate part 2.

9.13.2 Pressure limiting devices

These devices shall be so designed that the pressure will not permanently exceed the maximum allowable pressure of the controlled application; however, a short duration pressure surge of no more than 10 % of the maximum allowable pressure is acceptable, where appropriate, or where not specified in the relevant standard for the controlled application.

9.13.3 Temperature monitoring devices

These devices shall have an adequate response time on safety grounds, consistent with measurement function.

9.13.4 Batteries

9.13.4.1 **Controls** containing batteries shall be designed to reduce the **risk** of fire, explosion and chemical leaks under normal conditions and after a single **fault** in the **control**. For **user**-replaceable batteries, the design shall reduce the likelihood of reverse polarity installation if this would create a **hazard**.

9.13.4.2 Battery circuits designed for a total battery capacity > 1 000 mAh shall be designed so that

– the output characteristics of a battery charging circuit are compatible with its rechargeable battery; and

– for non-rechargeable batteries, discharging at a rate exceeding the battery manufacturer's recommendations, and unintentional charging, are prevented; and

– for rechargeable batteries, charging and discharging at a rate exceeding the battery manufacturer's recommendations, and reversed charging, are prevented; and

– replaceable batteries shall either

  - have contacts that cannot be shorted with the test finger (Figure 5); or
  - be inherently protected to avoid creating a **hazard** within the meaning of the document.

NOTE Reversed charging of a rechargeable battery occurs when the polarity of the charging circuit is reversed, aiding the discharge of the battery.

9.13.4.3 If a battery with a capacity > 1 000 mAh contains liquid or gel electrolyte, a battery tray shall be provided that is capable of retaining any liquid that could leak as a result of internal pressure build-up in the battery. The requirement to provide a battery tray does not apply if the construction of the battery is such that leakage of the electrolyte from the battery is unlikely.

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NOTE An example of a battery construction where leakage of the electrolyte is considered to be unlikely is the sealed **cell** valve-regulated type.

If battery tray is required, its capacity shall be at least equal to the volume of electrolyte of all the **cells** of the battery, or the volume of a single **cell** if the design of the battery is such that simultaneous leakage from multiple **cells** is unlikely.

NOTE If several **cells** (for example, the six **cells** in a 12 V lead-acid battery) are in a single casing, its fracture could lead to a greater volume of leakage than from a single **cell**.

9.13.4.4 *Compliance with 9.13.4.1 to 9.13.4.3 is checked by inspection and by evaluation of the data provided by the **equipment manufacturer** and battery manufacturer.*

When appropriate data is not available, compliance is checked by the test of a) to e) and 9.13.4.5. 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.

*Non-rechargeable batteries are subjected to the tests of a) and d). The battery used for the tests shall be a new non-rechargeable battery as provided with, or recommended by the manufacturer for use with, the **control**.*

*Rechargeable batteries are subjected to the tests of b) to d). The battery used for the tests shall be a new fully charged rechargeable battery as provided with, or recommended by the manufacturer for use with, the **control**.*

NOTE Some of the tests specified can be hazardous to the persons carrying them out; it is suggested that all appropriate measures to protect personnel against possible chemical or explosion **hazards** be taken.

a) Unintentional charging of a non-rechargeable battery: The battery is charged while briefly subjected to the simulation of any single component **failure** that is likely to occur in the charging circuit and that would result in unintentional charging of the battery. To minimize testing time, the **failure** is chosen that causes the highest charging current. The battery is then charged for a single period of 7 h with that simulated **failure** in place.

b) Overcharging of a rechargeable battery: The battery is charged under each of the following conditions in turn.

   1) The battery charging circuit is adjusted with the battery disconnected to give 106 % of the rated output voltage of the charger, or the maximum charging voltage available from the charger (without simulation of **faults**), whichever is the higher attainable value. The battery is then charged for 7 h.

   2) The battery charging circuit is adjusted, with the battery disconnected, to 100 % of the rated output voltage of the charger. The battery is charged while briefly subjected to the simulation of any single component **failure** that is likely to occur in the charging circuit and that results in overcharging of the battery. To minimize testing time, the **failure** is chosen that causes the highest overcharging current. The battery is then charged for a single period of 7 h with that simulated **failure** in place.

c) Reverse charging of a rechargeable battery: The battery is reverse charged while briefly subjected to the simulation of any single component **failure** that is likely to occur in the charging circuit and that would result in reverse charging of the battery. To minimize testing time, the **failure** is chosen that causes the highest reverse charging current. The battery is then reverse charged for a single period of 7 h with that simulated **failure** in place.

d) Excessive discharging rate of a rechargeable or non-rechargeable battery: The battery is subjected to rapid discharge by open-circuiting or short-circuiting any current-limiting or voltage-limiting components in the load circuit of the battery under test.

e) Compliance with the tests of a) to d) shall not result in any of the following:

   – chemical leaks caused by cracking, rupturing or bursting of the battery jacket, if such leakage could adversely affect required insulation; or

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- spillage of liquid from any pressure relief device in the battery, unless such spillage is contained by the **control** without **risk** of damage to the insulation or **harm** to the **user**; or
- explosion of the battery, if such explosion could result in injury to a **user**; or
- emission of flame or expulsion of molten metal to the outside of the **control** enclosure.

9.13.4.5 After completion of the tests of 9.13.4.4 a) to 9.13.4.4 d), the equipment is subjected to the electric strength tests of 15.2.

9.13.5 Smart enabled controls

9.13.5.1 A **smart enabled control** shall be so designed that the external communication signals (data or power demand) do not unintentionally override the operating parameters of a **type 2 action control** nor interfere with any protective function of the **control**.

A **smart enabled control** is permitted to alter the operating parameters of a **control** with **type 2 action** within defined limits so long as the protective functions remain intact.

9.13.5.2 A **smart enabled control** that integrates operating and protective functions shall be evaluated as a **protective control**.

9.13.5.3 Any transmitter or communication module that is external to the **control** and acts as the interface between the **control** and the telecommunication network shall comply with IEC 62151 or IEC 62368-1. Nevertheless, the measures to ensure protection against electric shock in this document (e.g. Annex P) shall be met.

9.13.5.4 Any transmitter or communication module that is part of the **smart enabled control** shall comply with the requirements of this document.

9.13.5.5 Compliance of 9.13.5 is checked by evaluating the **control** in accordance with the requirements of 13.1 and other relevant requirements of this document.

10 Threaded parts and connections

10.1 Threaded parts moved during mounting or servicing

10.1.1 Threaded parts, electrical or otherwise which are likely to be operated while the **control** is being mounted or during **servicing** shall withstand the mechanical stresses occurring in **normal use**.

NOTE Threaded parts which are operated while the **control** is being mounted, or during **servicing**, include items such as terminal screws, cord anchorage screws, fixing and mounting screws, nuts, threaded rings and **cover plate** screws.

10.1.2 Such parts shall be easily replaceable if completely removed.

NOTE Constructions which restrict the complete removal of a threaded part are deemed to meet this requirement.

10.1.3 Such threaded parts shall have a metric ISO thread or a thread of equivalent effectiveness.

NOTE SI, BA and Unified threads are deemed to be of equivalent effectiveness to a metric ISO thread.

10.1.4 If such a threaded part is a screw and if it generates a thread in another part, it shall not be of the thread cutting type. It can be of the thread forming (swaging) type. There is no requirement for the type of thread so produced.

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10.1.5 Such screws can be of the space threaded type (sheet metal), if they are provided with a suitable means to prevent loosening.

NOTE Suitable means to prevent loosening of space threaded screws include a spring nut, or other component of similar resilience, or a thread of resilient material.

10.1.6 Such threaded parts shall not be of non-metallic material if their replacement by a dimensionally similar metal screw could impair compliance with Clause 15 or 11.

10.1.7 Such screws shall not be of metal which is soft or liable to creep such as zinc or aluminium.

This requirement is not applicable to parts used either as a **cover** to limit access to **setting** means, or as **setting** means such as flow or pressure adjusters in gas **controls**.

10.1.8 Such screws operating in a thread of non-metallic material shall be such that the correct introduction of the screw into its counterpart shall be ensured.

NOTE The requirement for the correct introduction of a metal screw into a thread of non-metallic material can be met if the introduction of the screw in a slanting manner is prevented, for example, by guiding the screw or part to be fixed by a recess in the female thread, or by the use of a screw with the leading thread removed.

10.1.9 Such threaded parts transmitting contact pressure and having a nominal diameter less than 3 mm, shall screw into metal. If they are of non-metallic material, they shall have a nominal diameter of at least 3 mm, and shall not be used for any electrical connection.

10.1.10 Compliance with 10.1.1 to 10.1.9 inclusive is checked by inspection and by the test of 10.1.11 to 10.1.15, inclusive.

10.1.11 Threaded parts are tightened and loosened:

– *10 times if one of the threaded parts is of non-metallic material, or*

– *five times if both parts are of metallic material.*

10.1.12 *Screws in engagement with a thread of non-metallic material are completely removed and reinserted each time. When testing terminal screws and nuts, a conductor of the largest cross-sectional area used in 8.1.5 or of the minimum cross-sectional area specified in 8.2.1 is placed in the terminal.*

10.1.13 *The shape of the screwdriver should suit the head of the screw to be tested.*

10.1.14 *The conductor is moved each time the threaded part is loosened. During the test, no damage impairing the further use of the threaded parts shall occur, such as breakage of screws or damage to the slot head or washers.*

10.1.15 *The test is made by means of a suitable test screwdriver, spanner or key, applying a torque, without jerks, as shown in Table 9.*

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Table 9 – Threaded parts torque test values

Nominal diameter of thread mm	Torque Nm		
	I	II	III
Up to and including 1,7	0,1	0,2	0,2
Over 1,7 up to and including 2,2	0,15	0,3	0,3
Over 2,2 up to and including 2,8	0,2	0,4	0,4
Over 2,8 up to and including 3,0	0,25	0,5	0,5
Over 3,0 up to and including 3,2	0,3	0,6	0,6
Over 3,2 up to and including 3,6	0,4	0,8	0,6
Over 3,6 up to and including 4,1	0,7	1,2	0,6
Over 4,1 up to and including 4,7	0,8	1,8	0,9
Over 4,7 up to and including 5,3 [a]	0,8	2,0	1,0
Over 5,3 [a]	–	2,5	1,25

Use column I – for metal screws without heads if the screw when tightened does not protrude from the hole, or if the screwdriver access is limited to the major diameter of the screw.

Use column II – for other metal screws and for nuts:

- with a cylindrical head and a socket for a **special purpose tool**, the socket having a cross corner dimension exceeding the overall thread diameter;
- with a head having a slot or slots, the length of which exceeds 1,5 times the overall thread diameter.

– for screws of non metallic material having a hexagonal head with the dimension across flats exceeding the overall thread diameter.

Use column III – for other screws of non metallic material.

[a] Nuts and threaded rings of greater than 4,7 mm in diameter which are used for single-bush mounting are tested with a torque of 1,8 Nm, except that, for **controls** for single-bush mounting using thermoplastic materials and where there is no torque effected on the mounting for **setting** or resetting (i.e. for **thermal cut-outs**), the thread for mounting is tested with the maximum torque as declared by the manufacturer which in no case shall be less than 0,5 Nm.

10.2 Current-carrying connections and connections providing protective earthing continuity

10.2.1 Current-carrying connections and connections providing protective earthing continuity which are not disturbed during mounting or **servicing** and the efficiency or security of which is maintained by the pressure of a screw, threaded part, rivet or the like shall withstand the mechanical, thermal and electrical stresses occurring in **normal use**.

10.2.2 Such current-carrying connections which are also subject to torsion in **normal use**, (that is, having parts integral with or connected rigidly to **screw terminals**, etc.) shall be locked against any movement which could impair compliance with Clauses 15 or 11.

NOTE 1 The requirement regarding being locked against movement does not imply that the current-carrying connection shall be so designed that rotation or displacement is prevented, provided that any movement is appropriately limited and does not bring about non-compliance with this document.

NOTE 2 Connections made with one screw, rivet or the like are sufficient if the parts are themselves prevented from making such movement by mechanical interaction between parts or by the provision of spring washers or the like.

NOTE 3 Connections made with one rivet with a non-circular or notched shank corresponding to appropriately shaped holes in the current-carrying parts are considered to meet this requirement. Connections made with two or more screws or rivets also meet this requirement.

NOTE 4 Sealing compound can be used if the parts so sealed are not subjected to stress during **normal use**.

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10.2.3 Such current-carrying connections shall be so designed that contact pressure is not transmitted through non-metallic material other than ceramic or other non-metallic material having characteristics no less suitable, unless there is sufficient resilience in the corresponding metal parts to compensate for any shrinkage or distortion of the non-metallic material.

NOTE The suitability of non-metallic material is considered with respect to the stability of the dimensions within the temperature range applicable to the **control**.

10.2.4 Such current-carrying connections shall not make use of space threaded screws, unless the screws clamp the current-carrying parts directly in contact with each other, and are provided with a suitable means of locking.

Space threaded screws can be used to provide protective earthing continuity if at least two such screws are used for each connection.

10.2.5 Such current-carrying connections can make use of thread cutting screws if these produce a full-form standard machine screw thread.

Thread cutting screws can be used to provide protective earthing continuity if at least two such screws are used for each connection.

10.2.6 Such current-carrying connections, whose parts rely on pressure for their correct function, shall have resistance to corrosion over the area of contact not inferior to that of brass. This requirement does not apply to parts whose essential characteristics can be adversely affected by plating such as bimetallic blades, which if not plated shall be clamped into contact with parts which have adequate resistance to corrosion. Suitable corrosion resistance can be achieved by plating or a similar process.

10.2.7 Compliance with 10.2.1 to 10.2.6 inclusive is checked by inspection. In addition, compliance with 10.2.3 and 10.2.6 is checked by an inspection of the metallic resilient parts after the tests of Clause 19 have been completed.

11 Creepage distances, clearances and distances through solid insulation

11.1 General

Controls shall be constructed so that the **clearances**, **creepage distances** and distances through solid insulation are adequate to withstand the electrical stresses that can be expected.

Printed wiring boards conforming with all of the requirements for type 2 protection as specified in IEC 60664-3 shall comply with the minimum requirements of 11.4 for solid insulation. The spacing between the conductors before the protection is applied shall not be less than the values as specified IEC 60664-3. See also Annex M.

Creepage distances and **clearances** between terminals for the connection of **external conductors** shall be not less than 2 mm, or the specified limit, whichever is the highest. This requirement does not apply to such terminals if they are only used for factory attachment of conductors or if they are used for connection in **ELV** circuits.

Creepage distances, **clearances** and distances through solid insulation in switch mode power supplies and other high frequency switching circuits where the fundamental frequency is above 30 kHz and less than 10 MHz shall be dimensioned in accordance with IEC 60664-4.

The tabulated values of Clause 11 are absolute minimum values that shall be maintained for all manufacturing conditions and through the lifetime of the equipment.

A creepage distance shall not be less than the associated clearance. The shortest creepage distance possible is equal to the required clearance.

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Compliance is checked by inspection, by measurement and by the tests of this clause.

NOTE 1 The requirements and tests are based on IEC 60664-1 from which further information can be obtained.

NOTE 2 See Annex O for guidance.

Creepage distances, **clearances** and distances through insulation shall comply

– across **protective impedance** with the requirements for **double insulation** or **reinforced insulation**;

– across each separate component of **protective impedance** with the requirements for **supplementary insulation**.

11.2 Clearances

11.2.1 **Clearances** shall not be less than the values shown in Table 11 for case A, taking into account the **pollution degree** and the **rated impulse voltage** required to serve the overvoltage categories of Table 10, except that, for **basic insulation** and **functional insulation**, smaller distances can be used if the **control** meets the impulse withstand test of 11.2.14 and the parts are rigid or held by mouldings, or if the construction is such that there is no likelihood of the distances being reduced by distortion or by movement of the parts (for example, during **operation** or during assembly), but in no case shall the **clearances** be less than the values shown in Table 11 for case B.

Compliance is checked by inspection, by measurement and, if necessary, by the test of 11.2.14.

NOTE **Controls** normally are expected to comply with the requirements for the **overvoltage category** of equipment in which they are used unless special circumstances determine other categories to be appropriate. Annex D provides guidance.

***Detachable parts** are removed. **Clearances** are measured with movable parts and parts such as hexagon nuts which can be assembled in different orientations placed in the most unfavourable position.*

*A force is applied to bare conductors and **accessible surfaces** in order to attempt to reduce **clearances** when making the measurement.*

The force is: 2 N for bare conductors;
*30 N for **accessible surfaces**.*

The force is applied by means of the test finger of Figure 5. Apertures are assumed to be covered by a piece of flat metal.

After application of the force, the clearances are measured according to methods and assumptions given in Annex B.

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Table 10 – Rated impulse voltage for equipment energized directly from the supply mains (from IEC 60664-1:2007, Table F.1)

Nominal voltage of the supply based on IEC 60038 [a] [b] V		Voltage line-to-neutral derived from nominal voltages AC or DC up to and including V	Rated impulse voltage required according to overvoltage category [c] V			
Three-phase four-wire systems [a]	Single-phase [d] systems		I	II	III	IV
		50	330	500	800	1 500
		100	500	800	1 500	2 500
	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] The first value listed is the line-to-neutral or the line-to-earth voltage and the second value listed is the line-to-line voltage.

[b] For **controls** capable of generating an overvoltage at the **control** terminals, for example, switching devices, the **rated impulse voltage** implies that the **control** shall not generate overvoltage in excess of this value when used in accordance with the relevant standard and instructions of the manufacturer.

[c] See Annex D for an explanation of **overvoltage categories** and Annex E for application guidance. **Overvoltage category** may be specified in a part 2 or in the final equipment standard.

[d] See Annex C for other supply **systems** (for example, note that some three-phase, three-wire **systems** require higher **rated impulse voltage** than three-phase four-wire **systems** of similar voltage).

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Table 11 – Clearances for insulation co-ordination (from IEC 60664-1:2007, Table F.2)

Rated impulse voltage from Table 10 [a]	Clearances in air up to 2 000 m above sea-level [b] mm							
	Case A				Case B (impulse test required – see 11.2.14)			
	Pollution degree [c]				Pollution degree [c]			
kV	1	2	3	4	1	2	3	4
0,33	0,01	0,20	0,8	1,6	0,01	0,2	0,8	1,6
0,50	0,04				0,04			
0,80	0,10				0,1			
1,5	0,5	0,5			0,3	0,3		
2,5	1,5	1,5	1,5		0,6	0,6		
4,0	3	3	3	3	1,2	1,2	1,2	
6,0	5,5	5,5	5,5	5,5	2	2	2	2
8,0	8	8	8	8	3	3	3	3

NOTE For small values of **clearances**, the uniformity of the electric field can deteriorate in the presence of **pollution**, making it necessary to increase the **clearance** values above the values of case B.

[a] For **functional insulation**, the **rated impulse voltage** is derived from the value in column III of Table 10 which covers the measured voltage across the **clearance**, unless otherwise declared and justified by the manufacturer. If the secondary winding of the stepdown transformer is earthed, or if there is an earthed screen between the primary and secondary windings, the reference for the **rated impulse voltage** for the **clearances** of **basic insulation** on the secondary side shall be one step lower than that which covers the rated input voltage of the primary side of the transformer.

The use of an isolating transformer without an earthed **protective screen** does not allow a reduction in the **rated impulse voltage**.

[b] For altitudes of more than 2 000 m above sea-level, the values for **clearances** shall be multiplied with the correction factor specified in IEC 60664-1:2007, Table A.2.

[c] An explanation of **pollution degree** is given in Annex F.

11.2.2 The **clearances** of **basic insulation** shall be sufficient to withstand the overvoltages that can be expected in use, taking into account the **rated impulse voltage**. The values of Table 11, case A apply except as permitted by 11.2.9.

Compliance is checked by measurement.

11.2.3 If the **control** is supplied from a dedicated battery which has no provision for charging from an external mains supply, the **rated impulse voltage** shall be assumed to be 71 V peak.

11.2.4 For **functional insulation**, Table 11, case A applies

– except as permitted by 11.2.9;

or

– except that **clearances** for **electronic controls** are not specified if the requirements of 13.1.3.8 are met with the **clearances** short-circuited.

11.2.5 Compliance with 11.2 is checked by measurement using the methods of measurement as given in Annex B and Figure 18.

11.2.5.1 For **controls** provided with an equipment inlet or socket-outlet, the measurements are made twice, once with an appropriate connector or plug inserted, and once without a connector or plug inserted.

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11.2.5.2 For terminals intended for the connection of **external conductors**, the measurements of such terminals are made twice, once with conductors of the largest cross-sectional area used in 8.1.5 fitted, and once without conductors fitted.

11.2.5.3 For terminals intended for the connection of **internal conductors**, the measurements of such terminals are made twice, once with conductors of the minimum cross-sectional area used in 8.2.1 fitted, and once without conductors fitted.

11.2.6 Distances through slots or openings in surfaces of insulating material are measured to metal foil in contact with the surface. The foil is pushed into corners and the like by means of the test finger shown in Figure 5, but is not pressed into openings.

11.2.7 The test finger shown in Figure 5 is applied to apertures as specified in 6.1, the distance through insulation between **live parts** and the metal foil shall then not be reduced below the values specified.

11.2.8 If necessary, a force is applied to any point on bare **live parts** which are accessible before the **control** is mounted, and to the outside of surfaces which are accessible after the **control** is mounted, in an endeavour to reduce the **creepage distances**, **clearances** and distances through insulation while taking the measurements.

The force is applied by means of the test finger shown in Figure 5 and has a value of:

– *2 N for bare **live parts***;
– *30 N for **accessible surfaces***.

Compliance is checked by measurement and by test if necessary.

11.2.9 For **basic insulation** and **functional insulation**, smaller distances are permitted if the **control** meets the impulse withstand test of 11.2.14 and the parts are rigid or held by mouldings, or if the construction is such that there is no likelihood of the distances being reduced by distortion, by movement of the parts, or during assembly, but in no case shall the **clearances** be less than the values for case B.

Compliance is checked by the test of 11.2.14.

When testing **functional insulation**, the impulse voltage is applied across the **clearance**.

NOTE When carrying out the impulse test, parts or components of the **control** can be disconnected if necessary.

a) For **micro-disconnection** and **micro-interruption**, there is no specified minimum distance for the clearance between the contacts and between those current-carrying parts where the clearance varies with the movement of the contacts.
b) For **full disconnection**, the values specified in Table 11, case A apply to parts separated by the switching element including the contacts, when the contacts are in the fully open position.

11.2.10 Clearances of **supplementary insulation** shall be not less than those specified for **basic insulation** in Table 11, case A.

Compliance is checked by measurement.

11.2.11 Clearances of **reinforced insulation** shall be not less than those in Table 11, case A but using the next higher step for **rated impulse voltage** as a reference.

NOTE For **double insulation**, where there is no intermediate conductive part between the **basic insulation** and **supplementary insulation**, **clearances** are measured between **live parts** and the **accessible surface** or accessible metal parts. The insulation **system** is treated as **reinforced insulation**.

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Compliance is checked by measurement.

11.2.12 For **controls** or portions of **controls** supplied from a transformer with **double insulation**, **clearances** of **functional insulation** and **basic insulation** on the secondary side are based on the secondary voltage of the transformer which is used as the nominal voltage of Table 10.

NOTE 1 The use of a transformer with separate windings alone does not allow a change of **overvoltage category**.

In the case of supply voltages derived from transformers without separate windings, the **rated impulse voltage** shall be determined from Table 10 based on the primary voltage for step-down transformers, and based on the maximum measured RMS value of the secondary voltage for step-up transformers.

Part 2s can specify alternative criteria for some situations, for example, high voltage ignition sources.

Annex F, Table F.2 of IEC 60664-1:2007 gives **clearance** dimensions for higher **rated impulse voltage**.

NOTE 2 See also references in Clause 12.

Compliance is checked by measurement or test if necessary.

11.2.13 For circuits having **ELV** levels which are derived from the supply by means of **protective impedance**, **clearances** of **functional insulation** are determined from Table 10 based on the maximum measured value of the **working voltage** in the **ELV** circuit.

11.2.14 The impulse voltage test, when required, is applied in accordance with IEC 60664-1:2007, 6.1.2.2.1.

Part 2s can specify environmental test conditions.

*The impulse voltage is applied between **live parts** and metal parts separated by **basic insulation** or **functional insulation**.*

NOTE In the case of **functional insulation**, parts or components of the **control** can be disconnected if necessary.

11.2.15 If the secondary of a transformer is earthed, or if there is an earthed screen between the primary and secondary windings, the **clearances** of **basic insulation** on the secondary side shall not be less than those specified in Table 11 but using the next lower step for **rated impulse voltage** as a reference.

NOTE The use of an isolating transformer without an earthed **protective screen** or earthed secondary does not allow a reduction in the **rated impulse voltage**.

For circuits supplied with a voltage lower than rated voltage, for example, on the secondary side of a transformer, **clearances** of **functional insulation** are based on the **working voltage**, which is used as the nominal voltage for Table 10.

11.3 Creepage distances

11.3.1 Creepage distances shall be based on voltage, material group and the pollution degree.

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Allocation of the material group to the proof tracking index (PTI):

– material of material group IIIb with a PTI of 100 and up to but excluding 175;
– material of material group IIIa with a PTI of 175 and up to but excluding 400;
– material of material group II with a PTI of 400 and up to but excluding 600;
– material of material group I with a PTI of 600 and over.

Materials, the PTI values of which have previously been found to comply with these material groups, are acceptable without further testing.

The PTI values refer to values obtained in accordance with IEC 60112:2020, and tested with solution A.

Detachable parts *are removed.* ***Creepage distances*** *are measured with movable parts and parts which can be assembled in different orientations placed in the most unfavourable position.*

A force is applied to bare conductors and ***accessible surfaces*** *in order to attempt to reduce* ***creepage distances*** *when making the measurement.*

The force is: 2 N for bare conductors;
30 N for ***accessible surfaces****.*

The force is applied by means of the test finger of Figure 5. Apertures are assumed to be covered by a piece of flat metal.

After application of the force, the ***creepage distances*** *are measured according to Annex B.*

11.3.2 Creepage distances for **basic insulation** shall not be less than those specified in Table 12 for the **rated voltage**, taking into account the material group and the **pollution degree**.

Compliance is checked by inspection and measurement.

11.3.3 Creepage distances for **functional insulation** shall not be less than those specified in Table 13 for **working voltage**, taking into account the material group and the **pollution degree**.

Creepage distances smaller than those specified in Table 13 are permitted, if:

– compliance with 13.1.3.8 concerning inherent safety is met, and
– for **class B** and **class C control functions**, the **fault** mode as given in Table 14 for printed wiring board is considered.

Compliance is checked by inspection and measurement.

Part 2s can specify alternative criteria for some situations, for example, high voltage ignition sources.

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Table 12 – Minimum creepage distances for basic insulation

Rated voltage up to and including V	Creepage distances [a] [b] mm											
	Pollution degree											
	Printed wiring material [c]		1	2			3			4		
	Pollution degree			Material group			Material group			Material group		
	1 [d]	2 [e]		I	II	III [f]	I	II	III [f]	I	II	III [f]
50	0,025	0,04	0,2	0,6	0,9	1,2	1,5	1,7	1,9	2,0	2,5	3,2
125	0,16	0,25	0,3	0,8	1,1	1,5	1,9	2,1	2,4	2,5	3,2	4,0
250	0,56	1	0,6	1,3	1,8	2,5	3,2	3,6	4,0	5,0	6,3	8,0
400	1	2	1,0	2,0	2,8	4,0	5,0	5,6	6,3	8,0	10,0	12,5
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0	10,0	12,5	16,0
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0	9,0	10,0	12,5	16,0	20,0
800	2,4	4	2,4	4,0	5,6	8,0	10,0	11,0	12,5	16,0	20,0	25,0

[a] Lacquered conductors of windings are considered to be bare conductors but **creepage distances** are not required to be larger than the associated **clearance** specified in Table 11.

[b] For glass, ceramics, or other inorganic insulating materials which do not track, **creepage distances** need not be greater than their associated **clearance** for the purpose of insulation co-ordination.

[c] When printed circuit boards are coated or protected in accordance with Annex L or Clause M.1 respectively and the coating or protection has a PTI of at least 175, the values specified for pollution degree 1 are permitted.

[d] Material groups I, II, IIIa and IIIb.

[e] Material groups I, II and IIIa.

[f] Material group III includes IIIa and IIIb. Material group IIIb is not permitted for application above 630 V or for application in **pollution degree** 4.

Compliance is checked by measurement.

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Table 13 – Minimum creepage distances for functional insulation

Working voltage RMS [a] V	Creepage distances [b c] mm											
	Pollution degree											
	Printed wiring material [d]		1	2			3			4		
	Pollution degree			Material group			Material group			Material group		
	1[e]	2[f]		I	II	III	I	II	III [g]	I	II	III [g]
10	0,025	0,04	0,08	0,40	0,40	0,40	1	1	1	1,6	1,6	1,6
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05	1,6	1,6	1,6
16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1	1,6	1,6	1,6
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2	1,6	1,6	1,6
25	0,025	0,04	0,125	0,5	0,5	0,5	1,25	1,25	1,25	1,7	1,7	1,7
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3	1,8	1,8	1,8
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6
100	0,1	0,16	0,25	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4
160	0,25	0,4	0,32	0,8	1,1	1,6	2	2,2	2,5	3,2	4	5
200	0,4	0,63	0,42	1	1,4	2	2,5	2,8	3,2	4	5	6,3
250	0,56	1	0,56	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	5	6,3	8	10
400	1	2	1	2	2,8	4	5	5,6	6,3	8	10	12,5
500	1,3	2,5	1,3	2,5	3,6	5	6,3	7,1	8	10	12,5	16
630	1,8	3,2	1,8	3,2	4,5	6,3	8	9	10	12,5	16	21
800	2,4	4	2,4	4	5,6	8	10	11	12,5	16	20	25

[a] For higher **working voltages**, the values of IEC 60664-1:2007, Table F.4 apply.

[b] For glass, ceramics and other inorganic materials which do not track, **creepage distances** need not be greater than their associated **clearance**.

[c] There are no requirements across **micro-interruption** other than between terminals and **terminations**. Between terminals and **terminations**, the requirements are as specified in this table.

[d] When printed circuit boards are coated or protected in accordance with Annex L or Clause M.1 respectively and the coating or protection has a PTI of at least 175, the values specified for **pollution degree** 1 are permitted.

[e] Material groups I, II, IIIa and IIIb.

[f] Material groups I, II and IIIa.

[g] Material group III includes IIIa and IIIb. Material group IIIb is not permitted for application above 630 V or for application in **pollution degree** 4.

Compliance is checked by inspection.

11.3.4 Creepage distances of **supplementary insulation** shall be not less than those appropriate for **basic insulation** taking into account the material group and the **pollution degree**.

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Compliance is checked by inspection and measurement.

11.3.5 **Creepage distances** of **reinforced insulation** shall be not less than double those appropriate for **basic insulation**, taking into account the material group and the **pollution degree**.

Compliance is checked by inspection and measurement.

11.4 Solid insulation

11.4.1 Solid insulation shall be capable of durably withstanding electrical and mechanical stresses as well as thermal and environmental influences which can occur during the anticipated life of the equipment.

11.4.2 There is no dimensional requirement for the thickness of **basic insulation** or **functional insulation**.

11.4.3 The distance through insulation for **supplementary insulation** and **reinforced insulation**, for **working voltages** up to and including 300 V, between metal parts shall not be less than 0,7 mm.

NOTE This does not imply that the distance has to be through insulation only. The insulation can consist of solid material plus one or more air layers.

For **controls** having parts with **double insulation** where there is no metal between **basic insulation** and **supplementary insulation**, the measurements are made as though there is a metal foil between the two layers of insulation.

11.4.4 The requirement of 11.4.3 does not apply if the insulation is applied in thin sheet form, other than mica or similar scaly material.

– For **supplementary insulation**, it consists of at least two layers, provided that each of the layers withstands the electric strength test of 15.2 for **supplementary insulation**.
– For **reinforced insulation**, it consists of at least three layers, provided that any two layers together withstand the electric strength test of 15.2 for **reinforced insulation**.

Compliance is checked by inspection and by test.

11.4.5 The requirement of 11.4.3 does not apply if the **supplementary insulation** or the **reinforced insulation** is inaccessible and meets one of the following criteria.

– The maximum temperature determined during the tests of Subclause 13.1 does not exceed the permissible value specified in Table 17.
– The insulation, after having been conditioned for 168 h in an oven maintained at a temperature equal to 25 K in excess of the maximum temperature determined during the tests of Clause 16, withstands the electric strength test of 15.2, this test being made on the insulation both at the temperature occurring in the oven and after cooling to approximately room temperature.

For optocouplers, the conditioning procedure is carried out at a temperature of 25 K in excess of the maximum temperature measured on the optocoupler during the tests of Subclause 13.1 and Clause 16, the optocoupler being operated under the most unfavourable conditions which occur during these tests.

Compliance is checked by inspection and by test.

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12 Components

12.1 Transformers

12.1.1 Transformers other than those used in SMPS, intended to supply power to a **SELV**-circuit or **PELV**-circuit shall be of the safety isolating type and shall comply with the relevant requirements of IEC 61558-2-6.

12.1.2 **Controls** that incorporate a transformer as the source of supply to a **SELV**-circuit or **PELV**-circuit are subjected to an output test with the primary energized at the upper limit of the rated voltage as indicated in 19.2.2, 19.2.3 a) and 19.2.3 b).

a) Under any non-capacitive conditions of loading (from no load to the short-circuiting of any or all secondary **SELV**- or **PELV**-circuit terminals) and without disturbing internal connections, the secondary output voltage shall not be greater than that defined in 3.1.5.

b) The secondary output power at the terminals to an **isolated limited secondary circuit** shall not exceed 100 VA and the secondary output current shall not exceed 8 A after 1 min of **operation** with overcurrent protection, if provided, bypassed.

12.2 Switch mode power supplies and converters

12.2.1 Requirements

12.2.1.1 If a converter or switch mode power supply is used as the source of supply to a **SELV**-circuit or **PELV**-circuit, Clause P.3 applies.

12.2.1.2 Switch mode power supplies and transformers used in switch mode power supplies shall comply with the requirements of IEC 61558-2-16 or the relevant requirements of this document.

12.2.1.3 Switch mode power supplies not covered by 12.8.2, including their peripheral circuitry, used in **electronic controls** shall comply with the tests of 12.2.2 and all of the applicable requirements of this document.

NOTE Subclause 12.2.2.11 gives the compliance criteria for the tests.

12.2.2 Overload tests for switch mode power supplies

12.2.2.1 *The Switch mode power supply circuit is connected to its rated voltage source of supply and frequency. Each output winding, or section of a tapped winding, is overloaded in turn, one at a time, while the other windings are kept loaded or unloaded, whichever load conditions of* ***normal use*** *is the least favourable.*

12.2.2.2 *The overload is carried out by connecting a variable resistor (or an electronic load) across the winding or the rectified output. The resistor is adjusted as quickly as possible and readjusted, if necessary, after 1 min to maintain the applicable overload. No further readjustments are then permitted.*

12.2.2.3 *For this test, any protective devices such as a fuse, manual reset circuit protector, thermal protector, etc. are allowed to remain in the circuit.*

12.2.2.4 *If overcurrent protection is provided by a current-breaking device, the overload test current is the maximum current which the overcurrent protection device is just capable of passing for 1 h. If this value cannot be derived from the specification, it is to be established by test.*

12.2.2.5 *If no overcurrent protection is provided, the maximum overload is the maximum power output obtainable from the power supply.*

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12.2.2.6 In case of voltage foldback, the overload is slowly increased to the point which causes the output voltage to drop by 5 %. The overload is then established at the point where the output voltage recovers and held for the duration of the test.

12.2.2.7 *The duration of the test is to be for 1 h or until ultimate results are reached.*

12.2.2.8 *The maximum open-circuit voltage of each winding (directly at the winding of the transformer or at the DC link) and the maximum load current are measured and recorded such that the maximum output power is determined.*

12.2.2.9 The maximum open-circuit voltage measurements shall be made during normal **operation** and under single component **failure**, see Table 14.

12.2.2.10 *For **SELV** applications, where the maximum open-circuit voltage measured directly at the secondary of the transformer (or at the DC link) exceeds the limits specified in 3.1.5, the measurement of the maximum output voltage of each winding is made after certain **protective impedances**. In this case, the limits shall be in accordance with 6.1.10.*

12.2.2.11 *Following each test (while still in a heated condition), the switch mode power supply is to be subjected to the electric strength test of 15.2.*

Compliance shall be in accordance with items a), b), c), d), e) and f) of 13.1.3.8.

12.3 Capacitors

Capacitors connected between two line conductors or between a line conductor and the neutral or between **hazardous live parts** and protective earth shall be in accordance with IEC 60384-14 and shall be used in accordance with its rated values.

12.4 Fuses

Fuses shall comply with the requirements of IEC 60127 series or IEC 60269 series.

12.5 Varistors

12.5.1 Varistors are used as surge protective devices, they shall be selected to withstand the impulses corresponding to the installation class (declared in Table 1, requirement 43) for which it is intended to be used.

12.5.2 Varistors connected to the supply mains shall comply with IEC 61051-1, IEC 61051-2 or IEC 61051-2-2.

12.6 Thermistors

12.6.1 If a **thermistor** is used, J.12.8.2 applies or 12.6.2 shall be met.

12.6.2 Annex J is not applicable for **thermistors** used in a circuit that meets the following requirements from a) to d) or the requirement stated in e):

a) type 1 **control** as declared in Table 1, requirement 33;

b) connected to a **SELV**/**PELV** circuit as specified in Clause P.1, or protected against the risk of electric shock through double or **reinforced insulation**, or by means of **protective impedance**;

c) low power circuit as specified in 13.1.2, or the **control** or final equipment complies with 13.1 when the **thermistor** is open or short circuited;

d) **control** with **class A control functions** as declared in Table H.1, requirement H.12;

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e) **thermistors** used in **control** functions where further measures to ensure safety are implemented within the **control**.

12.7 Relays

Relays with forcibly guided (mechanically linked) contacts shall comply with the requirements of IEC 61810-3.

12.8 Other components

12.8.1 Components other than those detailed in 12.1 to 12.7 are checked when carrying out the tests of this document.

12.8.2 For components which have previously been found to comply with a relevant IEC safety standard, to reduce the testing necessary, assessment is limited to the following:

a) the application of the component within the **control** is checked to ensure that it is covered by previous testing to the IEC safety standard;

b) testing according to this document of any conditions not covered by the previous testing to the IEC safety standard.

13 Fault assessment on electronic circuits

13.1 Fault assessment for inherent safety

13.1.1 General

Electronic controls or circuits, as specified in items a) and b) below, shall be assessed in accordance with the requirements of 13.1.3 for the effects of **failure** or malfunction of circuit components, according to the **fault** conditions specified in Table 14.

a) electronic circuits which do not comply with the requirements for a low power circuit according to 13.1.2.

b) Low-power circuits where protection against electric shock, fire **hazard**, mechanical **hazard** or dangerous malfunction in other parts of the **control** relies on the correct functioning of this circuit.

Circuits supplied by rechargeable batteries are subjected to the tests of 13.1.

Non-electronic components such as switches, relays and transformers, which are assessed according to Clause 12 or to the relevant requirements of this document, are not subjected to the tests of 13.1.

During the tests of 13.1.1, for a **control** providing **electronic disconnection** (type 1.Y or 2.Y), any **failure** of the device described in footnote l to Table 16 is permitted.

13.1.2 Low-power point measurement test

*A low-power circuit is determined as follows and further explained in Figure 3. The **control** is operated at rated voltage or at the upper limit of the rated voltage range and a variable resistor, adjusted to its maximum resistance, is connected between the point to be investigated and the opposite pole of the supply source.*

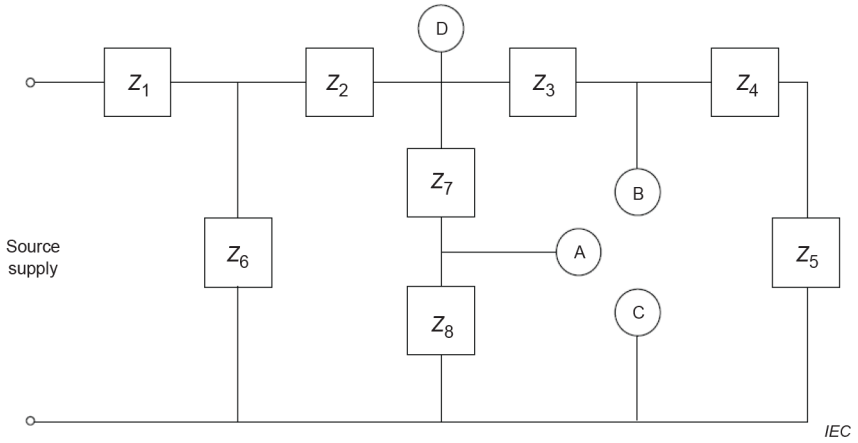
The resistance is then decreased until the power consumed by the resistor reaches a maximum. Any point nearest to the supply and at which the maximum power delivered to this resistor does not exceed 15 W at the end of 5 s is called a low-power point. The part of the circuit farther from the supply source than a low-power point is considered to be a low-power circuit.

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The measurements are made from only one pole of the supply source, preferably the one that gives the fewest low-power points.

NOTE When determining the low-power points, start with points close to the supply source. The power consumed by the variable resistor is measured by a convenient method, for example, by a wattmeter.



D is a point farthest from the supply source where the maximum power delivered to external load exceeds 15 W.

A and B are points closest to the supply source where the maximum power delivered to external load does not exceed 15 W. These are low-power points.

Figure 3 – Example of an electronic circuit with low power points

13.1.3 Component fault assessment

13.1.3.1 Guidelines for the tests of 13.1.3.2

*To avoid unnecessary testing, every endeavour should be made to assess all the conditions likely to result in non-compliance with the requirements of 13.1.3.2. Such an assessment shall involve an appraisal of the circuit diagram and simulation of the relevant **fault** conditions so as to test whether these conditions occur. For **controls** using software, the **fault** analysis of 13.1.3.2 shall be related to the software **fault** analysis as declared in Table H.1, requirement H.5.*

*All conditions which result from the introduction of an electronic circuit **fault** as specified in 13.1.3.8 are considered to be one **fault**.*

Printed circuit conductors which show signs of deterioration during the tests are considered liable to fail.

13.1.3.2 Test procedure

The control shall be operated under the following conditions.

a) *At the most unfavourable voltage for*

   i) mains powered controls the range 0,9 to 1,1 times the rated supply voltage,

   ii) battery powered controls in the range 0 to 100 per cent of the rated open-circuit voltage.

b) *Loaded with the type of load, within the declared or measured parameters, producing the most onerous effect.*

c) *In an ambient temperature of (20 ± 5) °C, unless there are significant reasons (as for example during item b) of 13.1.3.8) for conducting the test at another temperature within the manufacturer's declared range.*

d) *Connected to a power supply having a fuse rated such that the result of the test is not influenced by the **operation** of the fuse.*

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e) *With any **actuating member** set to the most unfavourable position.*

f) *The power supply to the control shall have the capability of supplying a short-circuit current of at least 500 A.*

g) *Components which fail as a result of cumulative stress are replaced if necessary.*

h) *For **in-line cord controls**, **free standing and independently mounted controls**, the enclosure is wrapped in tissue wrapping paper. For all other controls, the tissue paper is placed over the device under test.*

i) *The **control** is operated to steady state or for 1 h, whichever occurs first.*

13.1.3.3 Electronic circuit fault conditions

For the purpose of 13.1 and H.13.2, the applicable **failure** modes are given in Table 14.

Table 14 – Electrical/electronic component fault modes

Component type	Short [a]	Open [b]	Remarks
Resistors			
Thin-film [c]		X	Includes SMD type
Thick-film [c]		X	Includes SMD type
Wire-wound [c] (single layer) enamelled or suitably coated		X	
Wire-wound (single layer) potentiometer/trimmer		X	
All other types	X [d]	X	Includes MOV, VDR
Capacitors			
X1 and Y types according to IEC 60384-14		X	
Metallized film according to IEC 60384-16 and IEC 60384-17		X	
All other types	X	X	
Inductors			
Wire-wound		X	
All other types	X	X	
Diodes			
All types	X	X	
Semiconductor type devices like transistors			
All types (for example, bipolar; LF; RF; microwave; FET; thyristor; Diac; Triac; Uni junction)	X [d]	X	[e]
Hybrid circuit	[f]	[f]	
Integrated circuits			
All types not covered by H.9.12	X [g]	X	For IC outputs, footnote e applies
Optocouplers			
According to IEC 60747-5-5	X [h]	X	
Relays			
Coils		X	
Contacts	X [l, p]	X	
Reed-relays	X	X	Contacts only

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Component type	Short [a]	Open [b]	Remarks
Transformers			
According to IEC 61558-2-6 or IEC 61558-2-16		X	
All other types	X [d]	X	
Crystals	X	X	j
Switches	X	X	k
Connections (jumper wire)		X	l
Cable and wiring		X	
Printed circuit board conductors According to IEC 62326 series	X [m]	X [n]	
Sensors			
Polymeric type **thermistors**	X	X	o
Ceramic type **thermistors**		X	

[a] The conditions which have led to the design of the **clearances** and **creepage distances** according to Clause 11 on the assembly for which exclusion from the **fault** mode “short” is claimed shall be maintained over the lifetime of the **control**.

These conditions shall be declared or documented as follows.

Control pollution situation (declared in Table 1, requirement 44).

Pollution situation in the **micro-environment** of the **creepage distance** or **clearance**, if cleaner than that of the control, and how this is designed (documentation) (declared in Table 1, requirement 59).

Rated impulse voltage of the control (declared in Table 1, requirement 55).

Rated impulse voltage for the **creepage distance** or **clearance**, if different from that of the **control**, and how this is ensured (documentation) (declared in Table 1, requirement 60).

The values designed for tolerances of distances for which the exclusion from **fault** mode "short" is claimed. (declaration and documentation) (declared in Table 1, requirement 61).

[b] Only opening of one pin at any one time.

[c] These components may be used for protective impedance, if the components comply with 11.3.3 and withstand the impulse voltage test of 11.2.15 for at least overvoltage category III.

[d] Short-circuit each pin in turn with every other pin; only two pins at a time.

[e] For discrete or integrated thyristor type devices such as Triacs and SCRs, **fault** conditions shall include short circuit of any terminals with the third terminal open-circuited. The effect of any full wave type of component, such as a Triac going into a half-wave condition, either controlled or uncontrolled (thyristor or diode, respectively) shall be considered.

Failure of a field effect based electronic power switching device (FET, MOSFET, IGBT) by loss of gate (base) control* resulting in a partial turn-on mode, causing an undefined state shall be considered. Testing and assessment criteria shall correspond to the specific control function and circuitry. Guidance might be given in parts 2.

* Loss of gate control might occur due to, for example, an insufficient solder connection of the FET.

[f] **Failure** modes for individual components of the **hybrid circuit** are applicable as described for the individual components in this table.

[g] The short circuit of any two adjacent terminals and the short circuiting of

– each terminal to the IC-supply, when applicable at the IC;

– each terminal to the IC-ground, when applicable at the IC.

The number of tests implied for **integrated circuits** may normally make it impracticable to apply all the relevant **fault** conditions or to assess the likely **hazards** from an appraisal of the circuit diagram of the **integrated circuit**.

It is therefore permissible first to analyse in detail all the possible mechanical, thermal and electrical **faults** which may develop either in the **control** itself or its output, due to the malfunction of the electronic devices or other circuit components, separately or in any combination.

Except for types evaluated by H.9.12, a **fault**-tree analysis shall be conducted to include the results of multiple steady-state conditions to outputs and programmed bi-directional terminals for the purpose of identifying additional **fault** conditions for consideration. The **failure** mode "short circuit" is excluded between isolated sections for such ICs that have isolated sections. The isolation between the sections shall comply with the requirements of 15.2 for **functional insulation**.

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[h] When optocouplers comply with 11.4.5, the shorting between the input and output pins is not considered.

[i] The short-circuit mode is excluded for relays where the contact is controlling a Class A or B **control** function, and the relay contacts do not operate during the test of Clause 16, provided that it is successfully tested to Clause 19 under the following conditions:

For **class A control** functions, the number of cycles as declared in Table 1, requirement 20 applying the output load as declared in Table 1, requirement 8.

For **class B** control **functions**, a minimum of 100 000 cycles or as declared in Table 1, requirement 20, whichever is higher, applying the output load as declared in Table 1, requirement 8.

For **class C** control **functions**, the short-circuit mode is excluded for relays where

- the contact function is switching under normal operation without load (no current flowing during make or break), and
- the contact function is disconnecting the load under abnormal operation of the **control system** to reach **safety shut-down**, and
- the relay complies with Clause 19 at a minimum of 100 000 cycles or as declared in Table 1, requirement 20 whichever is higher, applying the output load as declared in Table 1, requirement 8.

[j] For crystal-based clocks, harmonic and sub-harmonic frequency variations affecting the timings should be considered.

[k] If switches are applied for the selection of safety times, purge times, programmes and/or other safety-related **settings**, these devices should function so that in the event of their opening, the safest possible condition arises (for example, in a burner **control system**, the shortest safety time or the longest purge time).

The short-circuit mode is excluded for switches where the contact is controlling a Class A or B **control** function, provided that it is successfully tested to Clause 19 under the following conditions:

For **class A control** functions, the number of cycles declared by the manufacturer, or certified for the application.

For **class B** control **functions**, a minimum of 6 000 cycles for **manual action**, or 100 000 cycles for automatic action, or otherwise specified by the end product standard, or certified for the application.

For **class C control functions**, short-circuit mode is not excluded.

[l] The requirements are the same as footnote n, except they are applied to jumper wires intended for clipping when selecting a **setting**.

[m] The short-circuit **failure** mode is excluded if the requirements of Clause 11 are fulfilled.

[n] The open-circuit **failure** mode, i.e. interruption of a conductor, is excluded if

- the thickness of the conductor is equal to, or greater than, a nominal value of 35 µm with a tolerance up to −30 % of the nominal value allowed, and the breadth of the conductor is equal to, or greater than, a nominal value of 0,3 mm with a tolerance up to −30 % of the nominal value allowed, or
- the conductor has an additional precaution against interruption, for example, roll-tinned, etc.

If a short circuit at the output terminals causes the opening of a printed circuit board conductor, that conductor shall be subject to an open-circuit **fault** analysis.

For temperature and current conditions when accepting conductor sizes, see IEC 62326 (all parts).

[o] For sensor components intended to measure activating quantities such as temperature, pressure, etc., **fault** modes in addition to open and short shall be considered. These **fault** modes can include step wise shift of resistance, non-responsive component, and component drifting out of accuracy.

[p] For relays with forcibly guided contacts according to IEC 61810-3, the **fault** mode "make contacts and break contacts are simultaneously in the closed position" is excluded since this failure in a closed position of the contacts is not possible due to the mechanical linkage of the contacts.

13.1.3.4 Criteria – termination by electronic circuit

If the test is terminated by the functioning of an electronic circuit in order to comply with 13.1.3.8, the following shall apply:

a) This function of the electronic circuit is disabled without affecting the normal operation of the control and the test is repeated with the same **fault** that caused the electronic circuit to function, or

b) If this function of the electronic circuit cannot be disabled without affecting the normal operation of the control, then the most onerous **fault** condition, as specified in Table 14, should be applied to the electronic circuit that functioned, or

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c) If this function of the electronic circuit includes a programmable component and this function cannot be disabled without affecting the normal operation of the control, then the programmable component shall comply with the requirements for a **class B control function** in Annex H.

13.1.3.5 Criteria – termination by intentionally weak part

If the test is terminated by the functioning of an intentionally weak part other than an overcurrent protective device, the following criteria shall be met, in addition to 13.1.3.8:

a) To ensure consistency and repeatability, the test is to be repeated on two additional samples resulting in the same component terminating the test.

b) To ensure that the disconnection is reliable, an electric strength potential corresponding to **functional insulation**, as specified in Table 16, shall be applied across the “functioned” component. Each sample shall comply with the criteria of 15.2. Parallel paths that could compromise the electric strength test results shall be disconnected.

To ensure reproducibility of the test results, the following information shall be recorded: specify the component by the type, ratings and other relevant technical information.

13.1.3.6 Criteria – termination by intentionally weak trace

If the test is terminated by the functioning of an **intentionally weak trace**, an analysis shall be conducted on the open trace and the control shall comply with the criteria of items a), c), and d) of 13.1.3.8. The analysis of the open trace shall consist of at least the following:

a) Upon functioning, an electric strength potential corresponding to **functional insulation**, as specified in Table 16, shall be applied across the two ends of the opened trace. Each sample shall comply with the criteria of 15.2.

b) To ensure consistency and repeatability, the test is to be repeated on two additional samples with complying results.

To ensure reproducibility of the test results, the following information shall be recorded:

– specify the dimensions of the weak trace (width, length, thickness, shape), and

– material of PCB, and

– other relevant technical information.

NOTE Examples of material are FR4, CEM1, CEM 3, type and thickness of protective coating, etc.

13.1.3.7 Criteria – control for motor loads

If the load includes a motor load, and the failure or malfunction of an electronic circuit component causes a change in the supply waveform to the controlled motor, the control shall be subjected to the following tests.

a) The load shall be adjusted under normal waveform conditions to six times the rated load or the locked rotor rating declared by the manufacturer.

b) Then the **fault** conditions shall be introduced.

c) The test is conducted under the conditions described in items a), c), d) and e) of 13.1.3.2.

The control shall be evaluated according to items a) to e) inclusive of 13.1.3.8, as appropriate to the component being assessed.

13.1.3.8 Compliance criteria

With each **fault** described in Table 14, simulated or applied to one circuit component at a time, the **control** shall comply with

– the following items a) to g) inclusive. For components complying with IEC 60065:2014, Clause 14, the **controls** need only comply with items a), c), d), f) and g);

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– any additional compliance criteria, as specified in the applicable subclauses of part 2; and
– the requirements of specified software class, if declared.

a) The **controls** shall not emit flames, hot metal or hot plastics, and no explosion shall result.

There shall be no burning of the tissue paper. Inside the enclosure, some parts can temporarily glow, and there can be a temporary emission of smoke or flame. The tissue paper shall comply with ISO 4046-4:2016, 4.215 as a soft and strong, lightweight wrapping paper of grammage generally between 12 g/m^2 and 30 g/m^2.

b) The temperature for **supplementary insulation** and **reinforced insulation** shall not exceed 1,5 times the relevant values specified in Clause 16, except in the case of thermoplastic material.

There is no specific temperature limit for **supplementary insulation** and **reinforced insulation** of thermoplastic material, the temperature of which shall, however, be recorded for the purpose of Clause 21.

c) Any change in the controlled outputs shall be as declared in Table 1, requirement 52.

d) The **control** shall comply with the requirements of Clause 6 and 15.2 for **basic insulation**.

e) There shall be no deterioration of the various parts of the **control** that would result in non-compliance with the requirements of Clause 11.

f) A fuse in the supply, external to the **control** under test and as described in item d) of 13.1.3.2 shall not blow unless an internal protective device also operates that is accessible only after the use of a **tool**.

An internal protective device is deemed not to be required if the sample still complies with the following requirements after replacement of the fuse of the supply:

– items a), b) and d) of 13.1.3.8;
– the requirements of Clause 11 for the **clearances** and **creepage distances** from **live parts** to the surfaces of the **control** that are accessible when the **control** is mounted as for its intended use.

g) The output waveform shall be as declared in Table 1, requirement 51.

13.2 Fault assessment to ensure functional safety

See H.13.2.

14 Moisture and dust resistance

14.1 Protection against ingress of water and dust

14.1.1 **Controls** shall provide the degree of protection against ingress of water and dust appropriate to their IP classification according IEC 60529 when mounted and used in the declared manner.

14.1.2 *Compliance is checked by first preparing the control as described in 14.1.3 to 14.1.6 inclusive and then by carrying out the appropriate test specified in IEC 60529. Immediately after the appropriate test, the control shall withstand the electric strength test specified in 15.2, and inspection shall show that any water which has entered the control does not impair compliance with this document: in particular, there shall be no trace of water on insulation which could result in reduction of creepage distances and clearances below the values specified in Clause 11.*

14.1.3 ***Controls*** *are allowed to stand in normal test room atmosphere for 24 h before being subjected to the appropriate test.*

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14.1.4 ***Controls*** *provided with a* ***detachable cord*** *are fitted with an appropriate equipment inlet and flexible cord;* ***controls*** *with a* ***non-detachable cord*** *using* ***type X attachment*** *are fitted with the appropriate conductors with the thinnest cord according to 9.8 in the range as declared in Table 1, requirement 27;* ***controls*** *provided with a* ***non-detachable cord*** *using* ***type M attachment****,* ***type Y attachment*** *or* ***type Z attachment*** *are tested with the cord declared or delivered with the samples.*

14.1.5 ***Detachable parts*** *are removed and subjected, if necessary, to the tests with the main part.*

14.1.6 *Sealing rings of glands and other sealing means, if any, are aged in an atmosphere having the composition and pressure of the ambient air, by suspending them freely in a heating cabinet, ventilated by natural circulation. They are kept in the cabinet at a temperature of (70 ± 2) °C, for 10 days (240 h).*

Immediately after ageing, the parts are taken out of the cabinet and left at room temperature, avoiding direct daylight, for at least 16 h, before being reassembled. The glands and other sealing means are then tightened with a torque equal to two-thirds of that given in Table 9 or as specified by the manufacturer in the manufacturer's instructions.

14.2 Protection against humid conditions

14.2.1 All **controls** shall withstand humid conditions which can occur in **normal use**.

14.2.2 Compliance is checked by the test sequence described in 14.2.3, after the humidity treatment of 14.2.5 to 14.2.9, inclusive.

14.2.3 *For* ***in-line cord****,* ***free-standing****,* ***independently mounted controls****, the test of 15.2 is conducted immediately after the humidity treatment, immediately followed by test of 15.1. For integrated and* ***incorporated controls****, the test of 15.2 is conducted immediately after the humidity treatment. These tests shall be conducted in such a manner that condensation does not occur on any surface of the test samples.*

14.2.4 The **control** shall show no damage so as to impair compliance with this document.

14.2.5 *Cable inlet openings, if any, and drain holes are left open. If a drain hole is provided for an IPX7* ***control****, it is opened.*

14.2.6 ***Detachable parts*** *are removed and subjected, if necessary, to the humidity treatment with the main part.*

14.2.7 *Before being placed in the humidity cabinet, the sample is brought to a temperature between t and (t + 4) °C, as specified in 14.2.8. The sample is then kept in the humidity cabinet for:*

– *2 days (48 h) for IPX0* ***controls***;

– *7 days (168 h) for all other* ***controls***.

NOTE In most cases, the sample can be brought to the specified temperature by keeping it at this temperature for at least 4 h before the humidity treatment.

14.2.8 *The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity between 91 % and 95 %. The temperature of the air, at all places where samples can be located, is maintained within (t – 1 K) and (t + 1 K), where t is any convenient value between 20 °C and 30 °C.*

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14.2.9 *After this treatment, the tests of Clause 15, as applicable, based on the type of control, are made either in the humidity cabinet, or in the room in which the samples were brought to the prescribed temperature after the reassembly of any* ***detachable part*** *removed before the humidity treatment.*

14.3 Touch current test for in-line cord controls and free-standing controls

14.3.1 For **in-line cord controls** and **free-standing controls**, one sample is subjected to the test of 14.3.2 to 14.3.6 inclusive prior to the other tests of Clause 14.

Class III controls are not tested under these subclauses.

14.3.2 *The* ***control*** *is connected to a supply voltage equal to 1,06 times the rated voltage. The test is conducted at the maximum rated current and the maximum declared ambient temperature.*

14.3.3 *The* ***touch current*** *is measured between any pole of the supply and*

– *accessible metal parts;*
– *metal foil with an area not exceeding 20 cm × 10 cm in contact with accessible surfaces of insulating material, connected together.*

Measurements shall be done individually as well as collectively where surfaces are simultaneously accessible from one surface to another.

Where a surface is less than 20 cm × 10 cm, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the control.

If the control is provided with protective earthing, the protective earthing connection is to be disconnected at the supply source.

14.3.4 *Measuring circuits for* ***controls*** *using different supplies are shown in the figures mentioned below:*

– *for a single-phase* ***control*** *having a rated voltage not exceeding 240 V, or three-phase* ***control*** *used as a single-phase control;*
  - *if a* ***class II control****, see Figure 19;*
  - *if other than a* ***class II control****, see Figure 20*;
– *for a single-phase* ***control*** *having a rated voltage exceeding 240 V, or a three-phase* ***control*** *not suitable for use as a single-phase* ***control****,*
  - *if a* ***class II control****, see Figure 21;*
  - *if other than a* ***class II control****, see Figure 22;*
– *for a single-phase* ***control*** *connected to a three-wire, center-tapped grounded neutral distribution* ***system*** *and having a rating not exceeding 120 V, other than* ***class II control****, see Figure 23;*
– *for a two-phase* ***control*** *connected to three-wire, center-tapped grounded neutral distribution* ***system*** *and having a rating not exceeding 240 V, other than* ***class II control****, see Figure 24.*

Controls *having a rated voltage exceeding 240 V shall be connected to two of the phase conductors of a three phase* ***system****, the remaining phase conductor not being used.*

Details of the measuring circuit are shown in Figure K.1 of Annex K.

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14.3.5 During measurement, all **control** circuits shall be closed. However, **controls** tested according to Figure 20, Figure 23 and Figure 24 shall have **touch currents** checked with switch S1 in the open and the closed position or with switch in positions 'a' and 'b', according to the applicable test diagram.

It is permissible to short circuit contact points to simulate closed circuits.

14.3.6 The maximum **touch current**, after the temperature of the **control** has stabilized, shall not exceed the values given in 15.3.5.

15 Electric strength and insulation resistance

15.1 Insulation resistance

15.1.1 The insulation resistance of **in-line cord**, **free standing** and **independently mounted controls** shall be adequate.

15.1.2 *Compliance is checked by the test of 15.1.3 to 15.1.5 inclusive. This test is made when specified in Clause 14.*

15.1.3 *When measuring **reinforced insulation** or **supplementary insulation** to other than metal parts, each appropriate surface of the insulation is covered with a metal foil to provide an electrode for the test.*

15.1.4 *The insulation resistance is measured with a DC voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage.*

15.1.5 *The insulation resistance shall not be less than that shown in Table 15.*

Table 15 – Minimum insulation resistance

Insulation to be tested	Insulation resistance MΩ
Functional insulation	–
Basic insulation	2
Supplementary insulation	5
Reinforced insulation	7

15.2 Electric strength

15.2.1 The electric strength of all **controls** shall be adequate.

Compliance of the electric strength of all controls shall be checked by the following test of 15.2.2 to 15.2.4 inclusive, using insulation or disconnection test voltages as shown in Table 16.

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Table 16 – Insulation or disconnection test voltages

Insulation or disconnection to be tested [b c]	Test voltage for working voltage (U) [a o]		
	SELV/PELV [d]	Working voltage ≤ 50 V [e]	Working voltage [e] 50 V < U ≤ 690 V
Functional insulation [f]	100	100	2 × U
Basic insulation [g h k]	500	1 250	1 200 + U
Supplementary insulation [g h i j k]	–	1 250	1 200 + (U)
Reinforced insulation [g h i j k]	–	2 500	2 400 + (2 × U)
Full disconnection [m]	N/A	1 250	1 200 + U
Micro-disconnection [m]	100	100	2 × U
Electronic disconnection [l]	100	100	2 × U
Micro-interruption [n]	–	–	–

NOTE 1 A DC potential equivalent to 1,414 times the test voltage specified in Table 16 is applied.

NOTE 2 For **controls** intended for incorporating into an appliance or in conjunction with other equipment, the higher electric strength test values of the equipment standard can be considered.

[a] The high voltage transformer used for the test shall be so designed that when the output terminals are short circuited after the output voltage has been adjusted to the test voltage, the output current is at least 200 mA. The overcurrent relay shall not trip when the output current is less than 100 mA. Care shall be taken that the RMS value of the test voltage is measured within ±3 %.

[b] Special components which might render the test impractical, such as electronic parts, neon lamps, coils or windings shall be disconnected at one pole or bridged as appropriate to the insulation being tested. Capacitors shall be bridged except for the tests for **functional insulation** when one pole is disconnected. Where such a proceeding is not practical, the tests of Clauses 17 to 19 inclusive are considered to be sufficient.

[c] For **class I controls** and **class 0I controls** and **controls** for **class** I situations, care shall be taken that adequate **clearance** is maintained between metal foil and accessible metal to avoid over stressing of insulation between **live parts** and earthed metal parts.

[d] Applies to circuits connected to **SELV systems** or **PELV systems**. In case of controls connected to **PELV systems**, **basic insulation** requirement between the circuit and earth is not applicable.

[e] Applies to **controls** galvanically connected to mains.

[f] **Functional insulation** on printed wiring boards submitted in **normal use** to a voltage up to 50 V is not subjected to the tests of 15.2.

[g] See 15.3.2.

[h] Any metal in contact with accessible metal is also regarded as accessible.

[i] For the tests of **supplementary insulation** and **reinforced insulation**, the metal foil is applied in such a way that sealing compound, if any, is effectively tested to accessible insulating surfaces.

[j] For **accessible parts** which are protected by means of **protective impedance**, the tests are carried out with the components disconnected, the mid-point of the two impedances being regarded as an intermediate metal part.

[k] For **controls** incorporating **reinforced insulation** as well as **double insulation**, care should be taken that the voltage applied to the **reinforced insulation** does not over stress the **basic insulation** or the supplementary parts of the **double insulation**.

[l] The device which actually performs the disconnection is first removed from the circuit. If necessary, any **control** input is connected such that the device is providing the disconnection. The test voltage is then applied to the terminals and **terminations** of the device which carry the load current.

[m] For the test of **full disconnection** and **micro-disconnection**, contacts are opened automatically or manually and tested as soon after opening as possible to ensure that the contact separation and the supporting insulation are satisfactory.

In the case of temperature **sensing controls**, it may be necessary to provide special samples specially calibrated to open between 15 °C and 25 °C to enable this test to be carried out at room temperature immediately after removal from the humidity cabinet.

[n] There are no electric strength requirements for **micro-interruption**, since the satisfactory completion of the tests of Clauses 17 to 19 inclusive is considered to be sufficient. Furthermore, for a control which has no **micro-disconnection** in one position of its **actuating means** and **micro-interruption** in other positions, there are no requirements for electric strength for those positions corresponding to **micro-interruption**.

[o] All AC voltages are RMS at 50 Hz to 60 Hz.

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15.2.2 When measuring **reinforced insulation** or **supplementary insulation** to other than metal parts, each appropriate surface of the insulation is covered with a metal foil to provide an electrode for the test.

15.2.3 The insulation is subjected to a voltage of substantially sine-wave form, having a frequency of 50 Hz or 60 Hz. Voltage is applied for 1 min across the insulation or disconnection indicated in Table 16 and has the value shown in the Table 16.

15.2.4 Initially, not more than half the prescribed voltage is applied, then it is raised rapidly to the full value. No flashover or breakdown shall occur. Glow discharges without drop in voltage are neglected.

15.3 Additional tests for in-line cord and free-standing controls

15.3.1 For **in-line cord** and **free-standing controls**, after the tests of 15.1 or 15.2, as appropriate, the sample that was subjected to the tests of 14.3 shall be subjected to the tests of 15.3.2 to 15.3.5 inclusive.

Class III controls are not tested to 15.3.2 to 15.3.5.

15.3.2 A test voltage, DC for **controls** for DC only and AC for all other **controls**, is applied between any **live part** and

– *accessible metal parts;*
– *metal foil with an area not exceeding 20 cm × 10 cm in contact with **accessible surfaces** of insulating material, connected together.*

Measurements shall be done individually as well as collectively where surfaces are simultaneously accessible from one surface to another.

*Where a surface is less than 20 cm × 10 cm, the metal foil is to be the same size as the surface. The metal foil is not to remain in place long enough to affect the temperature of the **control**.*

*If the **control** is provided with protective earthing, the protective earthing connection is to be disconnected at the supply source.*

15.3.3 The test voltage is

– *1,06 times rated voltage, or 1,06 times the upper limit of the rated voltage range, for **controls** for DC only, for single-phase **controls** and for three-phase **controls** which are also suitable for single-phase supply, if the rated voltage or the upper limit of the rated voltage range does not exceed 240 V;*
– *1,06 times rated voltage, or 1,06 times the upper limit of the rated voltage range, divided by $\sqrt{3}$, for other **controls**.*

15.3.4 *The **touch current** is measured within 5 s after the application of the test voltage.*

15.3.5 The maximum **touch current** to accessible metal parts and metal foil shall not exceed the following values:

– for class 0 controls, class 01 controls 0,5 mA,
– for **class I controls** 0,75 mA, and
– for **class II controls** 0,25 mA.

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16 Heating

16.1 **Controls** and their supporting surfaces shall not attain excessive temperatures in **normal use**.

Compliance is checked by the test of 16.2 to 16.7 inclusive.

During this test, the temperatures shall not exceed the values specified in Table 17, and the **controls** shall not undergo any change so as to impair compliance with this document and in particular with Clauses 6, 15 and 11.

16.2 Terminals and **terminations** which are intended for the connection of **external conductors**, other than those for **non-detachable cords** using **type M attachment**, **type Y attachment** or **type Z attachment**, shall be fitted with conductors of the intermediate cross-sectional area appropriate to the type of conductor and rating used in 8.1.5.

a) If **type M attachment**, **type Y attachment** or **type Z attachment** are used then the cord declared or supplied shall be used for the test.

b) If a terminal is suitable for both flexible cords and for fixed conductors, then the appropriate flexible cord is used.

c) Terminals not intended for the connection of **external conductors** shall be fitted with conductors of the minimum cross-sectional area, as specified in 8.2.1, or with a special conductor if declared in 5.2.

16.3 For this test, **controls** shall be mounted as indicated in a) to c).

a) **In-line cord controls** and **free-standing controls** are stood or rested on a dull black painted plywood surface.

b) **Independently mounted controls** are mounted as in normal use.

c) **Incorporated controls** are mounted according to the manufacturer’s instructions

16.4 Controls shall be connected to a supply having the most unfavourable voltage between 0,90 VR and 1,10 VR. Circuits which are not voltage sensitive are connected to a lower voltage (but not less than 10 % of VR and loaded such that the most unfavourable current between 0,90 and 1,10 times the rated current flows in the circuit). For battery powered controls, the test is carried out with a fully charged battery.

a) Circuits and contacts not intended for external loads shall be specified by the manufacturer.

b) **Actuating members** are placed in the most unfavourable position.

c) Contacts required to be closed initially for the purpose of this test are closed at the rated current and the rated voltage of the circuit.

   1) For temperature **sensing controls**, the temperature **sensing element** is raised or lowered to a temperature which differs from the measured operating temperature under the conditions of this clause (5 ± 1) K such that the contacts are then in the closed position.

   2) For all other **sensing controls**, the **sensing element** shall be maintained such that the contacts are in the closed position, but are as near the point of opening as is practical.

   3) It may be necessary to raise or lower, as appropriate, the value of the **activating quantity** beyond the **operating value** so as to cause **operation** and then to return the value of **activating quantity** to the required level.

   4) For other **automatic controls**, the most arduous **operating sequence** or segment of the **operating sequence** shall be selected.

d) If the **control** starts to operate during this test, the **control** is reset so that the contacts will remain closed.

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If resetting to reclose the contacts is not practical, then the test is discontinued. A new **operating value** is determined and the test repeated using this new **operating value**.

16.5 **Controls** are tested in an appropriate heating and/or refrigerating apparatus such that the conditions in a) and b) are obtained.

*Except for **controls** submitted in or with appliances, the test shall be conducted in an environment protected from drafts. Natural convection is permitted.*

a) The temperature of the **switch head** is maintained between T_{max} and either (T_{max} + 5) °C or 1,05 times T_{max}, whichever is greater. The temperature of any mounting surface is maintained between $T_{s\ max}$ and either ($T_{s\ max}$ + 5) °C or 1,05 times $T_{s\ max}$, whichever is the greater if $T_{s\ max}$ is higher than T_{max} by more than 20 K .

b) **In-line cord controls**, **independently mounted controls** and those parts of **integrated** and **incorporated controls** which are accessible when the **control** is mounted as in **normal use** shall be in a room temperature in the range of 15 °C to 30 °C, the resulting measured temperature being corrected to a 25 °C reference value. Accessible surfaces shall be tested at a higher temperature as declared in Table 1, requirement 15.

16.6 The temperatures specified for the **switch head**, the mounting surfaces and **sensing element** shall be attained in approximately 1 h.

a) The electrical and thermal conditions are maintained for 4 h, or for 1 h after steady state, whichever occurs first.

b) For **controls** designed for short-time or intermittent **operation**, the resting time(s) declared in Table 1, requirement 29, shall be included in the 4 h.

16.7 The temperature of the medium in which the **switch head** is located, and the value of the **activating quantity** to which the **sensing element** is exposed, shall be measured as near as possible to the centre of the space occupied by the samples and at a distance of approximately 50 mm from the **control**.

a) The temperature of the parts and surfaces indicated in Table 17 shall be determined by means of fine wire thermocouples or other equivalent means, so chosen and positioned that they have the minimum effect on the temperature of the part under test.

b) Thermocouples used for determining the temperature of supporting surfaces are attached to the back of small blackened discs of copper or brass, 15 mm in diameter and 1 mm thick, which are flush with the surface. So far as is possible, the **control** is positioned such that parts likely to attain the highest temperatures touch the discs.

c) In determining the temperature of **actuating members** and other handles, knobs, grips and the like, consideration is given to other parts which are gripped in **normal use**, and if of non-metallic material to parts in contact with hot metal.

d) The temperature of electrical insulation, other than that of windings, is determined on the surface of the insulation at places where **failure** could cause:

   – a short circuit;
   – a fire **hazard**;
   – an adverse effect on the protection against electric shock;
   – contact between **live parts** and accessible metal parts;
   – bridging of insulation;
   – reduction of **creepage distances** or **clearances** below the values specified in Clause 11.

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Table 17 – Maximum heating temperatures

Parts	Maximum temperature permitted °C
Pins of appliance inlets and plug-in devices [a]:	
– for very hot conditions	155
– for hot conditions	120
– for cold conditions	70
Windings [b c d e] and core laminations in contact therewith, if winding insulation is:	
– of class A material	100 [90]
– of class E material	115 [105]
– of class B material	120 [110]
– of class F material	140
– of class H material	165
Terminals and **terminations** for **external conductors** [a f g]	85
Other terminals and **terminations** [a h]	85
Rubber or polyvinyl chloride insulation of conductors: [a]	
– if flexing occurs or is likely to occur	60
– if no flexing occurs or is likely to occur	75
– with temperature marking or temperature rating	value marked
Cord sheath used as **supplementary insulation** [i]	60
Rubber other than synthetic when used for gaskets or other parts, the deterioration of which could impair compliance with this document:	
– when used as **supplementary insulation** or as **reinforced insulation**	65
– in other cases	75
Materials used as insulation other than for wires [i j k]:	
– impregnated or varnished textile, paper or press board	95
– laminates bonded with:	
• melamine formaldehyde, phenol-formaldehyde or phenol-furfural resins	110 [200]
• urea-formaldehyde resins	90 [175]
– mouldings of [j]	
• phenol-formaldehyde, with cellulose fillers	110 [200]
• phenol-formaldehyde, with mineral fillers	125 [225]
• melamine-formaldehyde	100 [175]
• urea-formaldehyde	90 [175]
• polyester with glass fibre reinforcement	135
• pure mica and tightly sintered ceramic material when such products are used as **supplementary insulation** or **reinforced insulation**	425
• other thermosetting materials and all thermo-plastic material [l]	–
All **accessible surfaces** except those of **actuating members**, handles, knobs, grips and the like	85
Accessible surfaces of handles, knobs, grips and the like used for carrying and transporting the **control**:	
– of metal	55
– of porcelain or vitreous material	65
– of moulded material, rubber or wood	75
Accessible surface of **actuating members**, or of other handles, grips or the like which are held for short periods only:	
– of metal	60
– of porcelain or vitreous material	70
– of moulded material, rubber or wood	85
Other parts made out of wood	90
Supported painted plywood surface	85

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Parts	Maximum temperature permitted °C
Current-carrying parts made of copper or brass [a m n]	230
Current-carrying parts made of steel [a]	400
Other current-carrying parts [a m]	–

[a] For these parts, the tests of 16.7 are repeated after Clause 19.

[b] The classification is in accordance with IEC 60085.

Examples of class A material are: impregnated cotton, silk, artificial silk and paper; enamels based on oleo- or polyamide resins.

Examples of class B material are: glass fibre, melamine and phenol formaldehyde resins.

Examples of class E material are:

– mouldings with cellulose fillers, cotton fabric laminates and paper laminates, bonded with melamine-formaldehyde, phenol-furfural resins;
– cross-linked polyester resins, cellulose triacetate films, polyethylene terephthalate films;
– varnished polyethylene terephthalate textile bonded with oil modified alkyd resin varnish;
– enamels based on polyvinylformal, polyurethane or epoxy resins.

More extensive accelerated temperature tests and, in addition, compatibility testing is required for insulation **systems** of class B and higher temperature classes.

For totally enclosed motors using class A, E and B material, the temperatures may be increased by 5 K. A totally enclosed motor is a motor so constructed that the circulation of the air between the inside and the outside of the case is prevented but not necessarily sufficiently enclosed to be called airtight.

[c] To allow for the fact that the temperature of windings of universal motors, relays, solenoids, etc., is usually below the average at the points accessible to thermo-couples, the figures without square brackets apply when the resistance method is used and those with square brackets apply when thermocouples are used. For the windings of vibrator coils and AC motors, the figures without square brackets apply in both cases.

[d] The value of the temperature rise of a copper winding is calculated from the formula:

$$\Delta t = \frac{R_2 - R_1}{R_1}(234{,}5 + t_1) - (t_2 - t_1)$$

where

Δt is the temperature rise [K];

R_1 is the resistance at the beginning of the test [Ω];

R_2 is the resistance at the end of the test [Ω];

t_1 is the working ambient temperature at the beginning of the test, to be set at $\boldsymbol{T}_{\mathbf{max}}$ [°C];

t_2 is the working ambient temperature at the end of the test [°C];

At the beginning of the test, the windings are to be at $\boldsymbol{T}_{\mathbf{max}}$.

It is recommended that the resistance of windings at the end of the test be determined by taking resistance measurements as soon as possible after switching off, and then at short intervals so that a curve of resistance against time can be plotted for ascertaining the resistance at the instant of switching off.

The maximum temperature attained for the purposes of Clause 16 is derived by adding the temperature rise to $\boldsymbol{T}_{\mathbf{max}}$.

[e] For small windings with a cross section, the minor dimension of which is no greater than 5 mm, the maximum temperature permitted when measured by the resistance method is:

Class	°C
A	105
E	120
B	130
F	155
H	180

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[f] For **controls** submitted in or on equipment, only the temperatures of terminals for fixed conductors are verified, as such equipment is not usually delivered with **external conductors**. For equipment with other than terminals for fixed conductors, the temperature of the insulation of the **external conductor** is determined instead of the temperature of the terminals.

[g] For incorporated and **integrated controls**, no temperature limit is applicable, but attention is drawn to the fact that most equipment standards limit the temperature of terminals of fixed appliances to 85 °C, which is the maximum allowable temperature for ordinary PVC cable insulation. The maximum temperature recorded should not exceed the value declared in Table 1, requirement 14.

When a **control** is incorporated/integrated into an appliance, the terminals for **external conductors** will, as part of the appliance, be subject to the specified tests of the appliance standard and assessed for compliance with the temperature limits of that standard.

[h] The temperature measured shall not exceed 85 °C unless a higher value has been declared by the manufacturer.

[i] The temperature values given, which are related to heat resistant properties of the material, may be exceeded where particular materials have been investigated and recognized as having special heat resistant properties.

[j] The values in square brackets apply to those parts of a material used for **actuating members**, handles, knobs, grips and the like and which are in contact with hot metal, but are not accessible.

[k] Where a metal part is in contact with a part made of insulating material, it is assumed that the temperature of the insulating material at the point of contact is the same as the temperature of the metal part.

[l] The maximum permissible temperatures shall not exceed those which can be shown to be acceptable in service for these materials. The temperatures shall be recorded for the purposes of Clause 21.

[m] The maximum permissible temperature shall not exceed those which have been shown to be acceptable in service for these materials.

[n] Higher temperatures are acceptable for specific copper alloys if substantiated by test data from the alloy manufacturer to a recognized metallurgical standard. See also footnote m.

17 Manufacturing deviation and drift

Manufacturing deviation and drift are required for **type 2 action** which are part of functional safety as indicated in Figure 2. See Clause H.17.

18 Environmental stress

18.1 Transportation and storage

Controls which are sensitive to the environmental stresses of temperature shall withstand the level of the appropriate stress likely to occur in transportation and storage.

*Compliance is checked by the appropriate tests of 18.2, carried out with the **control** being left in the same condition declared as a transportation condition. If no transportation condition is declared, the **control** is tested with an **actuating member** or **actuating means** in the most unfavourable position.*

18.2 Environmental stress of temperature

18.2.1 *The effect of temperature is tested as follows:*

– *The entire **control** shall be maintained at a temperature of (−10 ± 2) °C for a period of 24 h.*

– *The entire **control** shall then be maintained at a temperature of (60 ± 5) °C for a period of 4 h.*

18.2.2 *The **control** is not energized during either test.*

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18.2.3 *After each test, a **control** with an **actuating member** or **actuating means** shall be capable of being actuated to provide correctly the class of circuit disconnection declared, in so far as this can be determined without dismantling the **control**. This test is carried out at normal room temperature.*

*The **control** is held at room temperature for 8 h prior to **actuation**.*

18.2.4 *In addition, for **controls** with **type 2 actions**, the appropriate test of Clause 17 shall be repeated after each of the above tests. The value measured in these tests shall not differ from the value recorded in Clause H.17 for the same sample, by an amount greater than the **drift** declared in Table 1, requirement 36.*

19 Endurance

19.1 General requirements

19.1.1 Objectives of the test

The endurance test is intended

a) to evaluate the robustness of switching contacts and associated parts that are either integrated in the control or separately controlled,

b) to ensure inherent and functional safety as applicable, as well as normal operation of the control,

c) for electromechanical controls with **type 1** and **type 2 action**,

d) for **electronic controls** that have moving parts.

19.1.2 All controls

Controls, including those submitted in or with an equipment, shall withstand the mechanical, electrical and thermal stresses that occur in **normal use**.

19.1.3 Electronic controls

19.1.3.1 An endurance test is not carried out on **electronic controls** with **type 1 action** when the associated components with manual actions, relays, etc. do comply with the appropriate IEC standard or when they do comply with the appropriate IEC standard, ratings and conditions for the specific application of the control.

19.1.3.2 An endurance test is also carried out on **electronic controls** with **type 1 action** when the functions of integral switching elements or **manual actions** can not be realized by independence of the **control** and are dependent on the electronics or design of the control. **Electronic controls** with **type 2 action** are not subjected to an endurance test but to a thermal cycling test under the conditions described in H.19.1.3.3. This test can be combined with the testing of any associated components such as those with **manual actions**, relays, etc., if this is possible.

NOTE Electronic keypads are not subject to an endurance test unless they are used to manually operate a safety function. Examples include induction hob control units.

19.1.3.3 Thermal cycling test, see H.19.1.3.3

19.1.4 Controls with type 2 actions

Controls with **type 2 actions** shall operate such that any operating value, operating time or operating sequence does not change by an amount greater than the declared drift, see Clause H.17.

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19.1.5 Compliance criteria

Compliance with 19.1.2 and 19.1.3 is checked by the tests of 19.1.6 or as indicated in 19.15.

Compliance with 19.1.3 is checked by the tests of 19.1.6.

19.1.6 Test sequence and conditions

19.1.6.1 Unless specified otherwise in the part 2 or the end equipment standard, the sequence of tests is

– *an ageing test specified in 19.6 (this test applies only to those actions classified as type 1.M or 2.M);*

– *an overvoltage test of **automatic action** at accelerated rate specified in 19.7.;*

– *a test of **automatic action** at accelerated rate specified in 19.8;*

– *a test of **automatic action** at slow rate specified in 19.9 (this test applies only to **slow-make slow-break automatic actions**);*

– *an overvoltage test of **manual action** at accelerated speed specified in 19.10.;*

– *a test of **manual action** at slow speed specified in 19.11;*

– *a test of **manual action** at high speed specified in 19.12 (this test applies only to actions with more than one pole, and where polarity reversal occurs during the **operation**);*

– *a test of **manual action** at accelerated speed specified in 19.13.*

19.1.6.2 The electrical, thermal and mechanical conditions of test shall in general be those specified in 19.2, 19.3 and 19.4. The general test requirements are given in 19.6 to 19.14 inclusive. The particular test requirements are given in the appropriate part 2.

19.1.6.3 Tests for a **manual action** forming part of an **automatic action** are normally specified in the subclause appropriate to the **automatic action**. If, however, tests are not specified, then 19.10 to 19.13 inclusive apply to such **manual actions**.

19.1.6.4 After all the tests specified, the samples shall meet the requirements of 19.14, unless otherwise specified in the appropriate part 2.

19.1.6.5 *Independently mounted devices performing remote **reset** functions shall be tested for a minimum 1 000 reset actions. For integrated and incorporated devices, unless otherwise specified, the minimum reset cycles shall be declared by the manufacturer. After the test, the **reset** device shall be capable to reset the **system** as intended. Unintended **resets** shall not occur.*

19.2 Electrical conditions for the tests

19.2.1 Each circuit of the **control** shall be loaded according to the ratings declared by the manufacturer. Circuits and contacts which are not intended for external loads are operated with the designed load. Some changeover circuits may require testing separately for each part if such a manner has been declared by the manufacturer, particularly if the rating of one part of the changeover circuit depends upon the current carried by the other part.

19.2.2 In all countries which use an overvoltage test, the electrical loads to be used are those specified in Table 18 at rated voltage V_R, and with this voltage then being increased to 1,15 V_R for the overvoltage test of 19.7 and 19.10.

19.2.3 In all countries which use an overload test, the conditions specified in Table 19 and Table 20 apply. The overload tests are performed on a single pole or throw at a time, with all other poles or throws at normal load.

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a) The overload test, test voltages (VT) are
   - 120 V for **controls** rated at any voltage between 110 V to 120 V;
   - 208 V for controls rated at any voltage between 200 V to 208 V;
   - 240 V for **controls** rated at any voltage between 220 V to 240 V;
   - 277 V for **controls** rated at any voltage between 254 V to 277 V;
   - 480 V for **controls** rated at any voltage between 440 V to 480 V;
   - 600 V for **controls** rated at any voltage between 550 V to 600 V.

b) If the rating of the **control** does not fall within any of the indicated voltage ranges, it is to be tested at its rated voltage.

19.2.4 When there is an earthed neutral **system**, the enclosure shall be connected through a 3 A cartridge fuse to the **protective conductor** of the circuit, and for other than an earthed neutral **system**, the enclosure shall be connected through such a fuse to the live pole least likely to break down to earth.

19.2.5 For type 1.G or 2.G actions, or other off-load actions, auxiliary switches are used to simulate the intended **operation** during the test.

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Table 18 – Electrical conditions for the overvoltage and endurance tests

(This table applies to all tests in accordance with 19.2.2 and countries that uses an overvoltage test.)

Type of circuit as given in Table 1, Requirement 8	**Operation**	**AC circuit**			**DC circuit**		
		V	**A**	**Power factor** (±0,05) [a]	**V**	**A**	**Time constant (±1 ms)**
Substantially resistive [d]	Making and breaking	V_R	I_R	0,95	V_R	I_R	Non-inductive
Resistive or inductive [e]	Making [b]	V_R	6,0 I_X or I_R if arithmetically the greater	0,6 0,95	V_R	2,5 I_X or I_R if arithmetically the greater	7,5
	Breaking	V_R	I_X or I_R if arithmetically the greater	0,95		I_X or I_R if arithmetically the greater	Non-inductive
Declared specific load	Making and breaking	V_R	As determined by load		V_R	As determined by load	
20 mA load	Making and breaking	V_R	20 mA	0,95	V_R	20 mA	Non-inductive
Declared motor load	Making and breaking	V_R	As declared		V_R	As declared	
Pilot duty load	Making [b]	V_R	10 VA/ V_R	0,35		[c]	
	Breaking	V_R	VA/ V_R	0,95			

Circuits intended for inductive loads only can either be tested as resistive or inductive load by declaring that the resistive load is equal to the inductive load, or may be tested as a declared specific load.

The following abbreviations are used:

V_R is the rated voltage, I_R is the rated current for resistive load, I_X is the rated current for induction load.

For test purposes, a **pilot duty** load consists of an electromagnet representative of the magnet coil which is to be controlled. The normal current is that determined from the voltage and volt-ampere ratings of the electromagnet. The test current is the normal current and, for an alternating current, the power factor is to be 0,35 or less and the **inrush current** is to be 10 times the normal current. The test contactor is to be free to operate i.e., not blocked in either the open or the closed position.

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An alternating-current **pilot duty** rating may be determined for a **control** which has been tested for controlling an alternating-current motor on the following basis:

– during the overload test, the **control** was caused to make and break, for 50 cycles at a rate of 6 cycles per minute, a current having a value equivalent to six times the full-load motor current at a power factor of 0,5 or less, and

– the **pilot duty inrush current** rating (10 times the normal current rating) is to be not more than 67 % of the current value for the overload test described above.

A switch that is not intended primarily to make and break motor current under locked-rotor conditions, but which has a manual adjusting or regulating means that may cause it to be so used, shall comply with the requirements of 19.7 for a locked-rotor test.

For a switch intended for DC **operation**, the number of **operations** shall be five (5), conducted at intervals of 30 s and the device shall also comply with the requirements of a).

[a] Resistors and inductors are not connected in parallel except that if any air-core inductor is used, a resistor taking approximately 1 % of the current through the inductor is connected in parallel with it. Iron-core inductors may be used provided that the current has a substantially sine waveform. For three-phase tests, three-core inductors are used.

[b] The specified making conditions are maintained for a period between 50 ms and 100 ms, and are then reduced by an auxiliary switch to the specified breaking conditions. If during any test to this clause, contact break occurs within 2 s of contact make, the conditions specified for making are also used for breaking.

[c] These values are not applicable.

[d] Such circuits can be used for an inductive load, provided that the power factor is not less than 0,8, and the inductive load does not exceed 60 % of the current rating for the resistive load. Such circuits can also be used for other reactive loads provided that the reactive current does not exceed 5 % of the rated resistive current, and that the load is not greater than 10 VA.

[e] Circuit suitable for either a resistive load or for an inductive load with a power factor not less than 0,6 or a combination of both.

Example A circuit in a fan-heater which incorporates both a heating element and a motor.

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Table 19 – Electrical conditions for the overload tests of 19.7 and 19.10

(this table applies in all countries which use an overload test in accordance with 19.1.6.1)

Type of circuit as given in Table 1, requirement 8	Operation	AC circuit			DC circuit		
		V	A	Power factor	V	A	
Substantially resistive	Making and breaking	V_T	$1{,}5I_R$	1,0	V_T	$1{,}5I_R$	
Inductive (non-motor)	Making and breaking	V_T	$1{,}5I_X$	0,75 to 0,8	V_T	$1{,}5I_X$	
Declared motor load	Making and breaking	V_T	$6I_m$ or as declared	0,4 to 0,5 or as declared	V_T	$10I_m$ or as declared	
Declared specific load	Making and breaking	V_T	$1{,}5I_X$	0,75 to 0,8	V_T	$1{,}5I_X$	
20 mA load	Making and breaking	V_T	$1{,}5I_X$	0,95	V_T	20 mA	Non-inductive
Pilot duty load	Making	1,1 V_T	10 VA/ V_T	0,35 maximum	As declared		
	Breaking	1,1 V_T	VA/ V_T or as declared	or as declared			

The following abbreviations are used:

V_R is the rated voltage, V_T is the test voltage (see 19.2.3 a)). A circuit in which the closed-circuit voltage is 100 % to 110 % of V_T is acceptable for the tests.

I_m is the rated current or motor load, I_R is the rated current for resistive load, I_X is the rated current for induction load.

For test purposes, a **pilot duty** load consists of an electromagnet representative of the magnet coil which is to be controlled. The normal current is that determined from the voltage and volt-ampere ratings of the electromagnet. The test current is the normal current and, for an alternating current, the power factor is to be 0,35 or less and the **inrush current** is to be 10 times the normal current. The test contactor is to be free to operate i.e., not blocked in either the open or the closed position.

An alternating-current **pilot duty** rating may be determined for a **control** which has been tested for controlling an alternating-current motor on the following basis:

– during the overload test, the **control** was caused to make and break, for 50 cycles at a rate of 6 cycles per minute, a current having a value equivalent to six times the full-load motor current at a power factor of 0,5 or less, and

– the **pilot duty inrush current** rating (10 times the normal current rating) is to be not more than 67 % of the current value for the overload test described above.

For **controls** that may make a motor circuit under locked rotor conditions but that are never required to break the circuit under such conditions, the following applies:

a) 100 % V_T for AC and 0,5 V_T for DC for 1,5 rated current,

b) 100 % V_T for locked-rotor current (make only).

A switch that is not intended primarily to make and break motor current under locked-rotor conditions, but which has a manual adjusting or regulating means that may cause it to be so used, shall comply with the requirements of 19.7 for a locked-rotor test.

For a switch intended for DC **operation**, the number of **operations** shall be five (5), conducted at intervals of 30 s and the device shall also comply with the requirements of a) above.

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Table 20 – Electrical conditions for the endurance tests of 19.8, 19.9, 19.11, 19.12 and 19.13

(this table applies in all countries which use an overload test in accordance with 19.1.6.1)

Type of circuit as given in Table 1, requirement 8	Operation	AC circuit			DC circuit		
		V	A	Power factor	V	A	
Substantially resistive	Making and breaking	V_T	I_R	1	V_T	I_R	
Inductive (non-motor)	Making and breaking	V_T	I_X	0,75 to 0,8	V_T	I_X	
Declared motor load	Making and breaking	V_T	I_m or as determined by load	0,75 to 0,8 or as declared	V_T	I_m	
Declared specific load	Making and breaking	V_T	As determined by load[a]		V_T	As determined by load[a]	
20 mA load	Making and breaking	V_T	20 mA	0.95	V_T	20 mA	Non-inductive
Pilot duty load	Making	V_T	10 VA/ V_T	0,35 maximum	As declared		
	Breaking	V_T	VA/ V_T or as declared	or as declared			

The following abbreviations are used:

V_R is the rated voltage, V_T is the test voltage (see 19.2.3 a)).

I_m is the rated current for motor load, I_R is the rated current for resistive load, I_X is the rated current for induction load.

For test purposes, a **pilot duty** load consists of an electromagnet representative of the magnet coil which is to be controlled. The normal current is that determined from the voltage and volt-ampere ratings of the electromagnet. The test current is the normal current and for an alternating current the power factor is to be 0,35 or less and the **inrush current** is to be 10 times the normal current. The test contactor is to be free to operate i.e., not blocked in either the open or the closed position.

For **controls** that may make a motor circuit under locked rotor conditions but that are never required to break the circuit under such conditions, the following applies 100 % V_T for AC and 0,5 V_T for DC.

[a] A control may be operated faster than 1 cycle per minute if synthetic loads are used or if a sufficient number of banks of lamps controlled by a commutator are employed so that each bank will cool for at least 59 seconds between successive applications.

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19.3 Thermal conditions for the tests

19.3.1 For parts of the **control** other than any temperature **sensing element**, the following shall apply:

– *those parts which are accessible when the **control** is mounted in a declared manner shall be exposed to normal room temperature (see 4.3);*

– *the mounting surface of the control shall be maintained between $T_{s\ max}$, and either ($T_{s\ max}$ + 5) °C, or 1,05 times $T_{s\ max}$, whichever is greater;*

– *the remainder of the **switch head** shall be maintained between T_{max} and either (T_{max} + 5) °C or 1,05 times T_{max}, whichever is greater. If T_{min} is less than 0 °C, additional tests shall be carried out with the **switch head** maintained between T_{min} and (T_{min} – 5) °C.*

19.3.2 During the tests of 19.8 and 19.13, the temperatures of 19.3.1 are applied for the last 50 % of each test. For the first 50 % of each test, the **switch head** is maintained at normal room temperature.

Additional samples will be required if tests have to be performed at both temperatures (T_{max} and T_{min}).

19.4 Manual and mechanical conditions for the tests

19.4.1 For all **manual actions**, each cycle of **actuation** shall consist of a movement of the **actuating member** such that the **control** is successively moved into all positions appropriate to that action and then returned to its starting point; except that if a **control** has more than one intended **OFF position**, then each **manual action** shall be a movement from one **OFF position** to the next **OFF position**.

19.4.2 The speed of movement of the **actuating member** shall be

– *for slow speed:*

  (9 ± 1)° per s for rotary actions;

  (5 ± 0,5) mm/s for linear actions;

– *for high speed:*

  *the **actuating member** shall be actuated by hand as fast as possible. If an **actuating member** is not supplied with a **control** then a suitable **actuating member** shall be fitted by the test house for the purpose of this test;*

– *for accelerated speed:*

  (45 ± 5)° per s for rotary actions;

  (25 ± 2,5) mm/s for linear actions.

19.4.3 During the slow speed test of 19.4.2:

*the test apparatus shall drive the **actuating member** positively, without significant backlash between the apparatus and the **actuating member**.*

19.4.4 During the accelerated speed test of 19.4.2

– *the test apparatus allows the **actuating member** to operate freely, so that it does not interfere with the normal action of the mechanism;*

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– *for **controls** where the movement of the **actuating member** is limited:*

  - *there shall be a dwell period of not less than 2 s at each reversal of direction;*
  - *a torque (for rotary **controls**), or a force (for non-rotary **controls**) shall be applied at the extreme of each movement to verify the strength of the limiting end stops. The torque shall be either five times the normal actuating torque, or 1,0 Nm, whichever is the smaller, but with a minimum of 0,2 Nm. The force shall be either five times the normal actuating force, or 45 N, whichever is the smaller, but with a minimum of 9 N. If the normal actuating torque exceeds 1,0 Nm, or the normal actuating force exceeds 45 N, then the torque or force applied shall be the same as the normal actuating torque or force;*

– *for **controls** designed for a rotary **actuation** where the movement is not limited in either direction, three quarters of the number of cycles of **actuation** in each test shall be made in a clockwise direction, and one quarter in an anti-clockwise direction.*

– *for **controls** which are designed for **actuation** in one direction only, the test shall be in the designed direction, provided that it is not possible to rotate the **actuating member** in the reverse direction using the torques specified above.*

19.4.5 Additional lubrication shall not be applied during these tests.

19.5 Dielectric strength requirements

After all the tests of this clause, the requirements of 15.2 shall apply, with the exception that the samples are not subjected to the humidity treatment before the application of the test voltage. The test voltages shall be 75 % of the corresponding test voltages shown in 15.2.

19.6 Ageing test

19.6.1 During this test, the **sensing element** shall be maintained at that value of the **activating quantity** determined and used in Clause 16. Other parts shall be maintained as specified in 19.3. **Controls** are electrically loaded as specified in 19.2 for the appropriate breaking condition. The duration of the test is (100 + 0,02 y) h where "y" is the value declared in requirement 21 of Table 1. The test applies to **controls** with actions classified as type 1.M or 2.M.

19.6.2 If during this test, the action being tested operates, the value of the **activating quantity** is increased or decreased to cause reverse **operation** and then returned to a value differing by a quantity "x" from the original to enable the test to be resumed. This procedure can be repeated as many times as is necessary to complete the test, or until, when repeating the appropriate procedure of Clause H.17, the **drift** limits declared in 5.2 are exceeded. The value of "x" is given in the appropriate part 2.

19.7 Overvoltage test or overload test in all countries using an overload test of automatic action at accelerated rate

19.7.1 The electrical conditions shall be those specified for overvoltage or overload conditions in 19.2.

19.7.2 The thermal conditions shall be those specified in 19.3.

19.7.3 The method and rate of **operation** is:

– *for **type 1 actions**, the rate of **operation** and the method of **operation** shall be agreed between the test house and the manufacturer;*

– *for **type 2 actions**, the method of **operation** shall be that intended by design. For type 2 sensing actions, the rate of **operation** can be increased, either to the maximum cycling rate declared in Table 1, requirement 31 or so that the rates of change of **activating quantity** do not exceed α_2 and β_2 declared in the same subclause.*

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NOTE 1 Examples of such methods are the replacement of the capillary of a hydraulic **system** with an air pressure device or the fitting of a **prime mover** of a different speed.

– ***controls*** *with* ***type 2 action*** *are tested at the most unfavourable* ***operating value*** *declared in Table 1, requirement 42.*

NOTE 2 For temperature and pressure operated **controls**, this is normally the maximum value.

19.7.4 For type 2 sensing actions, overshoot at each **operation** shall be between the values declared in 5.2.

19.7.5 It is permissible in the case of sensing actions to increase the rates of change of **activating quantity**, or for other **type 1 actions**, to override the **prime mover** between **operations**, provided that this does not significantly affect the results.

19.7.6 The number of automatic cycles for the test is either one tenth of the number declared in Table 1, requirement 20, or 200 cycles, whichever is the smaller.

19.7.7 During the test, **actuating members** are placed in their most unfavourable position.

19.8 Test of automatic action at accelerated rate

19.8.1 The electrical conditions shall be those specified in 19.2.

19.8.2 The thermal conditions shall be those specified in 19.3.

19.8.3 The method and rate of **operation** shall be as used during the test of 19.7.3.

19.8.4 The number of automatic cycles (except as shown below for **slow-make slow-break automatic actions**) shall be as declared in Table 1, requirement 20, less the number of cycles actually made during the test of 19.7. During the test, **actuating members** shall be placed in their most unfavourable position. During the test, the **failure** of any component part of a **type 1 action** which is not significant according to the requirements of the test, and which is considered to have failed as a result of the acceleration of the test, shall not be a cause of rejection, provided that it can be repaired or replaced, or that the test can be continued in an agreed alternative manner, such that the total number of automatic cycles declared in Table 1, requirement 20 can be completed.

For **slow-make slow-break automatic actions**, only 75 % of the number of automatic cycles referred to in 19.8.4 shall be carried out during this test. The remaining 25 % are carried out as specified in 19.9.

19.9 Test of automatic action at slow rate

19.9.1 **Slow-make slow-break automatic actions** shall be tested for the 25 % remainder of the number of automatic cycles specified in 19.8.

19.9.2 The electrical and thermal conditions shall be as specified in 19.2 and 19.3.

19.9.3 The method of **operation** is either by imposing a change of value of **activating quantity** on the **sensing element**, or by the **prime mover**. For **sensing controls**, the rates of change of **activating quantity** shall be α_1 and β_1 as declared in 5.2. It is permissible, in the case of a **sensing control** to increase the rates of change of **activating quantity**, or for other **automatic controls** to override the **prime mover**, between **operations**, provided that this does not significantly affect the results. For **sensing controls**, overshoot at each **operation** shall be between the values declared in 5.2. During this test for a **type 2 action**, continuous monitoring is essential to provide a record of **operating value**, overshoots or **operating sequences**.

Such monitoring is also recommended for other **controls** to determine consistency of testing.

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19.9.4 If only the make or the break is a slow **automatic action**, then it may, by agreement between the test house and the manufacturer, be possible to accelerate the rest of the action, to which the details of 19.8 apply.

19.10 Overvoltage test or overload test in all countries that use the overload test of manual action at accelerated speed

19.10.1 The electrical conditions shall be those specified for overvoltage or overload in 19.2.

19.10.2 The thermal conditions shall be those specified in 19.3.

19.10.3 The method of **operation** shall be that specified in 19.4 for accelerated speed. The number of cycles of **actuation** shall be either one tenth of the number declared in 5.2 or 100, whichever is smaller. During the test, **sensing elements** are maintained at suitable values of **activating quantity**, and **prime movers** are so positioned as to ensure that **actuation** causes the appropriate **operation**.

19.11 Test of manual action at slow speed

19.11.1 The electrical conditions shall be those specified in 19.2.

19.11.2 The thermal conditions shall be those specified in 19.3.

19.11.3 The method of **operation** shall be that specified in 19.4 for slow speed.

19.11.4 The number of cycles of **actuations** shall be either one tenth of the number declared in 5.2 or 100, whichever is smaller. During the test, **sensing elements** are maintained at suitable values of **activating quantity**, and **prime movers** are so positioned, to ensure that **actuation** causes the appropriate **operation**.

19.12 Test of manual action at high speed which has multiple poles, and where polarity reversal occurs during the action

19.12.1 The electrical conditions are those specified in 19.2.

19.12.2 The thermal conditions are those specified in 19.3.

19.12.3 The method of **operation** is that specified in 19.4 for high speed.

19.12.4 The number of cycles of **actuation** is 100. During the tests, **sensing elements** are maintained at suitable values of **activating quantity**, and **prime movers** are so positioned as to ensure that **actuation** causes the appropriate **operation**.

19.13 Test of manual action at accelerated speed

19.13.1 The electrical conditions are those specified in 19.2.

19.13.2 The thermal conditions are those specified in 19.3.

19.13.3 The method of **operation** is that specified in 19.4 for accelerated speed.

19.13.4 The number of cycles of **actuation** is that number declared in 5.2 less the number actually made during the tests of 19.10, 19.11 and 19.12. During the test, **sensing elements** are maintained at a suitable value of **activating quantity**, and **prime movers** are so positioned as to ensure that **actuation** causes the appropriate **operation**.

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19.13.5 During the test, the **failure** of any component part of a **type 1 action** which is not significant according to the requirements of the test shall not be a cause of rejection providing that it can be repaired or replaced, or that the test can be continued in an agreed alternative manner such that the total required number of cycles of **actuation** can be completed.

19.14 Evaluation of compliance

19.14.1 After all the appropriate tests of 19.6 to 19.13 inclusive, modified as specified in the appropriate part 2, the **control** shall be deemed to comply if:

– *all actions function automatically and manually in the intended and declared manner within the meaning of this document;*

– *the requirements of Clause 16 with regard to those items designated by footnote a of Table 17, that is, terminals, current-carrying parts and supporting surfaces, are still met;*

– *the requirements of Clause 6, 11 and 19.5 are still met. For the tests of 19.5 and Clause 11, **controls** for which special samples were submitted for Clause 15, are tested at an appropriate condition to ensure that the contacts are open;*

– *for **type 2 actions**, the appropriate test of Clause H.17 is repeated and the **operating value**, **operating time** or **operating sequence** shall still be within the value of **drift**, or within the values of combined **drift** and **manufacturing deviation**, whichever was declared;*

– *the circuit disconnection declared for each **manual action** can still be obtained;*

– *there is no evidence (at least the fuse from 19.2.4 shall not have ruptured) that any transient **fault** between **live parts** and earthed metal, accessible metal parts or **actuating members** has occurred.*

19.14.2 For **electronic controls,** after all the appropriate tests of 19.6 to 19.13 inclusive and 19.1.4, modified as specified in the appropriate part 2, the **control** shall be deemed to comply if:

– the criteria of 19.14.1 are satisfied,

– for **controls** providing **electronic disconnection** (type 1.Y or 2.Y), the requirements of 9.4.16 are still met.

19.15 Test for particular purpose controls

The tests for particular purpose controls are specified in the appropriate part 2s.

19.16 See J.19.16.

19.17 See J.19.17.

20 Mechanical strength

20.1 General requirements

20.1.1 **Controls** shall be so constructed as to withstand the mechanical stress that occurs in **normal use**.

20.1.2 **Actuating members** of **class I controls** and **class II control**, and **actuating members** of **controls** for class I and class II equipment, shall either have adequate mechanical strength or be such that adequate protection against electric shock is maintained if the **actuating member** is broken.

20.1.3 **Integrated controls** and **incorporated controls** are not tested as in 20.2 as their impact resistance will be tested by the equipment standard.

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20.1.4 *Compliance is checked by the tests of the appropriate Subclauses 20.2 to 20.6 inclusive, carried out sequentially on one sample.*

20.1.5 After the appropriate tests, the **control** shall show no damage that would impair compliance with this document and in particular with Clauses 6, 15, and 11. Insulating linings, barriers and the like shall not have worked loose.

*It shall still be possible to remove and to replace detachable and other external parts such as **covers** without such parts or their insulating linings breaking.*

*It shall still be possible to actuate a **control** to any position which is intended to provide **full disconnection** and **micro-disconnection**.*

*In case of doubt, **supplementary insulation** or **reinforced insulation** is subject to an electric strength test as specified in Clause 15.*

*Damage to the finish, small dents which do not reduce **creepage distances** or **clearances** below the values specified in Clause 11, and small chips which do not adversely affect the protection against electric shock or moisture are neglected. Cracks not visible to the naked eye, and surface cracks in fibre reinforced mouldings and the like are ignored. If a decorative **cover** is backed by an inner **cover**, fracture of the decorative **cover** is neglected, if the inner **cover** withstands the test after removal of the decorative **cover**.*

20.2 Impact resistance

20.2.1 **In-line cord**, **free-standing** and **independently mounted controls**, except as provided in 20.3, are checked by applying blows to the sample by means of the apparatus in IEC 60068-2-75.

20.2.2 All surfaces which are accessible when the **control** is mounted as in **normal use** are tested with the apparatus.

20.2.3 *The **control** is held in contact with a vertical sheet of plywood 8 mm thick and 175 mm square without any metallic back plate, the plywood being mounted on a rigid frame which is fixed to a solid wall of brick, concrete or the like.*

20.2.4 *Blows are applied to all **accessible surfaces**, including **actuating members**, at any angle, the test apparatus being calibrated to deliver an energy of (0,5 ± 0,04) Nm.*

*Foot actuated **controls** shall be subject to the same test, but using a test apparatus calibrated to deliver an energy of (1,0 ± 0,05) Nm.*

20.2.5 *For all such surfaces, three blows are applied to every point that is likely to be weak*.

20.2.5.1 *Care shall be taken that the results from one series of three blows does not influence subsequent series.*

20.2.5.2 *If there is a doubt whether a defect has been caused by the application of preceding blows, this defect is neglected and the group of three blows which led to the defect is applied to the same place of a new sample, which shall then withstand the test.*

20.2.6 *Signal lamps and their **covers** are only tested if they protrude from the enclosure by more than 10 mm or if their area exceeds 4 cm², unless they form part of an **actuating member**, in which case they shall be tested in the same manner as an **actuating member**.*

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20.3 Free-standing controls

20.3.1 **Free-standing controls** shall be additionally checked by the test of 20.3.2 and 20.3.3 using the apparatus shown in Figure 7.

20.3.2 *Two metres of flexible cord of the lightest type used in 8.1.5 shall be connected to the input terminals and secured as intended.* ***Controls*** *intended for use with a flexible cord connected to the output terminals shall have 2 m of the lightest intended type similarly connected and arranged as shown in Figure 7.*

The sample shall be stood or rested on the glass surface as shown and the cord shall be subjected to a steady pull gradually increasing up to, but not exceeding that shown in Table 22. If the sample moves, it is pulled off the glass surface as slowly as possible and allowed to fall onto the concrete backed hard wood base.

The height of the surface above the base is 0,5 m. The size of the hard wood and concrete base shall be sufficient for the ***control*** *to remain on the base after falling.*

The test is repeated three times.

20.3.3 *After the test, the sample shall be evaluated as in 20.1.5.*

20.4 In-line cord controls

20.4.1 **In-line cord controls** other than **free-standing controls** shall be additionally tested in a tumbling barrel as shown in Figure 8. The width of the barrel shall not be less than 200 mm, and shall be as wide as is necessary to ensure the uninterrupted fall of the **control** when fitted with the cords as required in 20.4.2.

20.4.2 ***Controls*** *with* ***non-detachable cords*** *using* ***type X attachment*** *shall be fitted with the flexible cord or cords having the smallest cross-sectional area specified in 8.1.5 and a free length of approximately 50 mm. Terminal screws are tightened with two-thirds of the torque specified in 10.1.* ***Controls*** *with* ***non-detachable cords*** *using* ***type M attachment***, ***type Y attachment*** *or* ***type Z attachment*** *shall be tested with cord or cords declared or supplied, the cord or cords being cut so that a free length of about 50 mm projects from the* ***control****.*

20.4.3 *The sample falls from a height of 50 cm onto a steel plate, 3 mm thick, the number of falls being:*

– *1 000 if the mass of the sample without cord does not exceed 100 g;*

– *500 if the mass of the sample without cord exceeds 100 g, but does not exceed 200 g.*

20.4.4 ***In-line cord controls*** *with a mass exceeding 200 g are not tested in the tumbling barrel, but shall be subjected to the test of 20.3.*

20.4.5 *The barrel is turned at a rate of five revolutions per min, 10 falls per min thus taking place.*

20.4.6 *After this test, the* ***control*** *shall be evaluated as in 20.1.5. Special attention is paid to the connection of flexible cord or cords.*

20.5 Pull-cord actuated controls

20.5.1 **Pull-cord actuated controls** shall be additionally tested as in 20.5.2 and 20.5.3.

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20.5.2 *The **control** shall be mounted as declared by the manufacturer, and the **pull-cord** shall be subjected to a force, applied without jerks, first for 1 min in the normal direction, and then for 1 min in the most unfavourable direction, but not exceeding 45° from the normal direction.*

20.5.3 *The values of the force are shown in Table 21.*

Table 21 – Pull-cord force test values

Rated current A	Force N	
	Normal direction	Most unfavourable direction
Up to and including 4	50	25
Over 4	100	50

20.5.4 *After this test, the **control** shall be evaluated as in 20.1.5.*

20.6 Foot actuated controls

20.6.1 **Controls** actuated by foot shall be additionally tested as indicated in 20.6.2 to 20.6.4:

20.6.2 *The **control** is subjected to a force applied by means of a circular steel pressure plate with a diameter of 50 mm. The force is increased continuously from an initial value of about 250 N, up to 750 N, within 1 min, after which it is maintained at this value for 1 min.*

20.6.3 *The **control** is placed on a flat horizontal steel support with the appropriate flexible cord fitted. The force is applied three times with the sample placed in different positions, the most unfavourable positions being chosen.*

20.6.4 *After the test, the **control** shall be evaluated as in 20.1.5.*

20.7 Actuating member and actuating means

20.7.1 **Controls** supplied with, or intended to be fitted with **actuating members** shall be tested as follows.

– *First an axial pull shall be applied for 1 min to try to pull off the **actuating member**.*

– *If the shape is such that it is not possible to apply an axial pull in **normal use**, this first test does not apply.*

– *If the shape of the **actuating member** is such that an axial pull is unlikely to be applied in **normal use**, the force is 15 N.*

– *If the shape is such that an axial pull is likely to be applied, the force is 30 N.*

– *Secondly, an axial push of 30 N for 1 min is then applied to all **actuating members**.*

20.7.2 If a **control** is intended to have an **actuating member** but is submitted for approval without, or is intended to have an easily removable **actuating member** then a pull and push of 30 N are applied to the **actuating means**.

NOTE Sealing compound and the like, other than self-hardening resins, is not deemed to be adequate to prevent loosening.

20.7.3 During and after each of these tests, the **control** shall show no damage, nor shall an **actuating member** have moved so as to impair compliance with this document.

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20.8 Flexing – test

20.8.1 The flexing test is applied to in-line cord controls and free-standing controls. The **control** is mounted in the flexing apparatus shown in Figure 10. The axis of oscillation is so chosen that the weight attached to the cord and the cord itself make the minimum lateral movement during the test.

*Samples with flat cords are mounted so that the major axis of the cross-section is parallel to the axis of oscillation. Each flexible cord passing through the inlet opening is loaded with a weight of 1 kg. A current equal to the current passing through that particular core when the **control** is operated at rated voltage is passed through each core, the voltage between cores being maximum rated voltage. The oscillating member is moved backwards and forwards through an angle of 90° (45° on either side of the vertical). The number of flexings (that is one movement through 90°) being 5 000, and the rate of the flexing being 60 flexings per minute.*

20.8.2 After the test, the sample shall show no damage within the meaning of this document. During the test, no interruption of the current and no short circuit between the individual conductors shall occur, neither shall broken strands pierce the insulation to the outer surface of the accessory. A short circuit between individual conductors is considered to occur if the current reaches twice the value of the test current.

20.8.3 Not more than 10 % of the total number of conductors of the flexible cord shall have been broken.

20.9 Cord anchorages – test

20.9.1 The **control** is fitted with a flexible cord and the conductors are introduced into the terminals, the terminal screws, if any, being tightened just sufficiently to prevent the conductors from easily changing their position. The cord anchorage is used in the intended manner, the screws being tightened with a torque equal to two-thirds of the torque specified in 10.1.

20.9.2 After this preparation, it shall not be possible to push the cord into the **control** to such an extent that the cord or internal parts of the **control** could be damaged, or that internal parts are interfered with in a way which might impair compliance with this document.

20.9.3 The cord is then subjected to pulls of the value and number shown in Table 22. The pulls are applied in the most unfavourable direction, without jerks, each time for 1 s.

20.9.4 Immediately afterwards, the cord is subjected for 1 min to a torque of the value shown in Table 22.

Table 22 – Pull and torque values

Control	Pull [a] N	Torque [a] Nm	Number of pulls [a]
Free-standing controls and **independently mounted controls**:			
Up to and including 1 kg	30	0,1	25
Over 1 kg up to and including 4 kg	60	0,25	25
Over 4 kg	100	0,35	25
In-line cord controls (other than **free-standing controls**)	90	0,25	100

[a] Some equipment standards may require a different value.

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20.9.5 For **type X attachment**, the tests are made first with the lightest permissible type of flexible cord of the smallest cross-sectional area used in 8.1.5, and then with the next heavier type of flexible cord of the largest cross-sectional area used. For **type M attachment**, **type Y attachment** or **type Z attachment**, only declared or fitted cord is used.

20.9.6 During the tests, the cord shall not be damaged. After the tests, the cord shall not have been displaced longitudinally by more than 2 mm, the conductors shall not have been moved over a distance of more than 1 mm in the terminals, and there shall be no appreciable strain at the connection. **Creepage distances** and **clearances** shall not have been reduced below the value specified in Clause 11.

20.9.7 For the measurement of the longitudinal displacement, a mark is made on the cord while it is subjected to the pull, at a distance of approximately 20 mm from the cord anchorage, before starting the tests. After the tests, the displacement of the mark on the cord in relation to the cord anchorage is measured while the cord is subjected to the pull.

21 Resistance to heat, fire and tracking

21.1 General requirements

All non-metallic parts of a **control** shall be resistant to heat, fire and tracking.

*Compliance is checked by the tests of 21.2, except that **independently mounted controls** and **free-standing controls** are checked by the tests of 21.3.*

21.2 Integrated, incorporated and in-line cord controls

21.2.1 The test sequences shall be conducted as appropriate to the position or function of the non-metallic part and the declared ball pressure and glow-wire test temperatures.

21.2.2 *No requirements for heat and resistance to fire exist for small parts as specified in IEC 60695-2-11:2021, 4.4.*

21.2.3 *No requirements for heat and resistance to fire exist for insignificant mass of combustible material as specified in IEC 60695-2-11:2021, 4.1; default mass value of insignificant mass is 2 g.*

21.2.4 **Controls** declared in Table 1, requirement 74 shall be tested in accordance with IEC 60335-1:2020, Clause 30.

NOTE **Controls** can be used in widely different end applications. Selection of test levels from the requirements below can be influenced by consideration of the end-application standard's requirements.

21.2.5 For parts which are accessible when the **control** is mounted in its manner of intended use and the deterioration of which can result in the **control** becoming unsafe, the following tests are required. See Annex G:

– *ball pressure test 1 of G.3.2;*

– *the glow-wire test of Clause G.1 carried out at 550 °C.*

21.2.6 For parts which retain in position current-carrying parts other than electrical connections, the following tests are required. See Annex G:

– *ball pressure test 2 of G.3.3;*

– *the glow-wire test of Clause G.1 carried out at 550 °C.*

The tests are not applicable to parts retaining in position current-carrying parts in low-power circuits as described in 13.1.2.

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21.2.7 For parts which maintain or retain in position electrical connections, the following tests are required. See Annex G:

– *ball pressure test 2 of G.3.3,*

followed by the glow-wire test at the temperature appropriate for the application and as declared for the ***control****:*

Glow-wire test at 650 °C

– *the glow-wire test of Clause G.1 carried out at 650 °C.*

Glow-wire test at 750 °C

– *the glow-wire test of Clause G.1 carried out at 750 °C.*

Glow-wire test at 850 °C

– *the glow-wire test of Clause G.1 carried out at 850 °C.*

The tests are not applicable to parts retaining in position current-carrying parts in low-power circuits as described in 13.1.2.

21.2.8 For all other parts, (except decorative trim, knobs, etc.), the following test is required. See Annex G:

– *the glow-wire test of Clause G.1 carried out at 550 °C.*

Unless otherwise indicated in a part 2, diaphragms, gaskets and sealing rings of glands are not subjected to the tests of 21.2.8.

21.2.9 Resistance to tracking for all non-metallic parts for which a **creepage distance** is specified in 11.3 shall be as declared in Table 1*,* requirement 23.

NOTE 1 Required values of resistance to tracking are given either in the part 2s of IEC 60730 or in the relevant equipment standard.

NOTE 2 Within a **control**, different parts can have different PTI values appropriate to the **micro-environment** of the part.

Compliance is checked by the tests of Clause G.2 carried out at the value declared in Table 1, *requirement* 23*:*

– *100 V;*
– *175 V;*
– *250 V;*
– *400 V;*
– *600 V.*

NOTE 3 For the purposes of 21.2.9, the proximity of arcing contacts is not considered to increase the deposition of external conductive material as the endurance tests of Clause 19, followed by the electric strength tests of Clause 15, are deemed sufficient to determine the effect of **pollution** arising from within the **control**.

21.3 Independently mounted, free-standing controls

21.3.1 The test sequence of 21.2.5 through 21.2.9 applies, preceded by the preconditioning of 21.3.2.

21.3.2 *Preconditioning shall be carried out in a heating cabinet as follows:*

– *without T rating: 1 × 24 h at (80 ± 2) °C, the circuit of the switching part and the driving mechanism not being connected, with detachable* ***covers*** *removed;*

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– *with T rating for temperatures not exceeding 85 °C: 1 × 24 h at (80 ± 2) °C, the switching part of the **control** and the driving mechanism not being connected and without **covers** and subsequently 6 × 24 h at T_{max} ± 2 K with **covers**, with the circuit of the switching part and driving mechanism being connected;*

– *with T rating for temperatures exceeding 85 °C: 6 × 24 h at T_{max} ± 2 K with **covers**, with the circuit of the switching part and driving mechanism being connected.*

22 Resistance to corrosion

22.1 Resistance to rusting

22.1.1 Ferrous parts, including **covers** and enclosures, the corrosion of which might impair compliance with this document, shall be protected against corrosion.

22.1.2 This requirement does not apply to temperature **sensing elements** or to other component parts whose performance would be adversely affected by protective treatment.

22.1.3 *Compliance is checked by 22.1.4 to 22.1.6:*

22.1.4 *The parts are subjected to a test of 14 days duration at 93 % to 97 % relative humidity at (40 ± 2) °C.*

22.1.5 *After the parts have been dried for 10 min in a heating cabinet at a temperature of (100 ± 5) °C, their surfaces shall show no corrosion which might impair compliance with Clauses 6, 15, and 11.*

22.1.6 *Traces of rust on sharp edges and a yellowish film removable by rubbing are ignored.*

NOTE 1 Parts protected by enamelling, galvanizing, sherardizing, plating or other recognized equivalent protection are deemed to meet this requirement.

NOTE 2 For small helical springs and the like, and for parts exposed to abrasion, when a layer of grease is used to provide protection against rusting, such parts are subjected to the test only if the effectiveness of the grease film is unknown. The test is then made without removal of the grease.

23 Electromagnetic compatibility (EMC) requirements – Emission

23.1 General requirement

Electrical controls shall be so constructed that they do not emit excessive electric or electromagnetic disturbances in their environment as tested in 23.2 and 23.3.

Integrated and **incorporated controls** are not subjected to the tests of 23.2 and 23.3, as the results of these tests are influenced by the incorporation of the **control** into the equipment and the use of measures to control emissions used therein. They can, however, be carried out under declared conditions if so requested by the manufacturer or defined in dedicated standards given in Table 23 or Table 24.

An EMC test plan and report (see 25.2) shall be established prior to testing. It shall contain, as a minimum, the elements given in configuration of EUT during testing 23.2 to 23.3. It may be determined from consideration of the electrical characteristics and usage of a particular apparatus that some tests are inappropriate and therefore unnecessary. In such cases, the decision not to test shall be recorded in the EMC test plan and EMC test report.

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23.2 High frequency emission

23.2.1 Requirements

Electrical controls using wired network ports, software, oscillating circuits, or switching power supplies shall comply with the following:

– for **residential electromagnetic environment** or **industrial electromagnetic environments**, as indicated in Table 23,

NOTE 1 See also Table 1, requirement 75

– for **industrial electromagnetic environment**, as indicated in Table 24,

NOTE 2 See also Table 1, requirement 75

– for discontinuous disturbances as indicated in CISPR 14-1:2020, Subclause 4.4 if the test as detailed in 23.2.2 and 23.2.3 results in a maximum duration of radio frequency emission of 20 ms and where such controls have a click rate greater than 5 unless that examination and/or tests show that the minimum time between contact operations during normal operation cannot be less than 10 min.

– for ISM (Industrial, Scientific and Medical) equipment and free-standing, independently mounted and in-line cord controls for use with ISM equipments shall comply with the requirements of CISPR 11.

NOTE 3 See also Table 1, requirement 65.

NOTE 4 Wired network port is defined in CISPR 32:2015, 3.1.32.

NOTE 5 The relevant part 2 will indicate whether the requirements of this clause apply to integrated and incorporated **electrical controls**.

23.2.2 Test conditions

One previously untested sample is subjected to the test.

The electrical and thermal conditions are as specified in 19.2 and 19.3, except as follows:

– *for **sensing controls**, the rate of change of activating quantities is α_1 and β_1;*

– *for non-**sensing controls**, the **controls** are caused to operate at the lowest contact operating speed possible during normal operation;*

– *for **controls** declared for use with inductive loads, the power factor is 0,6, unless declared otherwise in Table 1, requirement 8. For **controls** declared with purely resistive loads, the power factor is 1,0.*

23.2.3 Test procedure

*The **control** is operated continuously but for a minimum of five **cycles of contact operation** during measuring cycle if relevant.*

*The duration of radio interference is measured by an oscilloscope connected to the **control** so as to measure the voltage drop across the contacts. The measuring instrumentation shall be in accordance with CISPR 14-1:2020, 5.1.7.*

NOTE For the purpose of this test, radio interference is any observed fluctuation of voltage across the contacts which is superimposed on the supply waveform as a result of contact **operation**.

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Table 23 – Emission limit for residential electromagnetic environment

Port	Frequency range	Limits	Limits for reference/example	Procedure	Applicability note	Remarks
Enclosure	30 MHz to 230 MHz 230 MHz to 1 GHz	CISPR 32 [a], Table A.4.2	40 dB(μV/m) quasi peak at 3 m 47 dB(μV/m) quasi peak at 3 m	CISPR 32 [a], Table A.1	See Note 1 Note 2	Allowed measurement distances: 3 m or 10 m
	30 MHz to 230 MHz 230 MHz to 1 GHz	CISPR 32 [a], Table A.4.1	30 dB(μV/m) quasi peak at 10 m 37 dB(μV/m) quasi peak at 10 m	CISPR 32 [a], Table A.1		
	1 GHz to 6 GHz	CISPR 32 [a], Table A.5	74 (μV/m) peak at 3 m 54 dB(μV/m) average at 3 m	CISPR 32 [a], Table A.1		
AC main	0,15 MHz to 0,5 MHz Limits decrease linearly with log. frequency	CISPR 32 [a], Table A.10	66 dB(μV) to 56 dB(μV) quasi peak 56 dB(μV) to 46 dB(μV) average	CISPR 32 [a], Table A.8, Clause A8.1		
	0,5 MHz to 5 MHz		56 dB(μV) quasi peak 46 dB(μV) average			
	5 MHz to 30 MHz		60 dB(μV) quasi peak 50 dB(μV) average			
	0,15 MHz to 30 MHz	CISPR 14-1:2020, Clause 4.4.2	Discontinuous disturbances	CISPR 14-1: 2020, Subclause 4.4		The statistical evaluation in the basic standard does not apply
DC power port	0,15 MHz to 0,5 MHz	IEC 61000-6-3 Table 5, Clause 5.1	79 dB(μV) quasi peak 66 dB(μV) average	IEC 61000-6-3: 2020, Annex B	See Note 3 Note 4	Measurement network V-AN
	0,5 MHz to 30 MHz		73 dB(μV) quasi peak 60 dB(μV) average			
	0,15 MHz to 0,5 MHz	IEC 61000-6-3 Table 5, Clause 5.2	84 dB(μV) to 74 dB(μV) quasi peak 74 dB(μV) to 64 dB(μV) average	IEC 61000-6-3: 2020, Annex B	See Note 3 Note 4	Measurement network Δ-AN
	0,5 MHz to 30 MHz		74 dB(μV) quasi peak 64 dB(μV) average			
HBES/BACS network port	0,15 MHz to 0,5 MHz Limits decrease linearly with log frequency	CISPR 32 [a], Table A.12 Clause A12.1	84 dB(μV) to 74 dB(μV) quasi peak 74 dB(μV) to 64 dB(μV) average	CISPR 32 [a], Table A.8, Clause A8.2	See Note 5	Coupling device AAN
		CISPR 32 [a], Table A.12 Clause A12.3	40 dB(μA) to 30 dB(μA) quasi peak 30 dB(μA) to 20 dB(μA) average	CISPR 32 [a], Table A.8, Clause A8.3	See Note 5	Coupling device Current probe
	0,5 MHz to 30 MHz	CISPR 32 [a], Table A.12 Clause A12.1	74 dB(μV) quasi peak 64 dB(μV) average	CISPR 32 [a], Table A.8, Clause A8.2	See Note 5	Coupling device AAN
		CISPR 32 [a], Table A.12 Clause A12.3	30 dB(μA) quasi peak 20 dB(μA) average	CISPR 32 [a], Table A.8, Clause A8.3	See Note 5	Coupling device Current probe

NOTE 1 Applicable only to **controls** containing processing devices, for example, microprocessors operating at frequencies greater than 9 kHz.

NOTE 2 Apply either 3 m or 10 m measuring distance.

NOTE 3 According IEC 61000-6-3, apply either Table 5, Subclause 5.1 (V-AM/V-AMN) or Subclause 5.2 (Δ-AN) across the required frequency range.

NOTE 4 For the applicability of the test in relation to the DC power source connection, see information in IEC 61000-6-3:2020 Annex B, Table B.1.

NOTE 5 According to CISPR 32, apply either coupling device A12.1 (AAN) or A12.3 (current probe).

[a] CISPR 32:2015 and CISPR 32:2015/AMD1:2019.

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Table 24 – Emission limit for industrial electromagnetic environment

Port	Frequency range	Limits	Limits for reference/example	Procedure	Applicability note	Remarks
Enclosure	30 MHz to 230 MHz 230 MHz to 1 GHz	CISPR 32 [a], Table A.2.2	50 dB(µV/m) quasi peak at 3 m 57 dB(µV/m) quasi peak at 3 m	CISPR 32 [a], Table A.1	See Note 1 Note 2	Allowed measurement distances: 3 m or 10 m
	30 MHz to 230 MHz 230 MHz to 1 GHz	CISPR 32 [a], Table A.2.1	40 dB(µV/m) quasi peak at 10 m 47 dB(µV/m) quasi peak at 10 m	CISPR 32 [a], Table A.1		
	1 GHz to 6 GHz	CISPR 32 [a], Table A.3	80 (µV/m) peak at 3 m 60 dB(µV/m) average at 3 m	CISPR 32 [a], Table A.1		
AC main	0,15 MHz to 0,5 MHz	CISPR 32 [a], Table A.9	79 dB(µV) quasi peak 66 dB(µV) average	CISPR 32 [a], Table A.8, Clause A8.1		
	0,5 MHz to 30 MHz		73 dB(µV) quasi peak 60 dB(µV) average			
	0,15 MHz to 30 MHz	CISPR 14-1: 2020, Clause 4.4.2	Discontinuous disturbances	CISPR 14-1:2020, Subclause 4.4		The statistical evaluation in the basic standard does not apply
DC power port	0,15 MHz to 0,5 MHz	IEC 61000-6-4 Table A.1, Clause A.1.1(informative)	89 dB(µV) quasi peak 76 dB(µV) average	IEC 61000-6-4: 2018, Annex A	See Note 3 Note 4	Measurement network AMN
	0,5 MHz to 30 MHz		83 dB(µV) quasi peak 70 dB(µV) average			
HBES/BACS network port	0,15 MHz to 0,5 MHz Limits decrease linearly with log frequency	CISPR 32 [a], Table A.11 Clause A11.1	97 dB(µV) to 87 dB(µV) quasi peak 84 dB(µV) to 74 dB(µV) average	CISPR 32 [a], Table A.8, Clause A8.2	See Note 5	Coupling device AAN
		CISPR 32 [a], Table A.11 Clause A11.3	53 dB(µA) to 43 dB(µA) quasi peak 40 dB(µA) to 30 dB(µA) average	CISPR 32 [a], Table A.8, Clause A8.3	See Note 5	Coupling device Current probe
	0,5 MHz to 30 MHz	CISPR 32 [a], Table A.11 Clause A11.1	87 dB(µV) quasi peak 74 dB(µV) average	CISPR 32 [a], Table A.8, Clause A8.2	See Note 5	Coupling device AAN
		CISPR 32 [a], Table A.11 Clause A11.3	43 dB(µA) quasi peak 30 dB(µA) average	CISPR 32 [a], Table A.8, Clause A8.3	See Note 5	Coupling device Current probe

NOTE 1 Applicable only to **controls** containing processing devices, for example, microprocessors operating at frequencies greater than 9 kHz.

NOTE 2 Apply either 3 m or 10 m measuring distance.

NOTE 3 According IEC 61000-6-4:2018, if declared in Table 1, requirement 75 of this document. Remark: IEC 61000-6-4:2018, Annex A is informative.

NOTE 4 For the applicable test in relation to the DC power source connection, see information in IEC 61000-6-4:2018 Annex A, Table A.2.

NOTE 5 According to CISPR 32, apply either coupling device A11.1 (AAN) or A11.3 (current probe).

[a] CISPR 32:2015 and CISPR 32:2015/AMD1:2019.

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23.3 Low frequency emission

23.3.1 Requirements

Controls in which an **electronic device** controls directly an external load connected to the mains power supply (the **control** port) shall comply with the requirements of IEC 61000-3-2 and IEC 61000-3-3 for external load current ≤ 16 A per phase, and IEC 61000-3-11 and IEC 61000-3-12 for external load current > 16 A and ≤ 75 A per phase.

23.3.2 Test procedure

For these tests, a load and measures to control emissions, if any, shall be used as declared by the manufacturer in Table 1 requirement 54. This requirement does not apply to **controls** declared and designed for **pilot duty** load only.

24 Normal operation

24.1 Output waveform of electronic controls

The output waveform of **electronic controls** shall be as declared.

*The output waveform of the **control** shall be examined under all normal operating conditions and shall be either sinusoidal or as declared in Table 1, requirement 48.*

NOTE Attention is drawn to IEC 61000-3-2 and IEC 61000-3-3, which impose restriction on mains disturbances.

24.2 Operation within the voltage range

A **control** incorporating an electro-magnet shall operate as intended at any voltage within the range of 85 % of the minimum rated voltage and 110 % of the maximum rated voltage, inclusive.

*Compliance is checked by subjecting the **control** to the following tests at the maximum and minimum operating conditions declared, except that only a **control** having T_{min} less than 0 °C is tested at T_{min}:*

*The **control** is subjected to 1,1 $V_{R\ max}$ until equilibrium temperature is reached and then tested immediately for **operation** at 1,1 $V_{R\ max}$ and at rated voltage.*

*The **control** is also subjected to 0,85 $V_{R\ min}$ until equilibrium temperature is reached and then tested immediately for **operation** at 0,85 $V_{R\ min}$.*

Battery powered controls shall be tested at a maximum voltage and at a minimum voltage as declared by the manufacturer in Table 1, requirement 85*.*

25 Electromagnetic compatibility (EMC) requirements – Immunity

25.1 General

Electronic controls shall be evaluated in accordance with the Table 25:

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Table 25 – The applicable EMC test in relation to the class of control function and type of Action

Construction of control/ application	Class of control function			
	Class A		Class B	Class C
	Type 1 action	Type 2 action		
Integrated controls	25.7 to 25.10 (if declared)[a] 25.5 to 25.10 (if requested)[b]	25.7 to 25.10 25.5 to 25.10 (if requested)[b]	25.5, 25.6 and Clause H.25	Clause H.25
Incorporated controls	25.7 to 25.10 (if declared)[a] 25.5 to 25.10 (if requested)[b]	25.7 to 25.10 25.5 to 25.10 (if requested)[b]	Clause H.25	Clause H.25
In-line cord controls, free-standing controls and **independently mounted controls** for HBES/BACS application and equipment that uses integrated/ incorporated controls for HBES/BACS application	25.5, 25.6 and 25.7 to 25.10 (if declared)[a]	25.5 to 25.10	25.5, 25.6 and Clause H.25	25.5, 25.6 and Clause H.25

[a] If declared in Table 1, requirement 86.

[b] If requested by the manufacturer of the control in Table 1, requirement 84.

25.2 EMC test plan and report

25.2.1 General

An EMC test plan shall be established prior to testing. It shall contain, as a minimum, the elements given in configuration of EUT during testing for emission in 23.1 and for immunity in 25.5 to 25.10. It may be determined from consideration of the electrical characteristics and usage of a particular apparatus that some tests are inappropriate and therefore unnecessary. In such cases, the decision not to test shall be recorded in the EMC test plan and EMC test report.

25.2.2 Configuration of EUT during testing

25.2.2.1 General

Controls and control equipment often consists of **systems** with no fixed configuration. The kind, number and installation of different subassemblies within the control equipment may vary from **system** to **system**. Thus it is reasonable, and also recommended, not to test every possible arrangement.

To simulate EMC conditions (related both to emission and immunity), the control equipment assembly shall represent a typical installation as specified by the manufacturer. Such tests shall be carried out as type tests under normal conditions as specified by the manufacturer.

25.2.2.2 Composition of EUT

All devices, racks, modules, boards, etc. significant to EMC and belonging to the EUT shall be documented in the EMC test plan and EMC test report. If relevant, the software version shall be documented in the EMC test plan and EMC test report.

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25.2.2.3 Assembly of EUT

If an EUT has a variety of internal and external configurations, the type tests shall be made with one or more typical configurations that represent normal use. The rationale for this selection shall be documented in the EMC test plan and EMC test report.

25.2.2.4 I/O ports

Where there are multiple I/O ports which are all of the same type, connecting a cable to just one of those ports is sufficient, provided that it can be shown that the additional cables would not affect the results significantly.

25.2.2.5 Auxiliary equipment

When a variety of devices is provided for use with the EUT, at least one of each type of device shall be selected to simulate actual operating conditions. Auxiliary devices can be simulated.

25.2.2.6 Cabling and earthing (grounding)

The cables and earth (ground) shall be connected to the EUT in accordance with the manufacturer's specifications. There shall be no additional earth connections.

25.2.3 Operation conditions of EUT during testing

25.2.3.1 Operation modes

A selection of representative operation modes shall be made, taking into account that not all functions, but only the most typical functions of the electronic control can be tested. The estimated worst-case operating modes for normal application shall be selected.

NOTE The standby condition of the control is considered to be an operating mode.

25.2.3.2 Environmental conditions

The tests shall be carried out within the manufacturer’s specified environmental operating range (for example, ambient temperature, humidity, atmospheric pressure), and within the rated ranges of supply voltage and frequency.

25.2.3.3 EUT software during test

The software used for simulating the different modes of operation shall be documented. This software shall represent the estimated worst-case operating mode for normal application.

25.2.3.4 Specification of performance criteria

For immunity tests, performance criteria for each operating mode and test shall be specified; where possible, as quantitative values.

25.2.3.5 Test description

Each test to be applied shall be specified in the EMC test plan. The description of the tests, the test methods, the characteristics of the test, and the test set-ups are given in the basic standards, which are referred for emission in Table 23 or Table 24 and for immunity in Table 26 or Table 27. Additional information needed for the practical implementation of the tests is given in this document. The contents of standards need not be reproduced in the test plan. In some cases, the EMC test plan shall specify the application in detail.

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25.3 Immunity requirements

25.3.1 Conditions during the test

The configuration and modes of operation during the tests shall be precisely noted in the test report.

Tests shall be applied to the relevant ports in accordance with Table 26 or Table 27 as applicable.

The tests shall be conducted in accordance with the basic standards. The tests shall be carried out one at a time. If additional methods are required, the method and rationale shall be documented in the test report.

25.3.2 Immunity test requirements

The immunity testing requirements for **residential electromagnetic environments** are given in Table 26 as declared in Table 1, requirement 77.

The immunity testing requirements for **industrial electromagnetic environment** are given in Table 27 as declared in Table 1, requirement 78.

Table 26 – Immunity test requirements for residential electromagnetic environments

Port	Phenomenon	Basic standard	Test value	Performance criteria	
				m	n
Enclosure	Electrostatic discharge ESD	IEC 61000-4-2	±8 kV air / ±4 kV contact	B	
	EM field	IEC 61000-4-3 [g, h, i]	3 V/m (80 MHz to 1 GHz)	A	
			3 V/m (1,4 GHz to 6 GHz)	A	
			10 V/m (80 MHz to 1GHz)		B
	Power-frequency magnetic field [e]	IEC 61000-4-8	3 A/m (50 Hz, 60 Hz)	A	
AC power supply (including protective earth)	Voltage dip [k]	IEC 61000-4-11	0 % during 0,5 cycle	B	A
			0 % during 1 cycle	B	A
			70 % during 25/30 cycles [l]	C	
			40 % during 10/12 cycles [l]		B
	Voltage interruptions [k]	IEC 61000-4-11	0 % during 250/300 cycles [l]	C	
	Burst	IEC 61000-4-4	±1 kV (5/50 ns, 5 kHz) [o]	B	A
			±2 kV (5/50 ns, 5 kHz) [o]		B
	Surge [p]	IEC 61000-4-5	±1 kV a, n / ±2 kV [b, o]	B	
	Conducted RF	IEC 61000-4-6	3 V (150 kHz to 80 MHz) [q]	A	
			10 V (150 kHz to 80 MHz) [q]		B
DC power port [f] (including protective earth)	Burst [j, r]	IEC 61000-4-4	±0,5 kV (5/50 ns, 5 kHz) [o]	B	A
			±1 kV (5/50 ns, 5 kHz) [o]		B
	Surge [c, j, r]	IEC 61000-4-5	±0,5 kV a, n /±1 kV [b, o]	B	
			±2 kV [b, o]		B
	Conducted RF [d]	IEC 61000-4-6	3 V (150 kHz to 80 MHz) [q]	A	
			10 V (150 kHz to 80 MHz) [q]		B

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Port	Phenomenon	Basic standard	Test value	Performance criteria	
				m	n
I/O signal/ control ports (including lines connected to functional earth port)	Burst [d]	IEC 61000-4-4	±0,5 kV (5/50 ns, 5 kHz) [o]	B	A
			±1 kV (5/50 ns, 5 kHz) [o]		B
	Surge [c]	IEC 61000-4-5	±1kV [b, o]	B	
			±0,5 kV [a, o] / ±2 kV [b, o]		B
	Conducted RF [d]	IEC 61000-4-6	3 V (150 kHz to 80 MHz) [q]	A	
			10 V (150 kHz to 80 MHz) [q]		B
HBES/BACS network lines	Burst [d]	IEC 61000-4-4	±0,5 kV (5/50 ns, 5 kHz) [o]		A
			±1 kV (5/50 ns, 5 kHz) [o]		B
	Surge [c]	IEC 61000-4-5	±0,5 kV [a, o] / ±2 kV [b, o]		B
	Conducted RF [d]	IEC 61000-4-6	3 V (150 kHz to 80 MHz) [q]		A
			10 V (150 kHz to 80 MHz) [q]		B

[a] Line to line.

[b] Line to earth (ground).

[c] Only in the case of long-distance lines, see 3.24.9 (declared in Table 1, requirement 79).

[d] Only in the case of lines >3 m (declared in Table 1, requirement 80).

[e] Applicable only to apparatus containing devices susceptible to magnetic fields (declared in Table 1, requirement 83).

[f] DC ports and connections between parts of equipment/**system** which are not connected to a DC distribution network are treated as I/O signal/control ports.

[g] IEC 61000-4-20 may be used for small EUTs as defined in IEC 61000-4-20.

[h] A fully anechoic room (FAR) as described in IEC 61000-4-22 may also be used as a test site for radio-frequency immunity test.

[i] A reverberation chamber (RVC) as described in IEC 61000-4-21 may also be used (details see IEC 61000-6-1 and IEC 61000-4-21).

[j] Not applicable to input ports intended for connection to a battery or a rechargeable battery which shall be removed or disconnected from the apparatus for recharging.

[k] Applicable only to input ports.

[l] For example, “25/30 cycles" means "25 cycles for 50 Hz test" or "30 cycles for 60 Hz test” (declared in Table 1, requirement 81).

[m] Default performance criteria for all controls.

[n] Additional requirement to Footnote [m] for controls intended to be used in accordance with IEC 63044-5-2 HBES/BACS networks (declared in Table 1, requirement 82).

[o] Open-circuit test voltage.

[p] Apparatus with an AC power input port intended for use with a mains transformer shall be tested on the mains input of the transformer specified by the manufacturer or, where none is so specified, using a typical transformer of min. 300 VA.

[q] The test level specified is the RMS value of the un-modulated carrier.

[r] Equipment with a DC power input port intended for use with an AC–DC power adaptor shall be tested on the AC power input of the AC–DC power adaptor specified by the manufacturer or, where no adaptor is specified, the test shall be done on the DC power port using the test levels of this table.

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Table 27 – Immunity test requirements for industrial electromagnetic environment

Port	Phenomenon	Basic standard	Test value	Performance criteria
Enclosure	Electrostatic discharge (ESD)	IEC 61000-4-2	±8 kV air / ±4 kV contact	B
	EM field	IEC 61000-4-3 [g, h, i]	10 V/m (80 MHz to 1 GHz)	A
			3 V/m (1,4 GHz to 6 GHz)	A
	Rated power frequency magnetic field [e]	IEC 61000-4-8	30 A/m	A
AC power supply	Voltage dip [k]	IEC 61000-4-11	0 % during 0,5 cycle	B
			0 % during 1 cycle	B
			70 % during 25/30 cycles [l]	C
	Short interruptions [k]	IEC 61000-4-11	0 % during 250/300 cycles [l]	C
	Burst	IEC 61000-4-4	±2 kV (5/50 ns, 5 kHz) [n]	B
	Surge [o]	IEC 61000-4-5	±1 kV [a, n] / ±2 kV [b, n]	B
	Conducted RF	IEC 61000-4-6	10 V (150 kHz to 80 MHz) [o]	A
DC power port [f] (including protective earth)	Burst [j, q]	IEC 61000-4-4	±1 kV (5/50 ns, 5 kHz) [n]	B
	Surge [c, j, q]	IEC 61000-4-5	±1 kV [a, n] / ±2 kV [b, n]	B
	Conducted RF [d]	IEC 61000-4-6	10 V (150 kHz to 80 MHz) [p]	A
I/O signal/ control ports (including lines connected to functional earth port)	Burst [d]	IEC 61000-4-4	±1 kV (5/50 ns, 5 kHz) [n]	B
	Surge [c]	IEC 61000-4-5	±1 kV [b, n]	B
	Conducted RF [d]	IEC 61000-4-6	10 V (150 kHz to 80 MHz) [p]	A
HBES/BACS network lines [m]	Burst [d]	IEC 61000-4-4	±0,5 kV (5/50 ns, 5 kHz) [n]	A
	Surge [c]	IEC 61000-4-5	±1kV [a, n] / ±2kV [b, n]	B
	Conducted RF [d]	IEC 61000-4-6	10 V (150 kHz to 80 MHz) [p]	A

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[a]	Line to line.
[b]	Line to earth (ground).
[c]	Only in the case of long-distance lines, see 3.24.9 (declared in Table 1, requirement 79).
[d]	Only in the case of lines >3 m (declared in Table 1, requirement 80).
[e]	Applicable only to apparatus containing devices susceptible to magnetic fields (declared in Table 1, requirement 83).
[f]	DC ports and connections between parts of equipment/**system** which are not connected to a DC distribution network are treated as I/O signal/control ports.
[g]	IEC 61000-4-20 may be used for small EUTs as defined in IEC 61000-4-20.
[h]	A fully anechoic room (FAR) as described in IEC 61000-4-22 may also be used as a test site for radio-frequency immunity test.
[i]	A reverberation chamber (RVC) as described in IEC 61000-4-21 may also be used (details see IEC 61000-6-1 and IEC 61000-4-21).
[j]	Not applicable to input ports intended for connection to a battery or a rechargeable battery which shall be removed or disconnected from the apparatus for recharging.
[k]	Applicable only to input ports.
[l]	For example “25/30 cycles" means "25 cycles for 50 Hz test" or "30 cycles for 60 Hz test” (declared in Table 1, requirement 81).
[m]	Additional requirement for controls intended to be used in accordance with IEC 63044-5-3 HBES/BACS networks (declared in Table 1, requirement 82).
[n]	Open-circuit test voltage.
[o]	Apparatus with an AC power input port intended for use with a mains transformer shall be tested on the mains input of the transformer specified by the manufacturer or, where none is so specified, using a typical transformer of min. 300 VA.
[p]	The test level specified is the RMS value of the un-modulated carrier.
[q]	Equipment with a DC power input port intended for use with an AC–DC power adaptor shall be tested on the AC power input of the AC–DC power adaptor specified by the manufacturer or, where no adaptor is specified the test shall be done on the DC power port using the test levels of this table.

25.4 Performance criteria

The performance criteria are given in Table 28 and are based on the operating conditions and the functional specification of the control during and after the test.

After the test, the control shall meet the requirements of Clause 6, 15.2 and Clause 11.

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Table 28 – Performance criteria

Operating conditions	Performance criteria		
	A	B	C
Digital Inputs/Outputs	No deviation on input readings. No deviation on output settings. (no change of state)	No deviation on input readings. No deviation on output settings. (no change of state)	Any error, such as a change of state, destruction of data, and loss of a connection is permitted, provided the initial state is restored automatically after the test – Automatic recovery after the test [b]
Analogue Inputs/Outputs	Deviation as declared in the final product specification is permitted [a]	Deviation is permitted during test	
Display, Monitor	Operation shall be possible at reasonable comfort	Deviation is permitted (e.g. display **fault**, such as flickering)	
Local operator override/ switching	No deviation	Deviation is permitted for analogue values No change of state for digital values	
HBES/BACS network port Communication ports	No deviation detectable by the user. The reduced data transfer rate shall be reasonable for the control operation	Degradation of performance is allowed, but not loss of communication for longer than 1 min.	

[a] The permissible deviation is with respect to the value without electromagnetic interference. This means that any basic deviation is ignored.

[b] This performance criteria is based on the fact that the control operation in the end user application will be unsupervised.

25.5 Surge immunity test

The control is mounted as specified in 4.3.2.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with IEC 61000-4-5.

The test values for the declared EMC level are specified in Table 26 or Table 27.

Repetition rate: maximum 1/min

Polarity: positive (+) and negative (−)

Number of pulses: five pulses for each polarity are applied

Phase angle: 0°, 90°, 180° and 270° versus the phase angle of the ac line voltage to the equipment under test.

NOTE Most protectors in common use have low average power capabilities, even though their peak power or peak energy handling can deal with high currents. Therefore, the maximum repetition rate (the time between two surges and the recovery time) depends on the built-in protection devices of the EUT.

25.6 Electrical fast transient immunity test

The control is mounted as specified in 4.3.2.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with IEC 61000-4-4.

The test values for the declared EMC level are specified in Table 26 or Table 27.

Polarity: positive (+) and negative (−)

Duration: one minute for each polarity

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25.7 Radio-frequency electromagnetic field immunity

25.7.1 Immunity to conducted disturbances

The control is mounted as specified in 4.3.2.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with IEC 61000-4-6. The complete frequency range being swept at least once.

The test levels/test voltage values for the declared EMC level are specified in Table 26 or Table 27.

25.7.2 Immunity to radiated electromagnetic fields

The control is mounted as specified in 4.3.2.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with IEC 61000-4-3. The complete frequency range being swept at least once.

The test values for the declared EMC level are specified in Table 26 or Table 27.

25.8 Electrostatic discharge

The control is mounted as specified in 4.3.2.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with IEC 61000-4-2.

The test values for the declared EMC level are specified in Table 26 or Table 27, where 5 discharges in each polarity (+/−) shall be applied:

- Contact discharges: shall be applied to those points and surfaces of the EUT which are accessible to persons during normal use and to the HCP and VCP in accordance with the basic standard.
- Air discharges: shall be applied to those points and surfaces of the EUT which are accessible to persons during normal use.

25.9 Immunity to power-frequency magnetic fields

This test is only applicable to controls containing devices susceptible to magnetic fields. (e.g. hall-effect devices) and if declared by the manufacturer (declared in Table 1, requirement 83).

The control is mounted as specified in 4.3.2.1, supplied at rated voltage and operated at representative operating conditions. It is tested in accordance with IEC 61000-4-8.

The test values for the declared EMC level are specified in Table 26 or Table 27.

25.10 Test of the influence of voltage dips and voltage interruption in the power supply network

During the test, the control shall be initially operated at its rated voltage. The control is operated at representative operating conditions.

It is tested in accordance with IEC 61000-4-11. The test is only applicable to AC power input ports.

The test values for the declared EMC level are specified in Table 26 or Table 27.

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26 Abnormal operation tests

26.1 Abnormal temperature test

26.1.1 Burnout test

26.1.1.1 Controls incorporating electro-magnets shall withstand the effects of blocking of the control mechanism.

Compliance is checked by the tests of 26.1.1.2 and 26.1.1.3.

NOTE For relays and contactors, compliance with this requirement is established by successful completion of the tests of Clause 19.

26.1.1.2 The control mechanism is blocked in the position assumed when the control is de-energized. The control is then energized at rated frequency and rated voltage as indicated in 19.2.2, 19.2.3 a) and 19.2.3 b).

The duration of the test is either 7 h; or until an internal protective device, if any, operates; or until burnout, whichever occurs first.

26.1.1.3 After this test, the control shall be deemed to comply if:

– *there has been no emission of flame or molten metal, and there is no evidence of damage to the **control** which would impair compliance with this document;*

– *the requirements of 15.2 are still met.*

NOTE The **control** need not be operative following the test.

26.1.2 Blocked mechanical output test

26.1.2.1 **Controls** with motors, such as electric actuators, shall withstand the effects of blocked output without exceeding the temperatures indicated in Table 29. Temperatures are measured by the method specified in 16.7 a). This test is not conducted on **controls** with motors, such as electric actuators, where, when tested under blocked output conditions for 7 h, any protective device, if provided, does not cycle under stalled conditions, and which do not exceed temperature limits in Table 17.

26.1.2.2 **Controls** with motors, such as electric actuators, are tested for 24 h with the output blocked at rated voltage and in a room temperature in the range of 15 °C to 30 °C, the resulting measured temperature being corrected to a 25 °C reference value.

For **controls** with motors declared for three-phase **operation**, the test is to be carried out with any one phase disconnected.

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Table 29 – Maximum winding temperature (for test of mechanical blocked output conditions)

Condition	Temperature of insulation by class °C							
	A	**E**	**B**	**F**	**H**	**200**	**220**	**250**
If impedance protected:	150	165	175	190	210	230	250	280
If protected by protective devices:								
During first hour	200	215	225	240	260	280	300	330
– maximum value								
After first hour								
– maximum value	175	190	200	215	235	255	275	305
– arithmetic average	150	165	175	190	210	230	250	280

26.1.2.3 The average temperature shall be within the limits during both the second and the twenty-fourth hours of the test.

NOTE The average temperature of a winding is the arithmetic average of the maximum and minimum values of the winding temperature during the 1 h period.

26.1.2.4 During the test, power shall be continually supplied to the motor.

26.1.2.5 Immediately upon completion of the test, the motor shall be capable of withstanding the electric strength test specified in Clause 15, without first applying the humidity treatment of 14.2.

26.2 Overload tests

26.2.1 Overload tests carried out on in-line cord controls as indicated in 9.10.2 and provided with a plug and socket outlet

The tests according to 26.2.3 shall be carried out.

The temperature shall not exceed those indicated in Table 17.

26.2.2 For controls not covered by 26.2.1

*The tests according to 26.2.3 shall be carried out at ambient temperature (20 ± 5) °C. If declared in Table 1, requirement 70, the test will not be done for **incorporated controls** and **integrated controls**.*

26.2.3 Tests

The tests of 26.2.3 are not applicable to controls where the load is integrated within the control or when the connected load is declared in Table 1, requirement 8 and controlled; Example: fixed equipment.

The tests are conducted as follows.

- ***Controls** as specified without protective devices and without incorporated fuses are loaded for 1 h with the conventional tripping current for the fuse which in the installation will protect the **control**.*
- ***Controls** protected by protective devices (including fuses) are loaded in such a way that the current through the **control** is 0,95 times the current with which the protective device releases after 1 h. The temperature rise is measured after a steady state has been reached or after 4 h, whichever is the shorter time.*

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– ***Controls*** *protected by incorporated fuses complying with IEC 60127 series or IEC 60269 series shall have those fuses replaced by links of negligible impedance and shall be loaded in such a manner that the current through the links shall be 2,1 times the rated current of the fuse. The temperature rise is measured after the* ***control*** *has been loaded for 30 min. The value 2,1 times can be de-rated by 0,5 %/K, if the overload test is carried out at a higher temperature compared to normal room temperature.*

– ***Controls*** *protected both by incorporated fuses and by protective devices are loaded either as described above with incorporated fuses or with another protective device, choosing the test requiring the lower load.*

– ***Controls*** *protected by protective devices which will short-circuit only in case of overload shall be tested both as* ***controls*** *with protective devices and as* ***controls*** *without protective devices.*

The compliance with items a) to g) of 13.1.3.8, where applicable, is verified.

26.3 Battery short-circuit test

26.3.1 For **controls** having batteries that can be removed without the aid of a **tool** and having terminals that can be short-circuited by a thin straight bar, the terminals of the battery are short-circuited with the battery being fully charged.

The duration of the test is either 1 h or until ultimate condition exists, whichever occurs first.

26.3.2 After this test, the **control** shall be deemed to comply if:

– *there has been no emission of flame or molten metal, and there is no evidence of damage to the* ***control*** *which would impair compliance with this document;*

– *the requirements of 15.2 are still met.*

NOTE The **control** need not be operative following the test.

Dimensions in millimetres

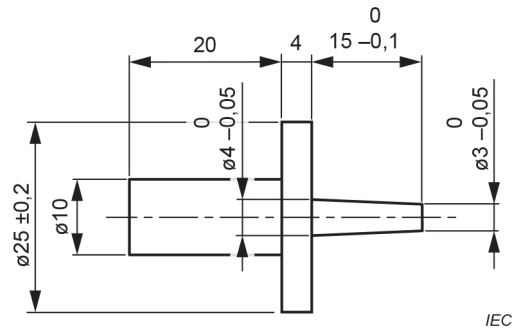
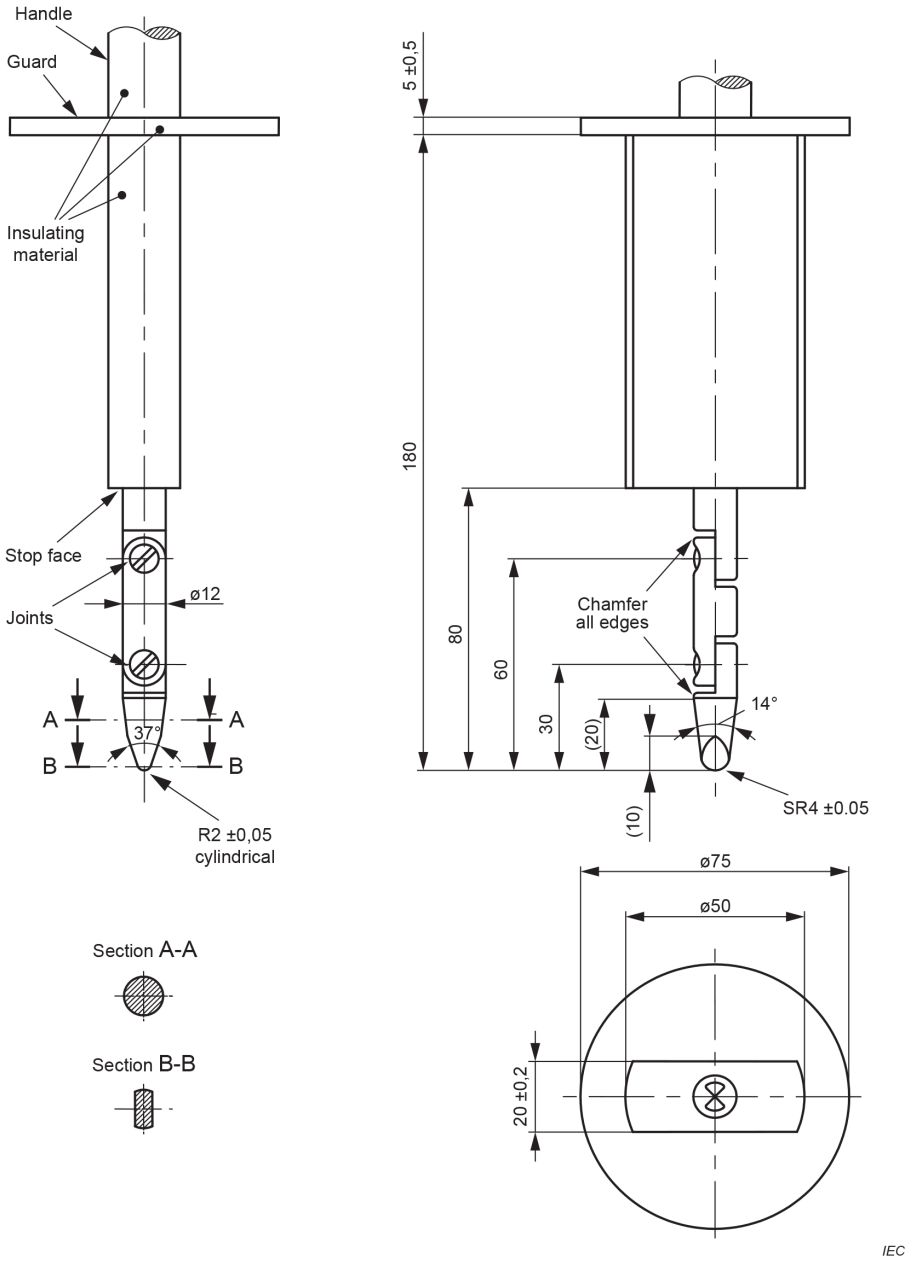


Figure 4 – Test pin probe 13 of IEC 61032:1997

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Linear dimensions in millimetres



Tolerances on dimensions without specific tolerance:

on angles $^{0}_{-10}$ °

on linear dimensions:

up to 25 mm: $^{0}_{-0,05}$

over 25 mm: ±0,2

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

Both joints of this finger may be bent through an angle of 90° but in one and the same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason, dimensions and tolerances of these details are not given in the drawing. The actual design shall ensure a 90° bending angle with a 0° to 10° tolerance.

Figure 5 – Test finger probe B of IEC 61032:1997

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Dimensions in millimetres

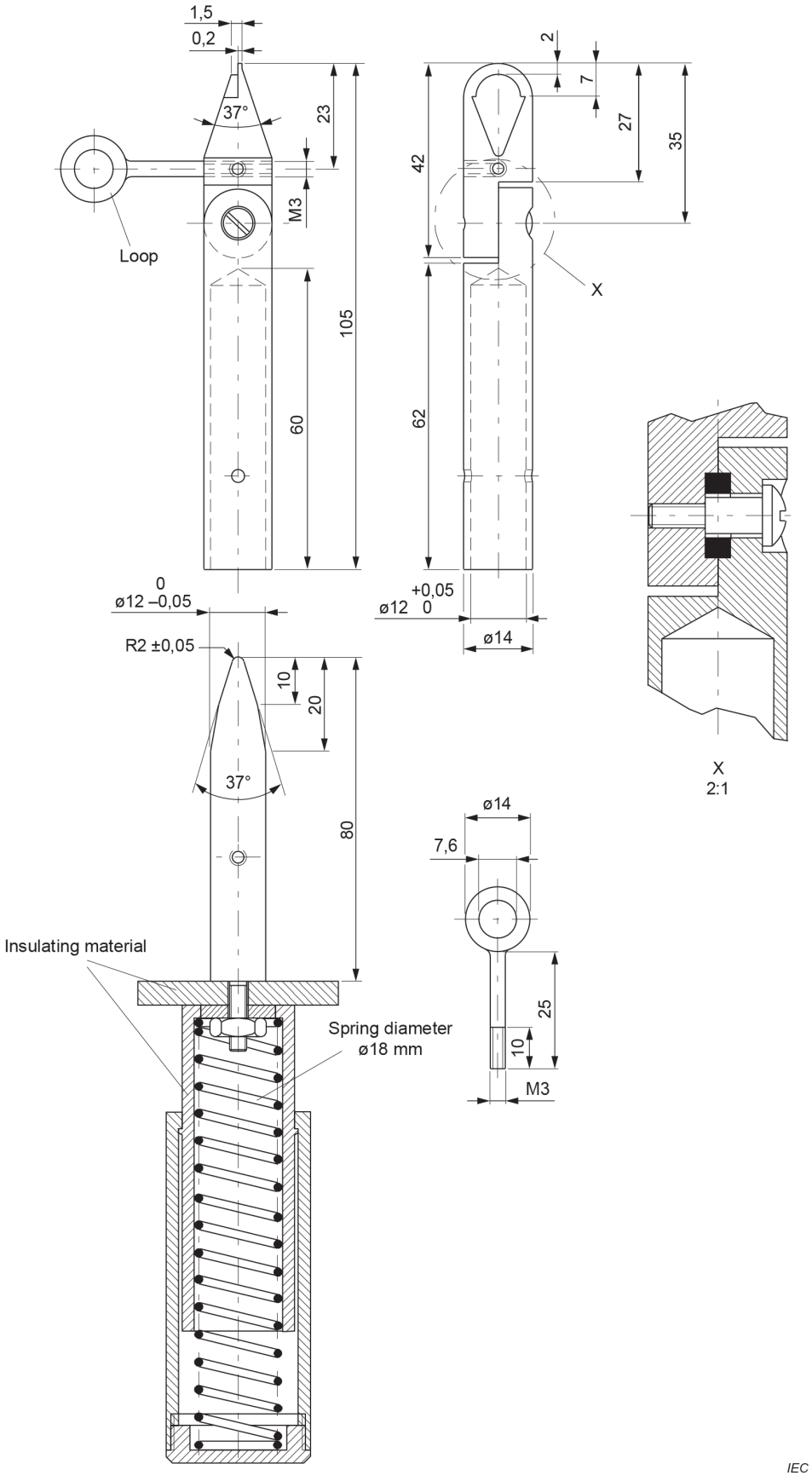


Figure 6 – Test fingernail

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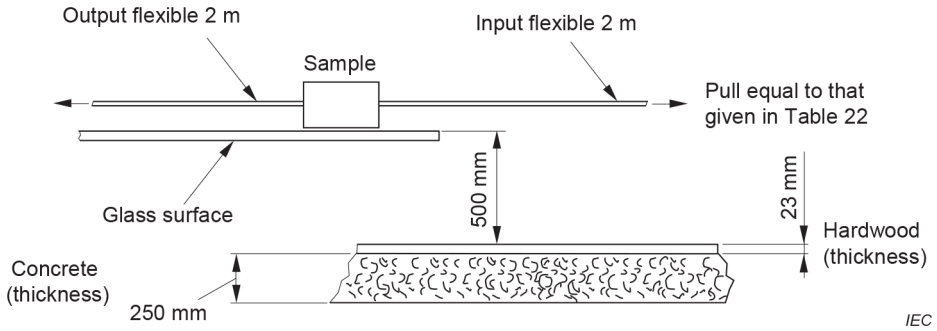


Figure 7 – Impact test for free-standing controls

Dimensions in millimetres

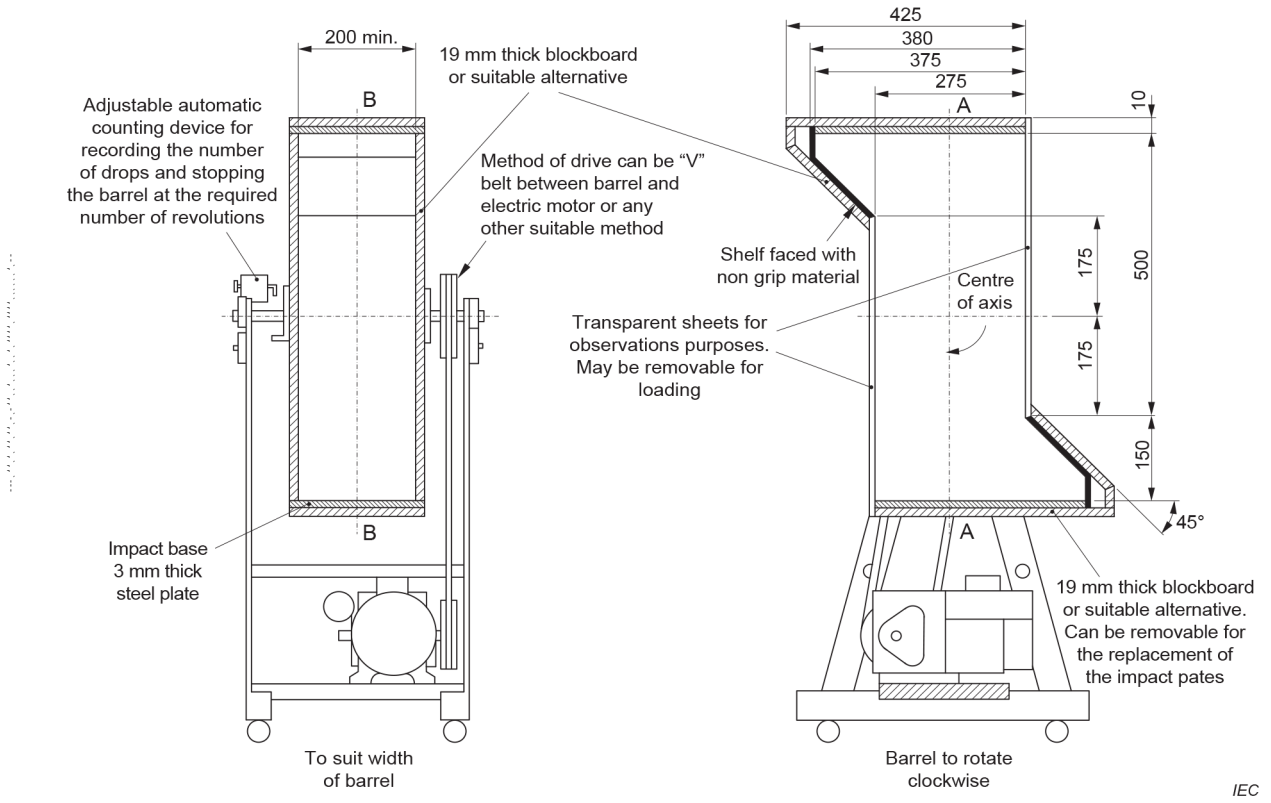


Figure 8 – Tumbling barrel

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Dimensions in millimetres

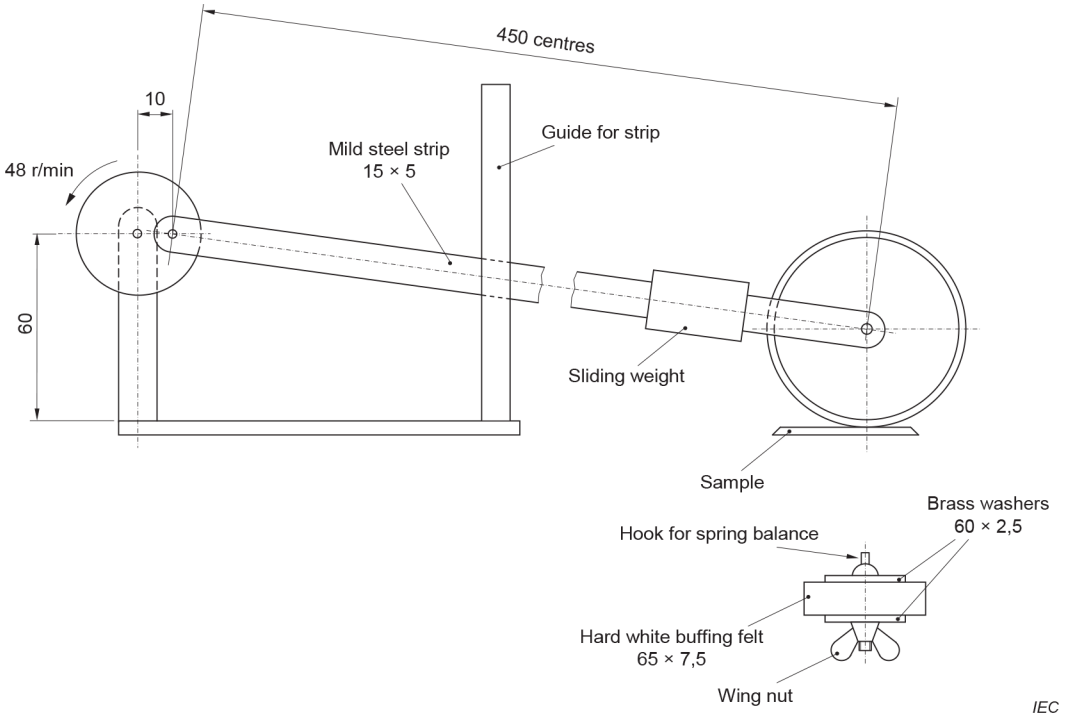


Figure 9 – Apparatus for testing durability of markings on rating labels

Dimensions in millimetres

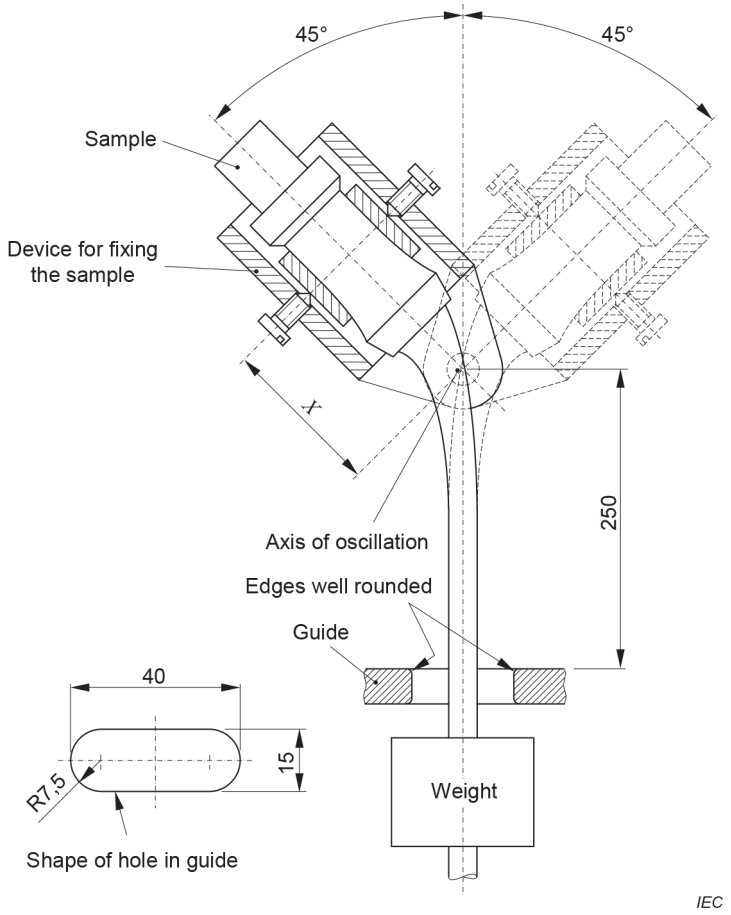
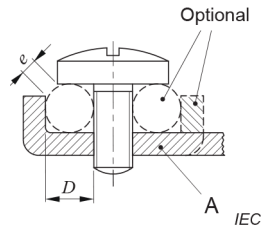
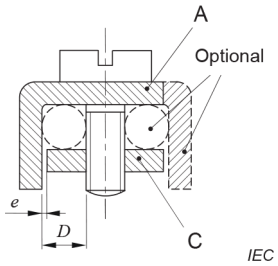


Figure 10 – Apparatus for flexing test

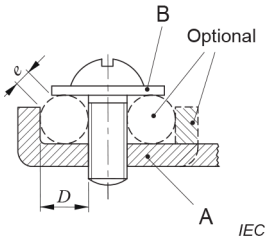
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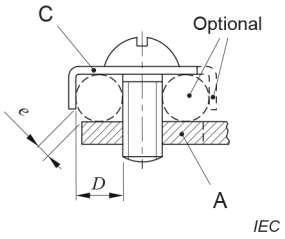
Screws not requiring washer, clamping plate or anti-spread device



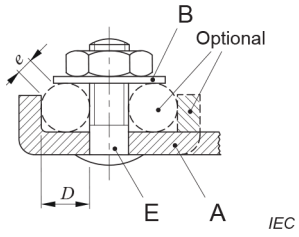


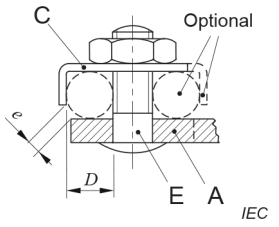
Screws requiring washer, clamping plate or anti-spread device





Screw terminals





Stud terminals

A fixed part B washer or clamping plate C anti-spread device

D conductor space E stud

Current carried by terminal [a]		**Minimum diameter conductor space**	**Maximum gap between conductor restraining parts**	**Minimum torque** Nm			
				Slotted screws		**Other screws**	
For flexible conductor	**For fixed conductor**			**One screw**	**Two screws**	**One screw**	**Two screws**
A	*A*	*D*	*e*	*g*	*g*		
0 to 6	0 to 6	1,4	1,0	0,4	–	0,4	–
6 to 10	0 to 6	1,7	1,0	0,5	–	0,5	–
10 to 16	6 to 10	2,0	1,5	0,8	–	0,8	–
16 to 25	10 to 16	2,7	1,5	1,2	0,5	1,2	0,5
25 to 32	16 to 25	3,6	1,5	2,0	1,2	2,0	1,2
–	25 to 32	4,3	2,0	2,0	1,2	2,0	1,2
32 to 40	32 to 40	5,5	2,0	2,0	1,2	2,0	1,2
40 to 63	40 to 63	7,0	2,0	2,0	2,0	3,0	2,0

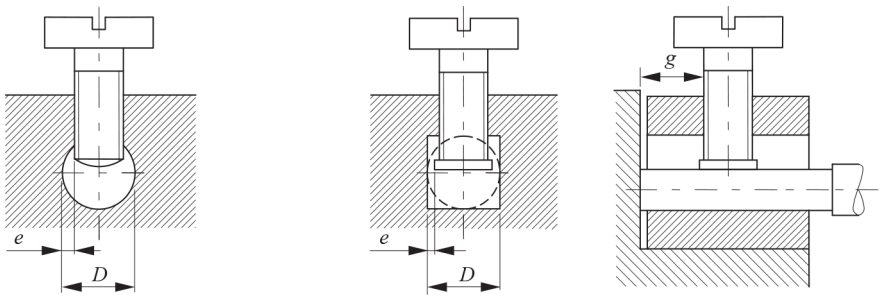
The part which retains the conductor in position may be of insulating material, provided that the pressure necessary to clamp the conductor is not transmitted through the insulating material.

The sketches are not intended to govern design except as regards the dimensions shown.

[a] Requirements for applications greater than 63 A are under consideration.

Figure 11 – Screw terminals and stud terminals

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Terminal without pressure plate

Terminal with pressure plate

IEC

Dimensions in millimetres

Current carried by terminal [a]		Minimum diameter conductor space	Maximum gap between conductor restraining parts	Minimum distance between clamping screw and end of conductor when fully inserted		Minimum torque Nm					
For flexible conductor	For fixed conductor					Screws without heads		Slotted screws		Other screws	
				One screw	Two screws	One screw	Two screws	One screw	Two screws	One screw	Two screws
A	A	*D*	*e*	*g*	*g*						
0 to 10	0 to 6	2,5	0,5	1,5	1,5	0,2	0,2	0,4	0,4	0,4	0,4
10 to 16	6 to 10	3,0	0,5	1,5	1,5	0,25	0,2	0,5	0,4	0,5	0,4
16 to 25	10 to 16	3,6	0,5	1,8	1,5	0,4	0,2	0,8	0,4	0,8	0,4
25 to 32	16 to 25	4,0	0,6	1,8	1,5	0,4	0,25	0,8	0,5	0,8	0,5
-	25 to 32	4,5	1,0	2,0	1,5	0,7	0,25	1,2	0,5	1,2	0,5
32 to 40	32 to 40	5,5	1,3	2,5	2,0	0,8	0,7	2,0	1,2	2,0	1,2
40 to 63	40 to 63	7,0	1,5	3,0	2,0	1,2	0,7	2,5	1,2	3,0	1,2

The part of the terminal containing the threaded hole and the part of the terminal against which the conductor is clamped by the screw may be two separate parts; as in the case of terminals provided with a stirrup.

The shape of the conductor space may differ from those shown in the figures, provided a circle with a diameter equal to the minimum value specified for D can be inscribed.

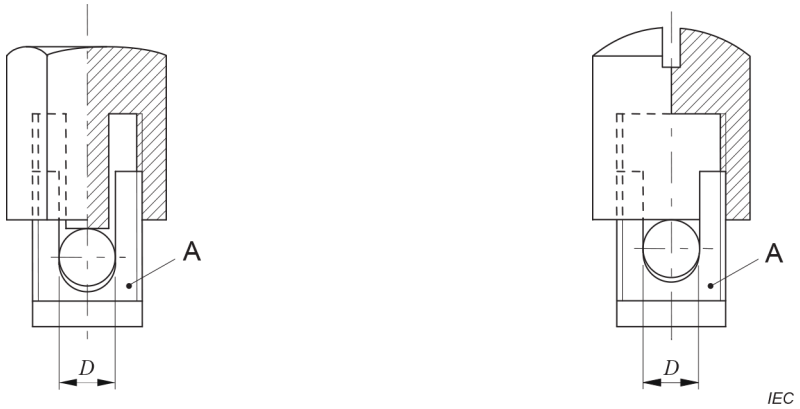
The minimum distance between the clamping screw and the end of the conductor when fully inserted applies only to the terminals in which the conductor cannot pass right through.

The sketches are not intended to govern design except as regards the dimensions shown.

[a] Requirements for applications greater than 63 A are under consideration.

Figure 12 – Pillar terminals

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A fixed part

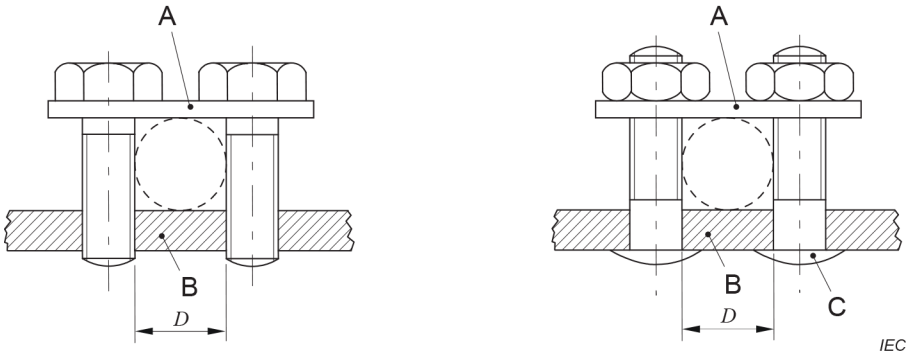
D conductor space

The bottom of the conductor space shall be slightly rounded, in order to obtain a reliable connection.

Terminal size	**Minimum diameter of conductor space** [a] mm	**Minimum distance between fixed part and end of conductor when fully inserted** mm
0	1,4	1,5
1	1,7	1,5
2	2,0	1,5
3	2,7	1,8
4	3,6	1,8
5	4,3	2,0
6	5,0	2,5
7	7,0	3,0
8	8,5	4,0
[a] The value of the torque to be applied is that specified in Table 9.		

Figure 13 – Mantle terminals

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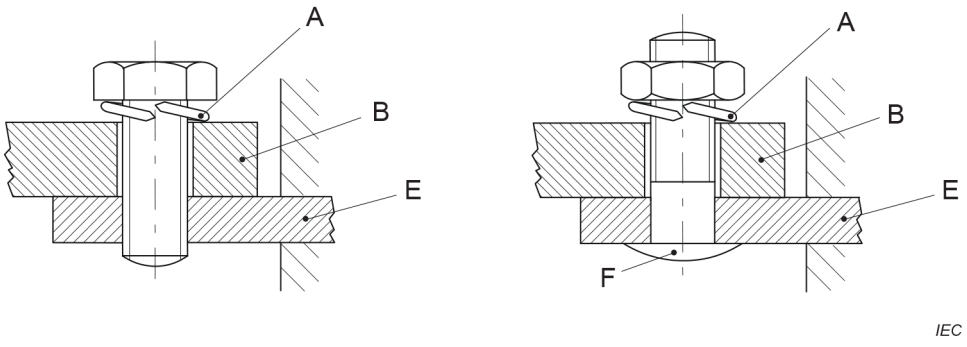
A saddle

B fixed part

C stud

D conductor space

a) Saddle terminals



A locking means

B cable lug or bar

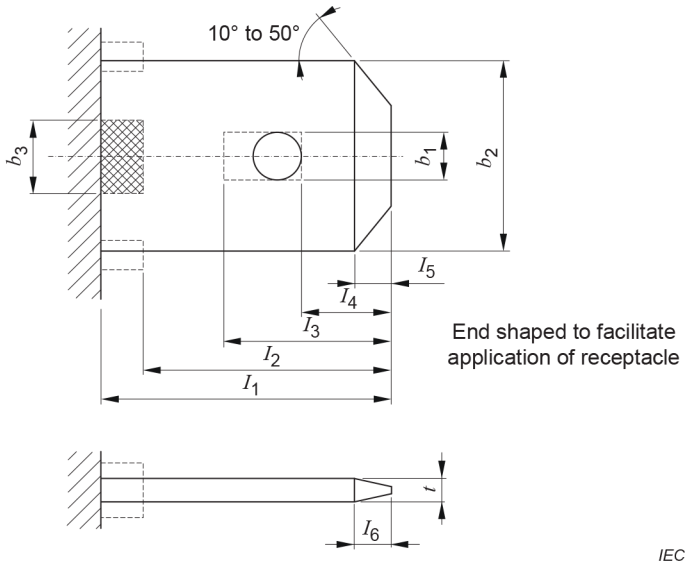
E fixed part

F stud

b) Lug terminals

Figure 14 – Saddle and lug terminals

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Dimensions in millimetres

Dimension for Figures 14 and 15 [a]	Connector size			
	2,8	**4,8**	**6,3**	**9,5**
l_1 (min.) [b]	7,7	6,9	8,6	14,0
l_2 (min). [b]	7,0	6,2	7,9	12,0
l_3 (max.) [c]	3,0	5,2	6,7	8,2
l_4	1,0 ± 0,2	2,5 ± 0,25	3,2 ± 0,3	4,2 ± 0,3
l_5 (max.)	0,7	1,2	1,3	1,7
l_6 (max.)	0,7	1,2	1,3	1,7
b_1 (hole) [a]	$1,2\,^{+0,1}_{0}$	$1,4\,^{+0,2}_{0}$	$1,6\,^{+2,0}_{0}$ [d]	$2,1\,^{+2,0}_{0}$ [d]
b_1 (slot) [a]	$1,2\,^{+0,1}_{0}$	$1,4\,^{+0,2}_{0}$	$1,6\,^{+0,1}_{0}$	$2,1\,^{+2,0}_{0}$
b_2	2,8 ± 0,1	4,75 ± 0,2	$6,3\,^{+0,15}_{-0,1}$	$9,5\,^{+0,15}_{-0,1}$
b_3 (min.) [e]	2,0	2,0	2,5	2,5
t [f]	0,5 ± 0,025	0,8 ± 0,03	0,8 ± 0,03	1,2 ± 0,03
p (max.) [g]	0,8	1,2	1,2	1,7
k	–	$0,7\,^{0}_{-0,1}$	$1,0\,^{0}_{-0,1}$	$1,5\,^{0}_{-0,1}$
x	–	1,0 ± 0,2	1,0 ± 0,2	1,4 ± 0,2

NOTE The sketches are not intended to govern design except as regards the dimensions shown.

[a] **Tabs** may have an optional detent for latching. Round dimple detents, rectangular dimple detents and hold detents shall be located in the area bounded by dimensions b_1, l_3 and l_4 along the centre line of the **tab**.

Tabs may be manufactured from more than one layer of materials, provided that the resulting **tab** complies with this document.

Details for **tabs** having corrugations or depressions are under consideration.

[b] In order to provide sufficient **clearance** for **receptacles** intended to be provided with a sleeve, it may be necessary to increase this dimension by 0,5 mm to ensure that the means of location operates correctly.

[c] The length of the slot (l_3-l_4) shall be at least equal to its width (b_1).

[d] These tolerances are chosen so as to allow the **tabs** to be used as a part of a terminal with screw clamping.

[e] Over the double-hatched area, the thickness shall not exceed the upper limit of the material thickness specified.

[f] With the exception of the dimple or hole and the area indicated by dimension "b", the thickness "t" shall be maintained over the whole connecting area. Compliance shall be determined by measurement over any section (3,2 ± 0,2) mm^2, in a circular area. In addition, the overall flatness shall have a tolerance of 0,03 mm.

[g] This dimension applies only to the raised side of the **tab**; on the reverse side, the flatness tolerance extends across the full width of the **tab**.

Figure 15 – Tabs

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For dimensions, see Figure 14

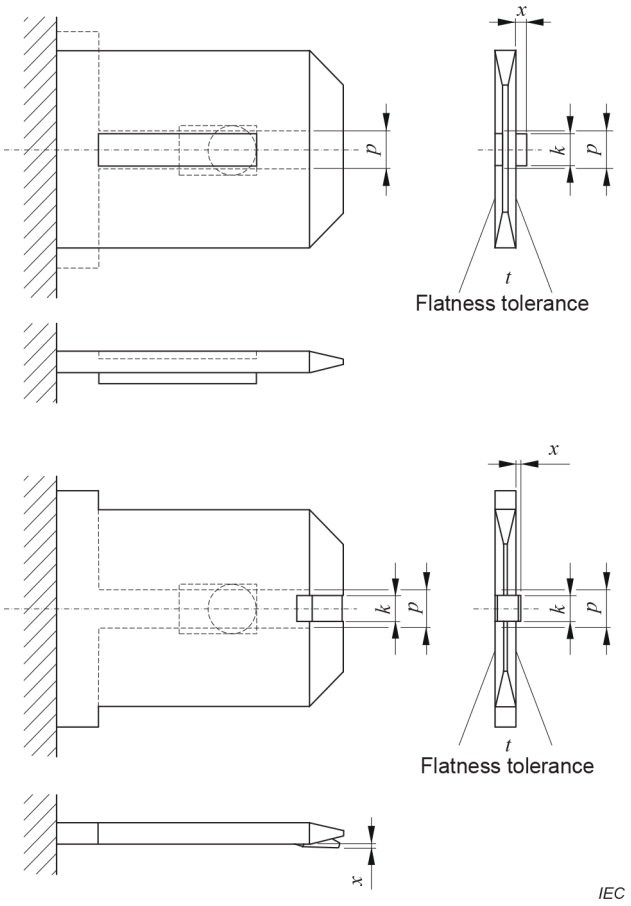
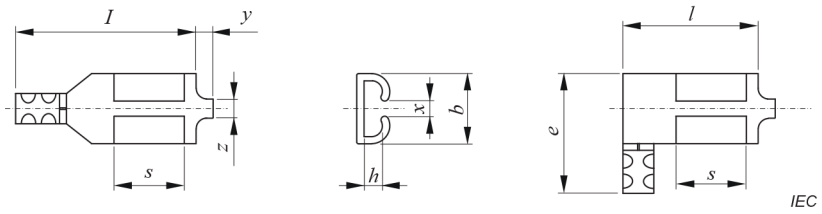


Figure 16 – Tabs for non-reversible connectors

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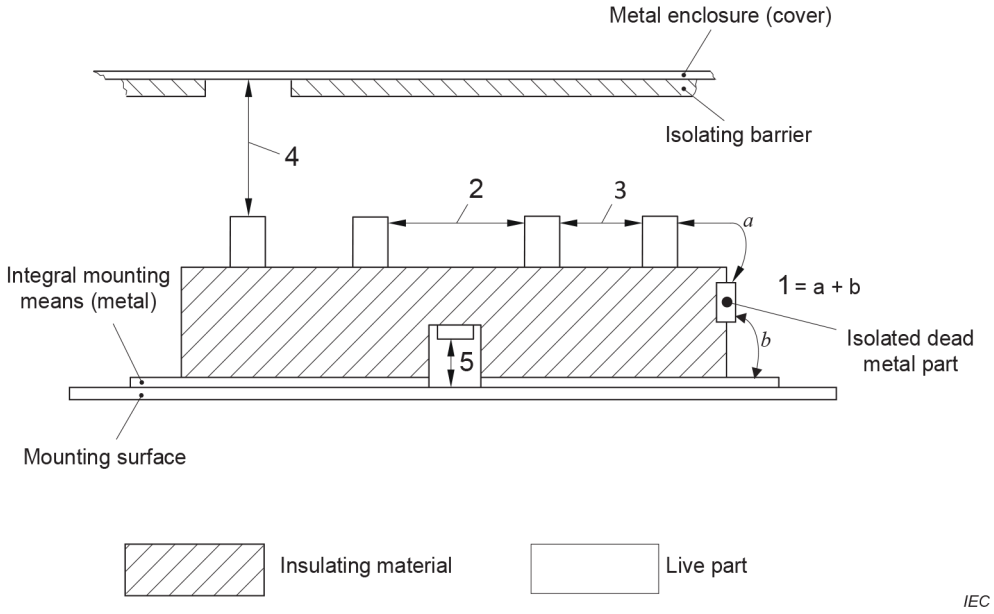


Dimensions in millimetres

Dimension	Connector size			
	2,8	**4,8**	**6,3**	**9,5**
b (max.)	4	6	8	12,5
e (max.)	12	12	15	20
h (max.)[a]	1	2	2,5	3,2
l (max.)	18	18	22	27
s (min.)	4,5	5	6	10
x (min.)[b]	-	0,9	1,2	1,7
y (max.)	0,5	0,5	0,5	1,0
z (max.)	1,5	1,5	2,0	2,0
The dimensions shown apply to the crimped condition. Dimensions for **receptacles** provided with a sleeve and for **receptacles** with a pre-insulated barrel are under consideration. The sketches are not intended to govern design except as regards the dimensions shown.				
[a] Maximum offset dimension from the centre line of the **tab** blade. [b] Applies only to **receptacles** for non-reversible connectors.				

Figure 17 – Receptacles

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Key

1 between **live parts** and other metal parts (including physically exposed electrical isolated metal parts)

2 between **live parts** required to be insulated from each other (**functional insulation**), except between contacts

3 between **live parts** separated by the action of the control where their interconnection allows a flow of current through a load, and which current is thus limited by the load:
– **full disconnection**
– this distance does not apply between terminals intended for connection to fixed wiring

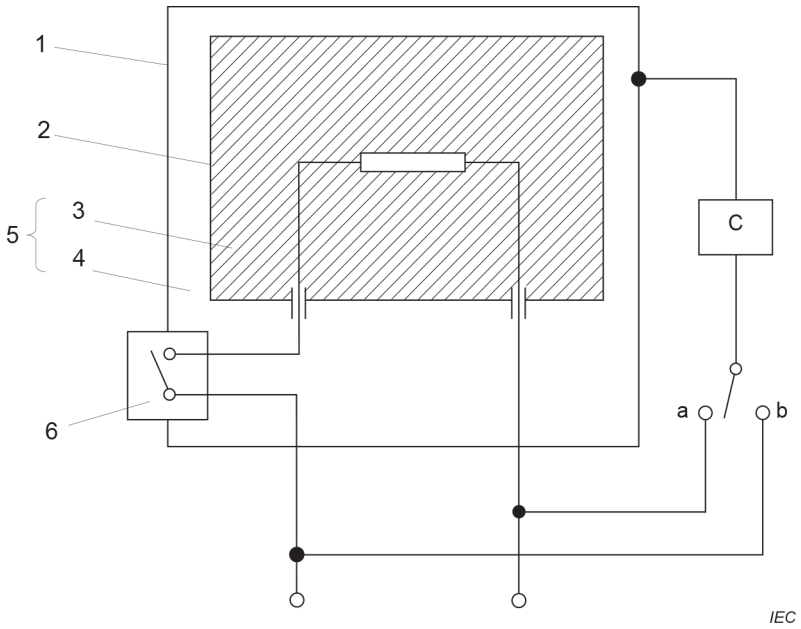
4 between **live parts** and metal enclosure of enclosed controls (these distances do not apply to the housing, frame or integral mounting means of a control intended for installation within an enclosure of the equipment controlled)

5 between **live parts** in recesses of independently mounted controls and the surface to which the control is mounted. This distance may be reduced with the addition of an appropriate seal or barrier.

Figure 18 – Measurement of creepage distance and clearance

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Key

C circuit of Figure K.1

1 **accessible part**

2 inaccessible metal part

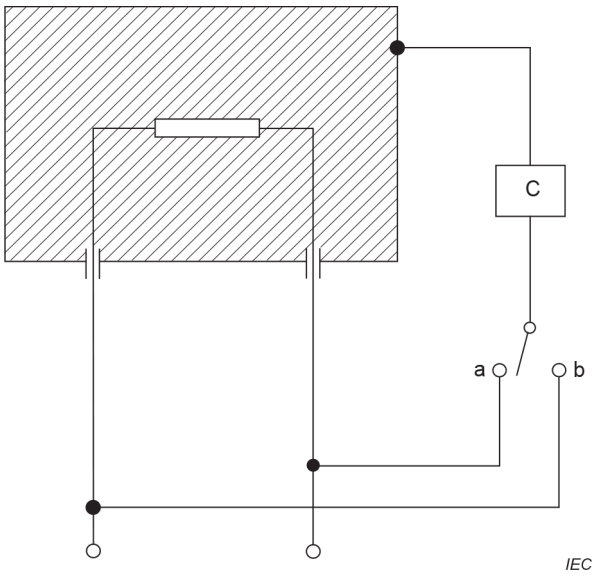
3 **basic insulation**

4 **supplementary insulation**

5 **double insulation**

6 **reinforced insulation**

Figure 19 – Diagram for touch current measurement at operating temperature for single-phase connection of class II controls



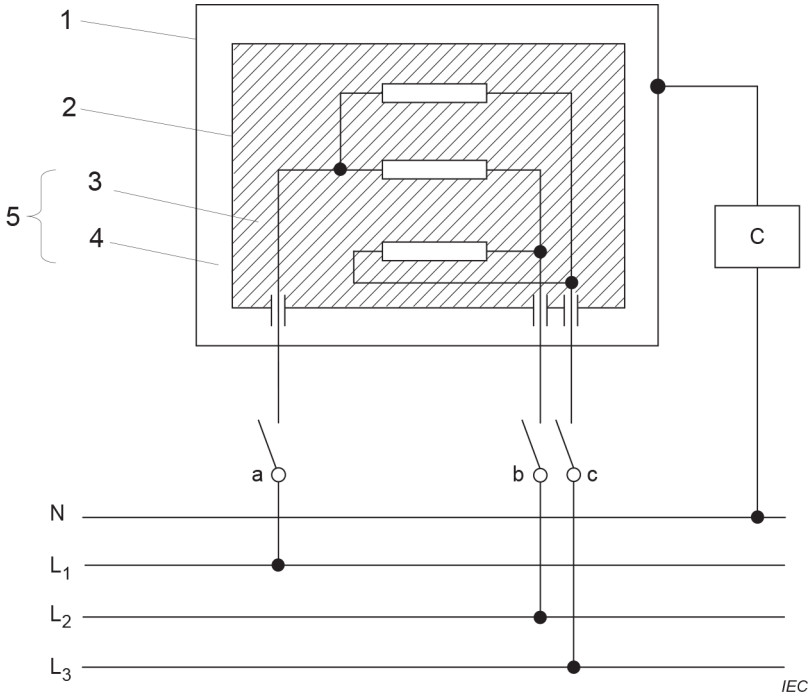
Key

C circuit of Figure K.1

Figure 20 – Diagram for touch current measurement at operating temperature for single-phase connection of controls other than class II

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Key

C circuit of Figure K.1

1 **accessible part**

2 inaccessible metal part

3 **basic insulation**

4 **supplementary insulation**

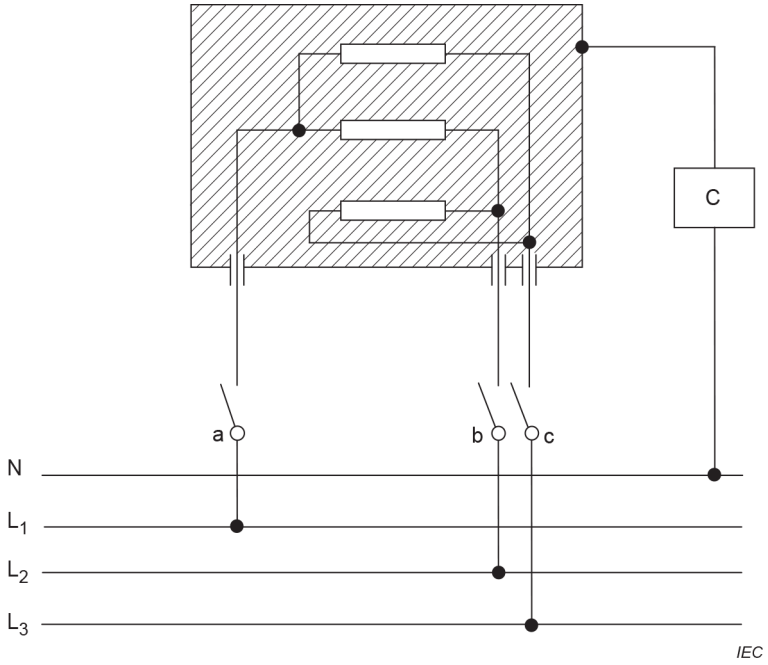
5 **double insulation**

Connections and supplies

L_1, L_2, L_3, N supply voltage with neutral

Figure 21 – Diagram for touch current measurement at operating temperature for three-phase connection of class II controls

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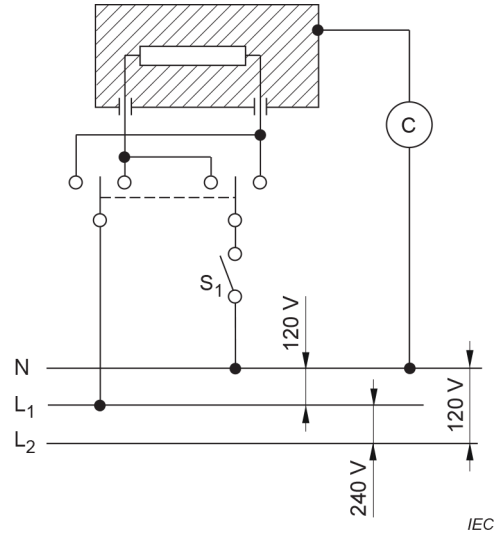
Key

C circuit of Figure K.1

Connections and supplies

L_1, L_2, L_3, N supply voltage with neutral

Figure 22 – Diagram for touch current measurement at operating temperature for three-phase connection of controls other than class II



Key

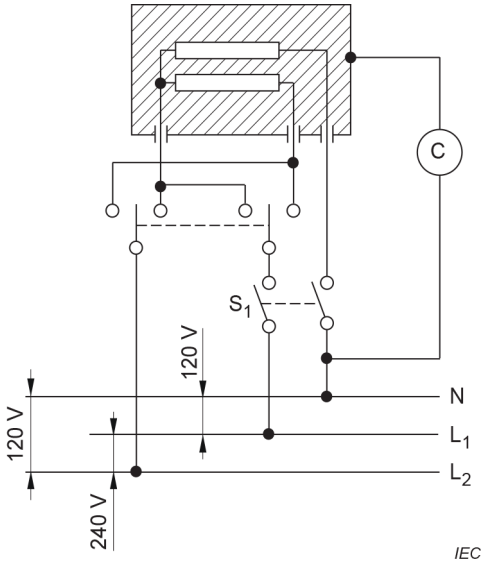
C circuit of Figure K.1

Connections and supplies

L_1, L_2, N supply voltage with neutral

Figure 23 – Diagram for touch current measurement at operating temperature for single-phase connection of controls to three-wire, ground neutral supply other than class II

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Key

C circuit of Figure K.1

Connections and supplies

L_1, L_2, N supply voltage with neutral

Figure 24 – Diagram for touch current measurement at operating temperature for two-phase connection of controls to three-wire, ground neutral supply other than class II

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Annex A
(normative)

Indelibility of markings

A.1 Requirements for indelibility

A.1.1 Markings on controls shall be adequately indelible for safety and are therefore classified according to the applicable requirements of A.1.2 to A.1.5.

A.1.2 Markings which are not mandatory within the requirements of this document.

A.1.3 Markings which are mandatory within the requirements of this document but which are not accessible to the final user when the control is mounted or installed in the equipment.

These markings have to be sufficiently resistant to removal to withstand the manual handling in the **control manufacturer's** factory after final inspection, being packed and transported to the **equipment manufacturer's** factory, and handled during installation. Additionally, the marking shall remain legible in the presence of any vapour or other contaminant likely to be present.

A.1.4 Markings which are mandatory within the requirements of this document and which are accessible to the final user of the equipment after the control is mounted or installed as for normal use.

These markings, in addition to being resistant to the handling, etc., described in A.1.3, have also to withstand the rubbing and handling expected during the use of the equipment. Markings on knobs, handles, etc., shall survive the continual handling and rubbing as a result of manual **actuation**. Other markings should be resistant to cleaning, polishing and the like.

A.1.5 Compliance with the requirements for indelibility of markings classified according to A.1.3 and A.1.4 is checked by the tests of Clause A.2 or Clause A.3 using the apparatus shown in Figure 9.

The principal part consists of a disc of hard white buffing felt, 65 mm in diameter and 7,5 mm thick. This is locked against rotation and is arranged to move across the surface to be tested with a stroke of 20 mm and to exert a measurable force on this surface. The standard test shall be 12 strokes (i.e., rotations of the eccentric) and shall take approximately 15 s.

During the tests, the appropriate part of the buffing disc is covered with one layer of white absorbent lint with the nap surface external.

The solvents used are

– neutral liquid detergent blended from alkyl benzene sulphonate and non-ionic detergents or 2 % of a solvent in deionized (distilled) water where the solvent consists of
  - 70 % (with volume) Natriumdodecylbenzylsulfonat, (Isomere), formula: C18H29NaO3S, CAS-No. 25155-30-0, and
  - 30 % (with volume) Glycerin (other names: Glycerol, 1,2,3-Propantriol, Propantriol,E 422), formula: C3H8O3, CAS-No. 56-81-5;
– n-hexane (aliphatic solvent hexane with a content of aromatics of maximum 0,1 volume %, initial boiling point of approximately 69 °C and specific gravity of approximately 0,66 g/cm^3, CAS-No. 110-54-3), and
– deionized (distilled) water.

A.2 Test procedure for markings classified to A.1.3

A.2.1 *The markings under consideration shall withstand drops of detergent standing on the marked surface for a period of 4 h. At the end of this period, the detergent "scab(s)" shall be removed by a very fine spray of warm water (40 ± 5) °C or by lightly wiping with a damp cloth.*

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A.2.2 *The sample shall then be allowed to dry completely in an ambient room temperature of (25 ± 5) °C.*

A.2.3 *The sample shall then be rubbed in the apparatus of Figure 9, using dry lint and a weight of 250 g measured as indicated.*

A.2.4 *The sample shall then be rubbed using water-soaked lint and a weight of 250 g.*

A.2.5 *If the shape or position of marking is such that it cannot be bleached or rubbed with this apparatus (for example, by recessing the marked surface), then the tests of A.2.3 and A.2.4 are not applied***.**

A.2.6 *At the conclusion of these tests, the marking shall still be legible.*

A.3 Test procedure for markings classified to A.1.4

A.3.1 *The marking under consideration shall be rubbed in the apparatus of Figure 9 using a dry lint and a weight of 750 g.*

A.3.2 *The marking shall then be rubbed in the apparatus using a water-soaked lint and a weight of 750 g.*

A.3.3 *The marking under consideration shall then withstand drops of detergent standing on the marked surface for a period of 4 h. At the end of this period, the detergent "scab(s)" shall be removed by a very fine spray of warm water (40 ± 5) °C or by lightly wiping with a damp cloth.*

A.3.4 *After being allowed to dry, it shall be rubbed in the apparatus using a detergent soaked lint and a weight of 750 g.*

A.3.5 *After surplus detergent has been shaken off, it shall be rubbed in the apparatus, using a petroleum spirit soaked lint and a weight of 750 g.*

A.3.6 *For the tests of A.3.1 to A.3.5, the thickness of the buffing disc can be progressively reduced such that the marking is reached and rubbed. However, the minimum thickness of the buffing disc shall be not less than 2,5 mm. If the thickness of the buffing disc is reduced, the weight of 750 g shall be reduced in linear proportion.*

A.3.7 *At the conclusion of these tests, the marking shall still be legible.*

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Annex B
(normative)

Measurement of creepage distances and clearances in air

*When determining and measuring **creepage distances** and **clearances**, the following assumptions are made, where D is equal to the **clearance** in air prescribed for the distance under consideration (see Figure B.1 to Figure B.11 for examples of methods of measurement of **creepage distance** and **clearances**):*

- *a groove may have parallel, converging or diverging side walls;*
- *if a groove has diverging side walls, it is regarded as an air gap if its minimum width exceeds $D/12$, its depth exceeds $D/2$ and its width at the bottom of the groove is at least equal to $D/3$ (see Figure B.8) but in no case smaller than the minimum value X as permitted in the tabulation below;*
- *any corner having an angle less than 80° is assumed to be bridged by an insulating link having a width equal to $D/3$ or 1 mm, whichever is less, which is placed in the most unfavourable position (see Figure B.3);*
- *if the distance across the top of a groove is a least equal to $D/3$, or 1 mm, whichever is less, the **creepage distance** path follows the contour of the groove unless otherwise specified immediately above (see Figure B.2);*
- *for **creepage distances** and **clearances** in air between parts moving relatively one to another, these parts are considered to be in their most unfavourable position to each other;*
- ***creepage distances** determined according to these rules are not less than the corresponding (measured) **clearances** in air;*
- *any air gap having a width less than $D/3$ or 1 mm, whichever is less, is ignored in calculating the total **clearance** in air;*
- *for inserted or set-up barriers, the **creepage distances** are measured through the joint unless the parts are so cemented or heat-sealed together that ingress of humidity or dirt into the joint is not liable to occur.*

In the examples shown in Figure B.1 to Figure B.11, the following identification is used:

— — — — — — Clearance Creepage distance

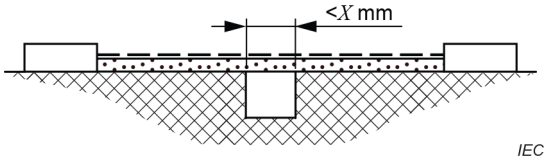
See Table B.1 for the value of X.

Table B.1 – Value of X

Pollution degree	Width X of grooves: minimum values mm
1	0,25
2	1,0
3	1,5
4	2,5

*If the associated **clearance** is less than 3 mm, the minimum groove width may be reduced to one-third of this **clearance**.*

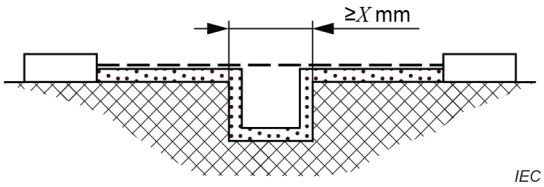
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The path under consideration includes a groove of any depth, having a width less than X.

Rule: The **clearance** path is the "line of sight" path.

Figure B.1 – Narrow groove

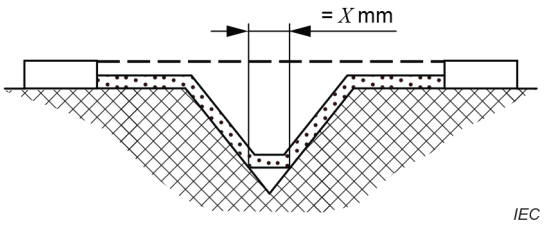


The path under consideration includes a groove of any depth, having a width equal to or more than X.

Rule: The **clearance** path is the "line of sight" path.

The **creepage distance** path follows the contour of the groove.

Figure B.2 – Wide groove

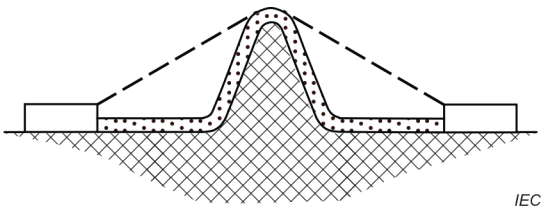


The path under consideration includes a V-shaped groove having a width greater or equal to X.

Rule: The **clearance** path is the "line of sight" path.

The **creepage distance** path follows the contour of the groove except that it bridges the groove where its width is equal to X.

Figure B.3 – V-shaped groove



The path under consideration includes a rib.

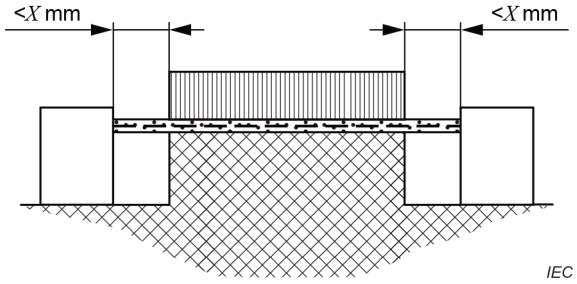
Rule: The **clearance** path is the shortest air path over the top of the rib.

The **creepage distance** path follows the contour of the rib.

Figure B.4 – Rib

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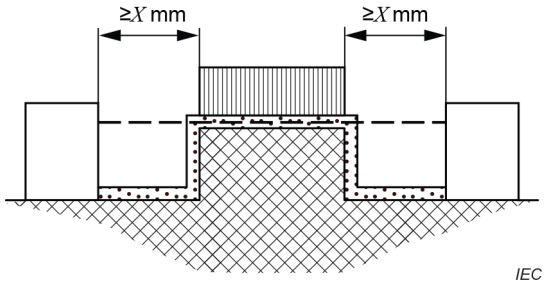
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The path under consideration includes an uncemented joint and grooves having a width less than X on either side.

Rule: The **creepage distance** path and the **clearance** path is the "line of sight" path as shown.

Figure B.5 – Uncemented joint with narrow groove

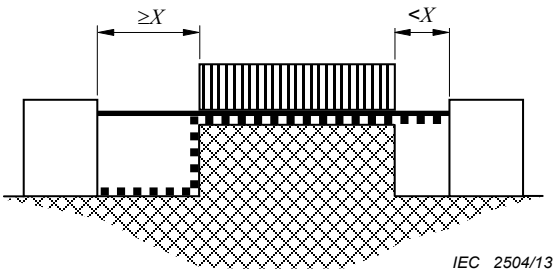


The path under consideration includes an uncemented joint and grooves having a width equal to or more than X.

Rule: The **clearance** path is the "line of sight" path as shown.

The **creepage distance** path follows the contour of the grooves.

Figure B.6 – Uncemented joint with wide groove

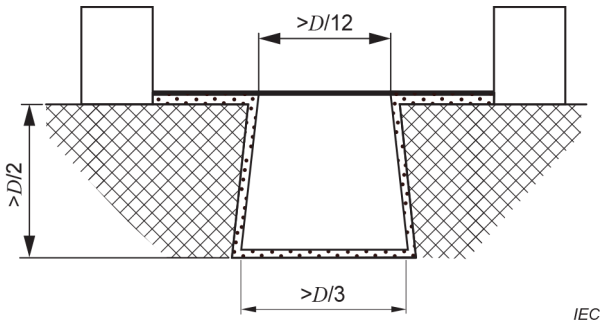


The path under consideration includes an uncemented joint, a groove on one side having a width less than X, and a groove on the other having a width equal to or more than X.

Rule: The **clearance** path and the **creepage distance** path are as shown.

Figure B.7 – Uncemented joint with narrow and wide grooves

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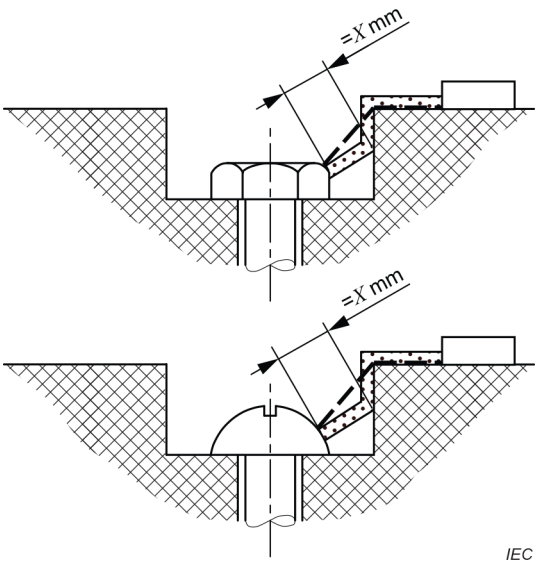
The path under consideration includes a groove having diverging side walls, a depth equal to or greater than $D/2$ and a width exceeding $D/12$ at the narrowest part and equal to or greater than $D/3$ at the bottom.

Rule: The **clearance** path is equal to the "line of sight" path.

The **creepage distance** path follows the contour of the groove.

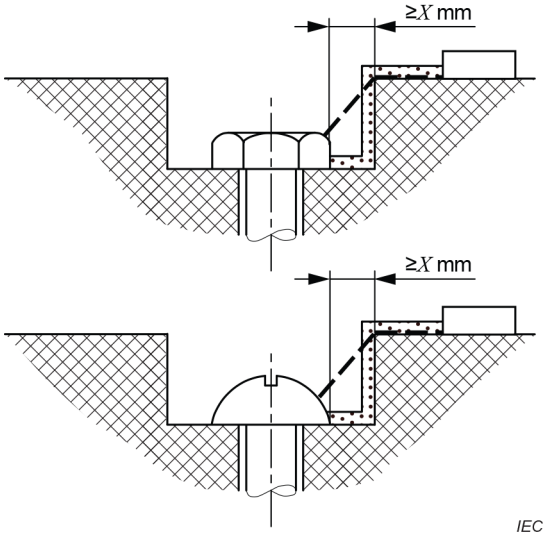
The rule for Figure B.3 applies as well to the internal corners if they are less than 80°.

Figure B.8 – Diverging side walls



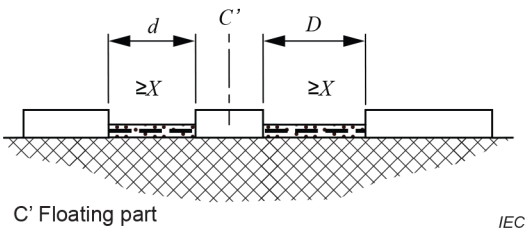
Gap between head of screw and wall of recess too narrow to be taken into account for the creepage distance path.

Figure B.9 – Narrow recess



Gap between head of screw and wall of recess wide enough to be taken into account for the creepage distance path.

Figure B.10 – Wide recess



Clearance is the distance $d + D$

Creepage distance is also $d + D$

Figure B.11 – Conductive floating part

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Annex C
(informative)

Nominal voltages of supply systems for different modes of overvoltage control

Nominal voltages of supply **systems** for different modes of overvoltage control are as indicated in Table C.1 and Table C.2.

Insulation coordination with regard to transient overvoltage is based on controlled overvoltage conditions. There are two kinds of control:

– inherent control: the condition within an electrical **system** wherein the characteristics of the **system** can be expected to limit the prospective transient overvoltages to a defined level;

– protective control: the condition within an electrical **system** wherein specific overvoltage attenuating means can be expected to limit the prospective transient overvoltages to a defined level.

NOTE The above paragraph is taken from IEC 60664-1:2007, 4.2.3.

Table C.1 – Inherent control or equivalent protective control

Voltage line-to-neutral from nominal voltages AC or DC [a]	Nominal voltages presently used in the world				Rated impulse voltage for equipment [a] V Overvoltage category			
	Three-phase four-wire systems with earthed neutral	Three-phase three-wire systems unearthed	Single-phase two-wire systems AC or DC	Single-phase three-wire systems AC or DC				
V	V	V	V	V	I	II	III	IV
50			12,5; 24; 25; 30; 42; 48	30 / 60	330	500	800	1 500
100	66 / 115	66	60		500	800	1 500	2 500
150	120 / 208 [b] 127 / 220	115; 120; 127	110; 120	110 / 220 120 / 240 [c]	800	1 500	2 500	4 000
300	220 / 380 230 / 400 240 / 415 260 / 440 277 / 480	220; 230; 240; 260; 277; 347; 380; 400; 415; 440; 480	220	220 / 440	1 500	2 500	4 000	6 000
600	347 / 600 380 / 660 400 / 690 417 / 720 480 / 830	500; 577; 600	480	480 / 960	2 500	4 000	6 000	8 000
1 000		660; 690; 720; 830; 1 000	1 000		4 000	6 000	8 000	12 000

[a] These columns are taken from IEC 60664-1:2007, Annex F, Table F.1 in which the **rated impulse voltage** values are specified.

[b] Practice in the USA and Canada.

[c] For 120/240 V in Japan, the preferred series of **rated impulse voltages** of 1 500 V, 2 500 V, 4 000 V and 6 000 V are used corresponding to **overvoltage categories** I, II, III and IV.

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Table C.2 – Cases where protective control is necessary and control is provided by surge arresters having a ratio of clamping voltage to rated voltage not smaller than that specified by IEC 60099-1

Voltage line-to-neutral from nominal voltages AC or DC [a]	Nominal voltages presently used in the world				Rated impulse voltage for equipment [a]			
	Three-phase four-wire systems with earthed neutral	Three-phase three-wire systems unearthed	Single-phase two-wire systems AC or DC	Single-phase three-wire systems AC or DC	V			
					Overvoltage category			
V	V	V	V	V	I	II	III	IV
50			12,5; 24; 25; 30; 42; 48	30/60	330	500	800	1 500
100	66 / 115	66	60		500	800	1 500	2 500
150	120 / 208 [b] 127 / 220	115; 120; 127	110; 120	110/220 120/240	800	1 500	2 500	4 000
300	220 / 380 230 / 400 240 / 415 260 / 440 277 / 480	220; 230; 240; 260; 277	220	220/440	1 500	2 500	4 000	6 000
600	347 / 600 380 / 660 400 / 690 417 / 720 480 / 830	347; 380; 400; 415; 440; 480; 500; 577; 600	480	480/960	2 500	4 000	6 000	8 000
1 000		660; 690; 720; 830; 1 000	1 000		4 000	6 000	8 000	12 000

[a] These columns are taken from IEC 60664-1:2007, Annex F, Table F.1 in which the **rated impulse voltage** values are specified.

[b] Practice in the USA and Canada.

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Annex D
(normative)

Overvoltage categories

Overvoltage category is a numeral characterizing a **transient overvoltage** condition.

The following information on **overvoltage categories** based on IEC 60664-1. IEC TR 60664-2 series may specify a different **overvoltage category** for particular applications.

Equipment of **overvoltage category** IV is for use at the origin of the installation.

NOTE 1 Examples of such equipment are electricity meters and primary overcurrent protection equipment.

Equipment of **overvoltage category** III is equipment in fixed installations and for cases where the reliability and the availability of the equipment is subject to special requirements.

NOTE 2 This category normally applies to **controls** intended for connection to **fixed wiring** or for incorporation into equipment intended for permanent connection to **fixed wiring**. When the **control** or equipment application is provided with a means of suppressing the transient voltage, for the purposes of insulation coordination, the expected impulse voltage is based on the clamping voltage of the voltage surge suppressor.

Equipment of **overvoltage category** II is energy consuming equipment to be supplied from the fixed installation.

NOTE 3 This category normally applies to **controls** not provided with terminals for **fixed wiring**, or connected after a socket-outlet, or for incorporation into equipment connected after a socket-outlet. **Controls** intended for permanent connection to **fixed wiring** are considered overvoltage category III; however, where methods of suppressing the transient voltage, such as voltage limiting means at the line terminal or **clearances** between conductive parts are incorporated in the **control** or equipment, for the purposes of insulation coordination, the expected impulse voltage is based on the clamping voltage of the voltage surge suppressor. Where the contacts of a **control** are designed to allow flashover of the transient voltage and are adequate to withstand the let-through current, this can provide adequate suppression; for example, **controls** for household appliances satisfying the above descriptions.

If such equipment is subjected to special requirements with regard to reliability and availability, **overvoltage category** III applies.

Equipment of **overvoltage category** I is equipment for connection to circuits in which measures are taken to limit **transient overvoltages** to an appropriately low level.

NOTE 4 This category normally applies to **controls** connected after category II equipment and which, for example, includes electronic logic **systems**, **isolated limited secondary circuits**, **SELV**-circuits or **PELV**-circuits, and circuits on the secondary side of a transformer.

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Annex E
(informative)

Typical usage of controls and related overvoltage categories

Table E.1 – Typical usage

Control situation	Overvoltage category			
	I	II	III	IV
Special				
Isolated limited secondary circuit	X			
Transient limited supply	X	X	X	X
Energy consuming utilization equipment				
Integrated and **incorporated controls** in household appliances		X		
Independently mounted controls for fixed-wiring to energy consuming loads		X	X	
Other household and similar applications:				
Controls which are not integrated, incorporated, or for fixed-wiring to energy consuming loads			X	
Controls mounted at the origin of installation (i.e. service entrance equipment, electricity meters and primary overcurrent equipment)				X
Controls covered by special part 2 considerations	X	X	X	X

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Annex F
(normative)

Pollution degrees

F.1 Pollution

The **micro-environment** determines the effects of **pollution** on the insulation. The **macro-environment**, however, shall be taken into account when considering the **micro-environment**.

Means may be provided to reduce **pollution** at the insulation under consideration by the effective use of coatings, enclosures, encapsulation or hermetic sealing. Such means to reduce **pollution** is not effective when the equipment is subject to condensation or if, in normal operation, it generates pollutants itself.

Small **clearances** can be bridged completely by solid particles, dust and water and therefore minimum **clearances** are specified where **pollution** can be present in the **micro-environment**.

NOTE 1 **Pollution** will become conductive in the presence of humidity. **Pollution** caused by contaminated water, soot, metal or carbon dust is inherently conductive.

NOTE 2 Conductive **pollution** by ionized gases and metallic depositions occurs only in specific instances, for example in arc chambers of switchgear or controlgear, and is not covered by this document.

F.2 Degrees of pollution in the micro-environment

For the purpose of evaluating **creepage distances** and **clearances**, the following four degrees of **pollution** in the **micro-environment** are established:

– **Pollution degree** 1

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

NOTE 1 Special considerations (for example, coating evaluated to Annex L or Annex M, sealed enclosure) are necessary to establish **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 representative of normal household air circulation.

NOTE 3 **Pollution** from the operation of contacts is classified as **pollution degree** 2 unless the area is affected by other **pollution**, in which case the **pollution degree** corresponding to the other **pollution** applies.

– **Pollution degree** 3

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

– **Pollution degree** 4

  The **pollution** generates persistent conductivity caused by conductive dust or by rain or snow.

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Annex G
(normative)

Resistance to heat, fire and tracking tests

G.1 Glow-wire test

The glow-wire test is carried out in accordance with IEC 60695-2-10 and IEC 60695-2-11.

*The glow-wire test shall be carried out on the complete **control**. If this is not possible, on parts removed from the **control**. If this is not possible, on test plaques of similar thickness but not thicker than the part.*

G.2 Proof tracking test

The proof tracking test is made in accordance with IEC 60112:2020.

For the purpose of this document, the following applies:

– *In IEC 60112:2020, Clause 5, Test specimen, Note 3 also applies to the proof tracking tests of Clause 10 of IEC 60112:2020.*

– *In IEC 60112:2020, Clause 7, Test apparatus, Note 1 in 7.1 does not apply. The test solution A described in IEC 60112:2020, 7.3 is used.*

– *In IEC 60112:2020, 8.2, Preparation, the voltage referred to in the last sentence is set in 21.2.9 of this document. The proof tracking test of IEC 60112:2020, Clause 10 is carried out, five times.*

G.3 Ball pressure test

G.3.1 Ball pressure tests

The ball pressure test is carried out in accordance with IEC 60695-10-2.

G.3.2 Ball pressure test 1

For the purpose of this document, the temperature in the heating oven is the highest of:

– *20 °C ± 2 K in excess of the maximum temperature measured during the tests of Clause 16,*

– *75 °C ± 2 °C,*

– *as declared.*

NOTE 1 For **controls** intended for incorporation into appliances within the scope of IEC 60335-1:2020, the temperature might differ as per 30.1 of that standard.

The support and the ball shall be at the prescribed test temperature before the test is started.

NOTE 2 The test is not made on parts of ceramic material and glass.

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G.3.3 Ball pressure test 2

The ball pressure test is carried out as described in G.3.2 except that the temperature in the heating oven shall be T_b ± 2 °C where T_b is equal to the higher of:

– *100 °C when T_{max} is 30 °C and up to, but excluding, 55 °C;*

– *125 °C when T_{max} is 55 °C and up to, but excluding, 85 °C;*

– *T_{max} + 40 °C if T_{max} is 85 °C or above;*

– *20 K in excess of the maximum temperature recorded during the heating test of Clause 16;*

– *the temperature achieved during the test of 13.1.3.8, if this is higher than the temperature given in the preceding four dashed paragraphs.*

NOTE For **controls** intended for incorporation into appliances within the scope of IEC 60335-1:2020, the temperature might differ as per 30.1 of that standard.

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Annex H
(normative)

Requirements related to functional safety

Annex H supplements or modifies the corresponding clauses of this document, However, this is not applicable for Clause H.5 and H.25.4 to H.25.10.

H.3 Terms and definitions

Add the following definitions:

H.3.16 Definitions relating to the structure of controls using software

H.3.16.1
dual channel
structure which contains two mutually independent functional means to execute specified **operations**

Note 1 to entry: Special provision may be made for control of **common mode fault/**errors. It is not required that the two channels each be algorithmic or logical in nature.

H.3.16.2
dual channel (diverse) with comparison
dual channel structure containing two different and mutually independent functional means, each capable of providing a declared response, in which comparison of output signals is performed for **fault**/error recognition

H.3.16.3
dual channel (homogeneous) with comparison
dual channel structure containing two identical and mutually independent functional means, each capable of providing a declared response, in which comparison of internal signals or output signals is performed for **fault**/error recognition

H.3.16.4
single channel
structure in which a single functional means is used to execute specified **operations**

H.3.16.5
single channel with functional test
single channel structure in which test data is introduced to the functional unit prior to its **operation**

H.3.16.6
single channel with periodic self-test
single channel structure in which components of the **control** are periodically tested during **operation**

H.3.16.7
single channel with periodic self-test and monitoring
single channel structure with periodic self-test in which independent means, each capable of providing a declared response, monitor such aspects as safety-related timing, sequences and software operations

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H.3.17 Definitions relating to error avoidance in controls using software

H.3.17.1
dynamic analysis
method of analysis in which inputs to a **control** are simulated and logic signals at the circuit nodes are examined for correct value and timing

H.3.17.2
failure rate calculation
calculation of the theoretical number of **failures** of a given kind per unit

Note 1 to entry: For example, **failures** per hour or **failures** per cycle of **operation**.

H.3.17.3
hardware analysis
evaluation process in which the circuitry and components of a **control** are examined for correct function within their specified tolerances and ratings

H.3.17.4
hardware simulation
method of analysis in which circuit function and component tolerances are examined by use of a computer model

H.3.17.5
inspection
evaluation process in which the hardware or the software specification, design or code is examined in detail by a person or group other than the designer or programmer in order to identify possible errors

Note 1 to entry: In contrast to the **walk-through**, the designer or programmer is passive during this evaluation.

H.3.17.6
operational test
evaluation process in which a **control** is operated under the extremes of its intended operating conditions (for example, cycle rate, temperature, voltage) to detect errors in design or construction

H.3.17.7 Static analysis

H.3.17.7.1
static analysis – hardware
evaluation process in which a hardware model is systematically assessed

Note 1 to entry: The evaluation may typically be computer-aided and may include examination of parts lists and circuit layouts, an interface analysis and functional checks.

H.3.17.7.2
static analysis – software
evaluation process in which a software programme is systematically assessed without necessarily executing the programme

Note 1 to entry: The evaluation may typically be computer-aided and usually includes analysis of such features as programme logic, data paths, interfaces and variables.

H.3.17.8
systematic test
method of analysis in which a **system** or a software programme is assessed for correct execution by the introduction of selected test data

Note 1 to entry: For example, see **black box test** and **white box test**.

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H.3.17.8.1
black box test
systematic test in which test data derived from the functional specification is introduced to a functional unit to assess its correct **operation**

H.3.17.8.2
white box test
systematic test in which test data based on the software specification is introduced to a programme to assess the correct **operation** of subparts of the programme

Note 1 to entry: For example, data may be selected to execute as many instructions as possible, as many branches as possible, as many subroutines as possible, etc.

H.3.17.9
walk-through
evaluation process in which a designer or programmer leads members of an evaluation team through the hardware design, software design and/or software code the designer or programmer has developed in order to identify possible errors

Note 1 to entry: In contrast to the **inspection**, the designer or programmer is active during this review.

H.3.17.10
software fault/error detection time
the period of time between the occurrence of a **fault**/error and the **initiation** by the software of a declared **control** response

H.3.18 Definitions relating to fault/error control techniques for controls using software

H.3.18.1 Bus redundancy

H.3.18.1.1
full bus redundancy
fault/error **control** technique in which full redundant data and/or address are provided by means of redundant bus structure

H.3.18.1.2
multi-bit bus parity
fault/error **control** technique in which the bus is extended by two or more bits and these additional bits are used for error detection

H.3.18.2
code safety
fault/error **control** techniques in which protection against coincidental and/or systematic errors in input and output information is provided by the use of **data redundancy** and/or **transfer redundancy** (see also H.3.18.2.1 and H.3.18.2.2)

H.3.18.2.1
data redundancy
form of **code safety** in which the storage of redundant data occurs

H.3.18.2.2
transfer redundancy
form of **code safety** in which data is transferred at least twice in succession and then compared

Note 1 to entry: This technique will recognize intermittent errors.

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H.3.18.3
comparator
device used for **fault**/error **control** in **dual channel** structures

Note 1 to entry: The device compares data from the two channels and initiates a declared response if a difference is detected.

H.3.18.4
DC fault mode
stuck-at fault mode incorporating short circuits between signal lines

Note 1 to entry: Because of the number of possible shorts in the device under test, usually only shorts between related signal lines will be considered. A logical signal level is defined, which dominates in cases where the lines try to drive to the opposite level.

H.3.18.5
equivalence class test
systematic test intended to determine whether the instruction decoding and execution are performed correctly

Note 1 to entry: The test data is derived from the CPU instruction specification.

Note 2 to entry: Similar instructions are grouped and the input data set is subdivided into specific data intervals (equivalence classes). Each instruction within a group processes at least one set of test data, so that the entire group processes the entire test data set. The test data can be formed from the following:

– data from valid range;

– data from invalid range;

– data from the bounds;

– extreme values and their combinations.

The tests within a group are run with different addressing modes, so that the entire group executes all addressing modes.

H.3.18.6
error recognizing means
independent means provided for the purpose of recognizing errors internal to the **system**

Note 1 to entry: Examples are monitoring devices, **comparators**, and code generators.

H.3.18.7
Hamming distance
statistical measure, representing the capability of a code to detect and correct errors

Note 1 to entry: The **Hamming distance** of two code words is equal to the number of positions different in the two code words.

Note 2 to entry: See H. Holscher and J. Rader; "Microcomputers in safety techniques." Verlag TUV Bayern. TUV Rheinland. (ISBN 3-88585-315-9).

H.3.18.8
input comparison
fault/error **control** technique by which inputs that are designed to be within specified tolerances are compared

H.3.18.9
internal error detection
fault/error **control** technique in which special circuitry is incorporated to detect or correct errors

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H.3.18.10 Programme sequence

H.3.18.10.1
frequency monitoring
fault/error **control** technique in which the clock frequency is compared with an independent fixed frequency

Note 1 to entry: An example is comparison with the line supply frequency.

H.3.18.10.2
logical monitoring of the programme sequence
fault/error **control** technique in which the logical execution of the programme sequence is monitored

Note 1 to entry: Examples are the use of counting routines or selected data in the programme itself or by independent monitoring devices.

H.3.18.10.3
time-slot and logical monitoring
this is a combination of H.3.18.10.2 and H.3.18.10.4

H.3.18.10.4
time-slot monitoring of the programme sequence
fault/error **control** technique in which timing devices with an independent time base are periodically triggered in order to monitor the programme function and sequence

Note 1 to entry: An example is a watchdog **timer**.

H.3.18.11
multiple parallel outputs
fault/error **control** technique in which independent outputs are provided for operational error detection or for **independent comparators**

H.3.18.12
output verification
fault/error **control** technique in which outputs are compared to independent inputs

Note 1 to entry: This technique may relate an error to the output which is defective.

H.3.18.13
plausibility check
fault/error **control** technique in which programme execution, inputs or outputs are checked for inadmissible programme sequence, timing or data

Note 1 to entry: Examples are the introduction of an additional interrupt after completion of a certain number of cycles or checks for division by zero.

H.3.18.14
protocol test
fault/error **control** technique in which data is transferred to and from computer components to detect errors in the internal communications protocol

H.3.18.15
reciprocal comparison
fault/error **control** technique used in **dual channel** (homogeneous) structures in which a comparison is performed on data reciprocally exchanged between the two processing units

Note 1 to entry: Reciprocal refers to an exchange of similar data.

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H.3.18.17
redundant monitoring
availability of two or more independent means such as watchdog devices and **comparators** to perform the same task

H.3.18.18
scheduled transmission
communication procedure in which information from a particular transmitter is allowed to be sent only at a predefined point in time and sequence, otherwise the receiver will treat it as a communication error

H.3.18.19
software diversity
fault/error **control** technique in which all or parts of the software are incorporated twice in the form of alternate software code

Note 1 to entry: For example, the alternate forms of software code may be produced by different programmers, different languages or different compiling schemes and may reside in different hardware channels or in different areas of memory within a **single channel**.

H.3.18.20
stuck-at fault mode
fault mode representing an open-circuit or a non-varying signal level

Note 1 to entry: These are usually referred to as "stuck-open", "stuck at 1" or "stuck at 0".

H.3.18.21
tested monitoring
the provision of independent means such as watchdog devices and **comparators** which are tested at start-up or periodically during **operation**

H.3.18.22
testing pattern
fault/error **control** technique used for periodic testing of input units, output units and interfaces of the **control**

Note 1 to entry: A test pattern is introduced to the unit and the results compared to expected values. Mutually independent means for introducing the test pattern and evaluating the results are used. The test pattern is constructed so as not to influence the correct **operation** of the **control**.

H.3.19 Definitions relating to memory tests for controls using software

H.3.19.1
Abraham test
specific form of a **variable memory** pattern test in which all stuck-at and coupling **faults** between memory cells are identified

Note 1 to entry: The number of **operations** required to perform the entire memory test is about 30 n, where n is the number of cells in the memory. The test can be made transparent for use during the operating cycle, by partitioning the memory and testing each partition in different time segments.

Note 2 to entry: See Abraham, J.A.; Thatte, S.M.; "Fault coverage of test programs for a microprocessor", Proceedings of the IEEE Test Conference 1979, pp 18-22.

H.3.19.2
GALPAT memory test
fault/error **control** technique in which a single cell in a field of uniformly written memory cells is inversely written, after which the remaining memory under test is inspected

Note 1 to entry: After each read **operation** to one of the remaining cells in the field, the inversely written cell is also inspected and read. This process is repeated for all memory cells under test. A second test is then performed as above on the same memory range without inverse writing to the test cell.

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Note 2 to entry: The test can be made transparent for use during the operating cycle, by partitioning the memory and testing each partition in different time segments (see **transparent GALPAT test**).

H.3.19.2.1
transparent GALPAT test
GALPAT memory test in which first a signature word is formed representing the content of the memory range to be tested and this word is saved

Note 1 to entry: The cell to be tested is inversely written and the test is performed as above. However, the remaining cells are not inspected individually, but by formation of and comparison to a second signature word. A second test is then performed as above by inversely writing the previously inverted value to the test cell.

Note 2 to entry: This technique recognizes all static bit errors as well as errors in interfaces between memory cells.

H.3.19.3 Checksum

H.3.19.3.1
modified checksum
fault/error **control** technique in which a single word representing the contents of all words in memory is generated and saved

Note 1 to entry: During self-test, a checksum is formed from the same algorithm and compared with the saved checksum.

Note 2 to entry: This technique recognizes all the odd errors and some of the even errors.

H.3.19.3.2
multiple checksum
fault/error **control** technique in which a separate words representing the contents of the memory areas to be tested are generated and saved

Note 1 to entry: During self-test, a checksum is formed from the same algorithm and compared with the saved checksum for that area.

Note 2 to entry: This technique recognizes all the odd errors and some of the even errors.

H.3.19.4 Cyclic redundancy check (CRC)

H.3.19.4.1
CRC – single word
fault/error **control** technique in which a single word is generated to represent the contents of memory

Note 1 to entry: During self-test, the same algorithm is used to generate another signature word which is compared with the saved word.

Note 2 to entry: This technique recognizes all one-bit, and a high percentage of multi-bit, errors.

H.3.19.4.2
CRC – double word
fault/error **control** technique in which at least two words are generated to represent the contents of memory

Note 1 to entry: During self-test, the same algorithm is used to generate the same number of signature words which are compared with the saved words.

Note 2 to entry: This technique can recognize one-bit and multi-bit errors with a greater accuracy than in **CRC – single word**.

H.3.19.5
redundant memory with comparison
structure in which the safety-related contents of memory are stored twice in different format in separate areas so that they can be compared for error control

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H.3.19.6
static memory test
fault/error control technique which is intended to detect only static errors

H.3.19.6.1
checkerboard memory test
static memory test in which a checkerboard pattern of zeros and ones is written to the memory area under test and the cells are inspected in pairs

Note 1 to entry: The address of the first cell in each pair is variable and the address of the second cell is derived from a bit inversion of the first address. In the first **inspection**, the variable address is first incremented to the end of the address space of the memory and then decremented to its original value. The test is repeated with the checkerboard pattern inversed.

H.3.19.6.2
marching memory test
static memory test in which data is written to the memory area under test as in normal operation

Note 1 to entry: Every cell is then inspected in ascending order and a bit inversion performed on the contents. The **inspection** and bit inversion are then repeated in descending order. Then this process is repeated after first performing a bit inversion on all the memory cells under test.

H.3.19.7
walkpat memory test
fault/error control technique in which a standard data pattern is written to the memory area under test as in normal operation

Note 1 to entry: A bit inversion is performed on the first cell and the remaining memory area is inspected. Then the first cell is again inverted and the memory inspected. This process is repeated for all memory cells under test. A second test is conducted by performing a bit inversion of all cells in memory under test and proceeding as above.

Note 2 to entry: This technique recognizes all static bit errors as well as errors in interfaces between memory cells.

H.3.19.8 Word protection

H.3.19.8.1
word protection with multi-bit redundancy
a **fault**/error control technique in which redundant bits are generated and saved for each word in the memory area under test

Note 1 to entry: As each word is read, a parity check is conducted.

Note 2 to entry: An example is a Hamming code which recognizes all one and two bit errors as well as some three bit and multi-bit errors.

H.3.19.8.2
word protection with single bit redundancy
a **fault**/error control technique in which a single bit is added to each word in the memory area under test and saved, creating either even parity or odd parity

Note 1 to entry: As each word is read, a parity check is conducted.

Note 2 to entry: This technique recognizes all odd bit errors.

H.3.20 Definitions of software terminology – General

H.3.20.1
common mode error
error(s) in a **dual channel** or other redundant structure such that each channel or structure is affected simultaneously and in the same manner

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H.3.20.2
common cause error
errors of different items, resulting from a single event, where these errors are not consequences of each other

Note 1 to entry: **Common cause errors** should not be confused with **common mode errors**.

H.3.20.3
failure modes and effects analysis
FMEA
analytical technique in which the **failure** modes of each hardware component are identified and examined for their effects on the safety-related functions of the **control**

H.3.20.4
independent
not being adversely influenced by the control data flow and not being impaired by **failure** of other **control** functions, or by common mode effects

H.3.20.5
invariable memory
memory ranges in a processor **system** containing data which is not intended to vary during programme execution

Note 1 to entry: **Invariable memory** may include RAM construction where the data is not intended to vary during programme execution.

H.3.20.6
variable memory
memory ranges in a processor **system** containing data which is intended to vary during programme execution

H.3.21 Definitions relating to classes of control functions

For the evaluation of protective measures for **fault** tolerance and avoidance of **hazards**, it is necessary to classify **control** functions with regard to their **fault** behaviour.

At the classification of **control** functions, their integration into the complete safety concept of the appliance shall be taken into account.

NOTE A **control** function consists of the entire loop beginning with the sensing means through the processing circuitry (hardware and software if used) and including the actuator drive.

For the purpose of evaluating the design of a **control** function, present requirements recognise three distinct classes, given in the following definitions.

H.3.21.1
class A control function
control functions which are not intended to be relied upon for the safety of the application

Note 1 to entry: Examples are: room **thermostats**, temperature **control**.

H.3.21.2
class B control function
control functions which are intended to prevent an unsafe state of the appliance

Note 1 to entry: **Failure** of the **control** function will not lead directly to a hazardous situation.

Note 2 to entry: Examples are: thermal limiter, pressure limiter.

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H.3.21.3
class C control function
control functions which are intended to prevent special **hazards** such as explosion or whose **failure** could directly cause a **hazard** in the appliance

Note 1 to entry: Examples are: burner **control systems**, **thermal cut-outs** for closed water **systems** (without vent protection).

H.3.22 Definitions relating to functional safety

H.3.22.1
functional safety
correct operation of the declared safety related output function(s), failure or malfunction of which, can cause a hazard

Note 1 to entry: The hazard could result from a loss of protective function (output function) leading to a risk of explosion, excessive temperature, electric shock, fire and/or personal injury, etc.

H.3.22.2
fault tolerating time
time between the occurrence of a **fault** and the shut-down of the controlled equipment, which is tolerated by the application without creating a hazardous situation

Note 1 to entry: Actions other than shut-down of the controlled equipment are possible if they can be shown to prevent hazardous situations.

H.3.22.3
fault reaction time
time between the occurrence of a **fault** and the point where the **control** has reached a **defined state**

H.3.22.4
defined state
state of a **control** with the following characterisation:

a) the **control** passively assumes a state in which the output terminals ensure a safe situation under all circumstances. When the cause of the transition to **defined state** is lifted, the application should start-up in accordance with the appropriate requirements; or
b) the **control** actively executes a protective action, within the time as specified in the relevant part 2, causing a shut-down, or preventing an unsafe condition; or
c) the **control** remains in **operation**, continuing to satisfy all safety related functional requirements

H.3.22.5
complex electronics
denote assemblies which use electronic components with the following characteristics:

a) the component provides more than one functional output;
b) it is impractical or impossible to represent the **failure** mode of such a component by stuck-at and cross-links at the pins or by other **failure** modes which are described in Table 14.

H.3.22.6
reset
action which provides reset from safe-state to allow the **system** to attempt a restart

H.3.22.7
degradation (of performance)
undesired departure in the operational performance of any device, equipment or **system** from its intended performance

Note 1 to entry: The term "degradation" can apply to temporary or permanent **failure**.

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[SOURCE: IEC 60050-161:1990, 161-01-19]

H.3.22.8
harm
physical injury or damage to health of people, or damage to property or the environment

[SOURCE: ISO/IEC Guide 51:2014, 3.1]

H.3.22.9
hazard
potential source of **harm**

[SOURCE: ISO/IEC Guide 51:2014, 3.2]

H.3.22.10
risk
combination of the probability of occurrence of **harm** and the severity of that **harm**

[SOURCE: ISO/IEC Guide 51:2014, 3.9]

H.3.23 Definitions related to access to data exchange

H.3.23.1
sequence number
additional data field containing a number that changes in a predefined way from message to message

H.3.23.2
time stamp
information concerning time of **transmission** attached to a message by the sender

H.3.23.3
source and destination identifier
identifier which is assigned to each entity

Note 1 to entry: This identifier can be a name, number or arbitrary bit pattern. This identifier will be used for the safety-related communication. Usually the identifier is added to the **user** data.

H.3.23.4
feed-back message
response from a receiver to the sender, via a return channel

H.3.23.5
identification procedure
procedure that forms a part of the safety-related application process

Note 1 to entry: Two types of **identification procedure** can be distinguished:

– bi-directional identification – Where a return communication channel is available, exchange of entity identifiers between senders and receivers of information can provide additional assurance that the communication is actually between the intended parties,

– dynamic **identification procedures** – Dynamic exchange of information between senders and receivers, including transformation and feedback of received information to the sender. Can provide assurance that the communicating parties not only claim to possess the correct identity, but also behave in the manner expected. This type of dynamic **identification procedure** can be used to preface the transmission of information between communicating safety-related processes and/or it can be used during the information transmission itself.

H.3.23.6
safety code
redundant data included in a safety-related message to permit data corruptions to be detected by the safety-related transmission function

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H.3.23.7
cryptographic techniques
output data are calculated by an algorithm using input data and a key as a parameter

Note 1 to entry: By knowing the output data, it is impossible within a reasonable time to calculate the input data without knowledge of the key. It is also impossible within a reasonable time to derive the key from the output data, even if the input data are known.

H.3.23.8
time-out
delay between two messages exceeding a predefined allowed maximum time

Note 1 to entry: If this is the case, an error can be assumed.

H.3.23.9
public network
data and signals not confined to the physical space within the household, or locations specified as being covered within the scope of this document

Note 1 to entry: Examples of **public networks** include but are not limited to:

– Internet;
– Wi-Fi Devices;
– Bluetooth > 10 m Devices.

H.5 Information

Table H.1 – Additional items to Table 1

	Information	Clause or subclause	Method
H.1	For integrated and incorporated **electronic controls**, if any protection against mains borne perturbations, magnetic and electromagnetic disturbances is claimed, which of the tests of Clause H.25 shall be performed and the effect on controlled output(s) and function after a **failure** to operate as a result of each test	Table H.12, H.25.2 H.25.14	X
H.2	For other than integrated and incorporated **electronic controls**, the effect on controlled output(s) and function after a **failure** to operate as a result of the tests of Clause H.25	H.25.1 H.25.14	X
H.3	Software sequence documentation [a b c d]	H.9.12.2.9	X
H.4	Programme documentation [a d e]	H.9.12.2.9 H.9.12.2.11	X
H.5	Software **fault** analysis [a c d]	H.9.12, 13.1.3	X
H.6	Software class(es) and structure [f] This information is not required for class A **controls**	H.9.12.2 H.9.12.3 H.13.2.2.1 H.13.2.3.1	D
H.7	Analytical measures and **fault**/error control techniques employed [a g]	H.9.12.1.2 H.9.12.2.2 H.9.12.2.4	X
H.8	**Software fault/error detection time**(**s**) for **controls** with software classes B or C [a h]	H.3.17.10 H.9.12.2.6	X
H.9	**Control** response(s) in case of detected **fault**/error [a]	H.9.12.2.7	X
H.10	**Controls** subjected to a second **fault** analysis and declared condition as a result of the second **fault**	H.13.2.3	X

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	Information	Clause or subclause	Method
H.11	**Fault** reaction time	H.3.22.2 H.13.2.2.2 H.13.2.2.3 H.13.2.3.2 H.13.2.3.3 H.13.2.4.2 H.13.2.4.3	X
H.12	Class or classes of **control** function(s)	H.13.2.2 H.13.2.3	X

[a] For **controls** declared as entirely class A, the requirements H.3, H.4, H.5, H.7, H.8 and H.9 of Table H.1 are exempted. For **controls** with software classes B or C, information shall be provided only for the safety-related segments of the software. Information on the non-safety related segments shall be sufficient to establish that they do not influence the safety-related segments.

[b] The software sequence shall be documented and, together with the **operating sequence** of table requirement 46, shall include a description of the **control system** philosophy, the **control** flow, data flow and the timings.

[c] Safety-related data and safety-related segments of the software sequence, the malfunction of which could result in non-compliance with the requirements of Clause 13, 19, 24 and H.25 shall be identified. This identification shall include the **operating sequence** and may, for example, take the form of a **fault** tree analysis which shall include those **fault**/errors of Table H.2 which could result in non-compliance. The software **fault** analysis shall be related to the hardware **fault** analysis in H.13.2.

[d] Examples of other information which may be suitable for inclusion in the documentation required by footnotes a, b, c, e, f and g are:

Original software **system** specification, for example:

- functional specification, including procedure for restart on loss of supply,
- module design, including description of equipment interfaces, and description of user interfaces,
- detailed design, including description of use of memory,
- code listing, including programming language identification, comments and listing of subroutines,
- test specification,
- manuals for installation, use and/or maintenance.

[e] Programming documentation shall be supplied in a programming design language declared by the manufacturer.

[f] Within a **control**, different software classes may apply to different **control** functions. Examples of **control** functions that may include software classes A to C are as follows:

Class A – Examples are room thermostats, humidity controls, lighting controls, timers and time switches.

Class B – An example is a thermal cut-out.

Class C – Examples are automatic burner **controls** and thermal cut-outs for closed water heater **systems** (unvented).

[g] Measures to be declared are those chosen by the manufacturer from the requirements of H.9.12.1.2 to H.9.12.2.4 inclusive.

[h] This can be expressed as a time following the execution of a specific software segment.

H.9 Constructional requirements

H.9.12 Controls using software

Controls using software shall be so constructed that the software does not impair compliance with the requirements of this document.

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*Compliance is checked by the tests for **electronic controls** in this document, by **inspection** according to the requirements of H.9.12 and by examination of the documentation required in Table H.1, requirements H.3 to H.9 inclusive.*

Subclauses H.9.12.1 to H.9.12.4 inclusive are only applicable to **control** functions using software class B or class C.

Subclause H.9.12.4 contains additional requirements for **remotely actuated control functions**.

H.9.12.1 Requirements for the architecture

H.9.12.1.1 **Control** functions with software class B or C shall use measures to **control** and avoid software-related **fault**s/errors in safety-related data and safety-related segments of the software, as detailed in H.9.12.1.2 to H.9.12.3 inclusive.

H.9.12.1.2 Structure for control functions with software class B or C

H.9.12.1.2.1 **Control** functions with software class C shall have one of the following structures:

– **single channel with periodic self-test and monitoring** (H.3.16.7);
– **dual channel (homogenous) with comparison** (H.3.16.3);
– **dual channel (diverse) with comparison** (H.3.16.2).

NOTE Comparison between **dual channel** structures can be performed:
– by the use of a **comparator** (H.3.18.3), or
– by **reciprocal comparison** (H.3.18.15).

H.9.12.1.2.2 **Control** functions with software class B shall have one of the following structures:

– **single channel with functional test** (H.3.16.5);
– **single channel with periodic self-test** (H.3.16.6);
– **dual channel** without comparison (H.3.16.1).

A software class C structure is also acceptable for a software class B structure.

H.9.12.1.3 Other structures are permitted if they can be shown to provide an equivalent level of safety to those in H.9.12.1.2.

H.9.12.2 Measures to control faults/errors

H.9.12.2.1 When redundant memory with comparison is provided on two areas of the same component, the data in one area shall be stored in a different format from that in the other area (see H.3.18.19 **software diversity**).

H.9.12.2.2 **Controls** with software class C using dual channel structures with comparison shall have additional **fault**/error detection means (such as **periodic functional tests**, **periodic self-tests**, or independent monitoring) for any **fault**/errors not detected by the comparison.

H.9.12.2.3 For **controls** with software class B or C, means shall be provided for the recognition and control of errors in transmissions to external safety-related data paths within a closed network (non-public network). Such means shall take into account errors in data, addressing, transmission timing and sequence of protocol (see Table H.2, external communication).

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H.9.12.2.4 For **control** with software class B or C, the manufacturer shall provide, within the control, measures to address the **fault**/errors in safety-related segments and data indicated in Table H.2 and declared in Table H.1, requirement H.5.

Table H.2 – Acceptable measures to address fault/errors [a]

Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
1. CPU					
1.1 Registers	Stuck-at	rq		Functional test, or	H.3.16.5
				periodic self-test using either:	H.3.16.6
				– **static memory test**, or	H.3.19.6
				– **word protection with single bit redundancy**	H.3.19.8.2
	DC **fault**		rq	Comparison of redundant CPUs by either:	
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**, or	H.3.18.3
				internal error detection, or	H.3.18.9
				redundant memory with comparison, or	H.3.19.5
				periodic self-tests using either	
				– **walkpat memory test**	H.3.19.7
				– **Abraham test**	H.3.19.1
				– **transparent GALPAT test**; or	H.3.19.2.1
				word protection with multi-bit redundancy, or	H.3.19.8.1
				static memory test and **word protection**	H.3.19.6
				with single bit redundancy	H.3.19.8.2
1.2 Instruction decoding and execution	Wrong decoding and execution		rq	Comparison of redundant CPUs by either:	
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**, or	H.3.18.3
				internal error detection, or	H.3.18.9
				periodic self-test using **equivalence class test**	H.3.18.5
1.3 Programme counter	Stuck at	rq		Functional test, or	H.3.16.5
				periodic self-test, or	H.3.16.6
				independent time-slot monitoring of the program sequence, or	H.3.18.10.4
				logical monitoring of the programme sequence	H.3.18.10.2
				Periodic self-test and monitoring using either:	H.3.16.7
	DC **fault**		rq	**– independent time-slot and logical monitoring**	H.3.18.10.3
				– **internal error detection**, or	H.3.18.9
				comparison of redundant functional channels by either:	
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**	H.3.18.3

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Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
1.4 Addressing	DC **fault**		rq	Comparison of redundant CPUs by either: – **reciprocal comparison** – **independent** hardware **comparator**; or **Internal error detection**; or periodic self-test using a **testing pattern** of the address lines; or **full bus redundancy**, or **multi-bit bus parity**	 H.3.18.15 H.3.18.3 H.3.18.9 H.3.16.7 H.3.18.22 H.3.18.1.1 H.3.18.1.2
1.5 Data paths instruction decoding	DC **fault** and execution		rq	Comparison of redundant CPUs by either: **reciprocal comparison**, or **independent** hardware **comparator**, or **Internal error detection**, or periodic self-test using a **testing pattern**, or **data redundancy**, or **multi-bit bus parity**	 H.3.18.15 H.3.18.3 H.3.18.9 H.3.16.7 H.3.18.2.1 H.3.18.2.2
2. Interrupt handling and execution	No interrupt or too frequent interrupt	rq		Functional test; or time-slot monitoring	H.3.16.5 H.3.18.10.4
	No interrupt or too frequent interrupt related to different sources		rq	Comparison of redundant functional channels by either **reciprocal comparison**, **independent** hardware **comparator**, or **Independent time-slot and logical monitoring**	 H.3.18.15 H.3.18.3 H.3.18.10.3
3. Clock		rq		**Frequency monitoring**, or time slot monitoring	H.3.18.10.1 H.3.18.10.4
	Wrong frequency (for quartz synchronized clock: harmonics/ subharmonics only)		rq	**Frequency monitoring**, or time-slot monitoring, or comparison of redundant functional channels by either: – **reciprocal comparison** – **independent** hardware **comparator**	H.3.18.10.1 H.3.18.10.4 H.3.18.15 H.3.18.3

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Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
4. Memory					
4.1 Invariable memory	All single bit **faults**	rq		Periodic **modified checksum**; or	H.3.19.3.1
				multiple checksum, or	H.3.19.3.2
				word protection with single bit redundancy	H.3.19.8.2
	99,6 % coverage of all information errors		rq	Comparison of redundant CPUs by either:	
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**, or	H.3.18.3
				redundant memory with comparison, or	H.3.19.5
				periodic cyclic redundancy check, either	
				– single word	H.3.19.4.1
				– double word, or	H.3.19.4.2
				word protection with multi-bit redundancy	H.3.19.8.1
4.2 Variable memory	DC **fault**	rq		Periodic **static memory test**, or	H.3.19.6
				word protection with single bit redundancy	H.3.19.8.2
	DC **fault** and dynamic cross links		rq	Comparison of redundant CPUs by either:	
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**, or	H.3.18.3
				redundant memory with comparison, or	H.3.19.5
				periodic self-tests using either:	
				– **walkpat memory test**	H.3.19.7
				– **Abraham test**	H.3.19.1
				– **transparent GALPAT test**, or	H.3.19.2.1
				word protection with multi-bit redundancy	H.3.19.8.1
4.3 Addressing (relevant to **variable memory** and **invariable memory**)	Stuck-at	rq		**Word protection with single bit redundancy** including the address, or	H.3.19.8.2
	DC **fault**		rq	comparison of redundant CPUs by either:	
				– **reciprocal comparison**, or	H.3.18.15
				– **independent** hardware **comparator**, or	H.3.18.3
				full bus redundancy	H.3.18.1.1
				Testing pattern, or	
				periodic cyclic redundancy check, either:	H.3.18.22
				– single word	H.3.19.4.1
				– double word, or	H.3.19.4.2
				word protection with multi-bit redundancy including the address	H.3.19.8.1

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Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
5. Internal data path					
5.1 Data	Stuck-at	rq		**Word protection with single bit redundancy**	H.3.19.8.2
	DC **fault**		rq	Comparison of redundant CPUs by either:	
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**, or	H.3.18.3
				word protection with multi-bit redundancy	H.3.19.8.1
				including the address, or **data redundancy**, or	H.3.18.2.1
				testing pattern, or	H.3.18.22
				protocol test	H.3.18.14
5.2 Addressing	Wrong address	rq		**Word protection with single bit redundancy** including the address	H.3.19.8.2
	Wrong		rq	Comparison of redundant CPUs by:	
	address and			– **reciprocal comparison**	H.3.18.15
	multiple			– **independent** hardware **comparator**, or	H.3.18.3
	addressing			**word protection with multi-bit redundancy**, including the address, or **full bus redundancy**; or **testing pattern** including the address	H.3.19.8.1 H.3.18.1.1 H.3.18.22
6. External communication					
6.1 Data					
	Hamming distance 3	rq		**Word protection with multi-bit redundancy**, or **CRC – single word** , or	H.3.19.8.1 H.3.19.4.1
				transfer redundancy, or	H.3.18.2.2
				protocol test	H.3.18.14
	Hamming distance 4		rq	**data redundancy** or comparison of redundant functional channels by either:	H.3.18.2.1
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**	H.3.18.3
	Wrong	rq		**Word protection with multi-bit redundancy**,	H.3.19.8.1
6.2 Addressing	address			including the address, or **CRC – single word**	H.3.19.4.1
				including the addresses, or	
				transfer redundancy or	H.3.18.2.2
				protocol test	H.3.18.14
	Wrong and		rq	**CRC – double word**, including the address, or	H.3.19.4.2
	multiple			**full bus redundancy** of data and address, or	H.3.18.1.1
	addressing			comparison of redundant communication channels by either:	
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**	H.3.18.3

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Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
6.3 Timing	Wrong point in time	rq		Time-slot monitoring, or **scheduled transmission**	H.3.18.10.4 H.3.18.18
			rq	**Time-slot and logical monitoring**, or	H.3.18.10.3
				comparison of redundant communication channels by either:	
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**	H.3.18.3
	Wrong	rq		Logical monitoring, or	H.3.18.10.2
	sequence			time-slot monitoring, or	H.3.18.10.4
				scheduled transmission	H.3.18.18
			rq	(same options as for wrong point in time)	
7. Input/output periphery	**Fault** conditions	rq		**Plausibility check**	H.3.18.13
	specified in		rq	Comparison of redundant CPUs by either:	
	Clause 13			– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**, or	H.3.18.3
7.1 Digital I/O					
				input comparison, or	H.3.18.8
				multiple parallel outputs; or	H.3.18.11
				output verification, or	H.3.18.12
				testing pattern, or	H.3.18.22
				code safety	H.3.18.2
7.2 Analog I/O					
7.2.1 A/D- and	**Fault** conditions	rq		**Plausibility check**	H.3.18.13
D/A- convertor	specified in		rq	Comparison of redundant CPUs by either:	
	Clause 13			– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**, or	H.3.18.3
				input comparison, or	H.3.18.8
				multiple parallel outputs, or	H.3.18.11
				output verification, or	H.3.18.12
				testing pattern	H.3.18.22
7.2.2 Analog multiplexer	Wrong addressing	rq		**Plausibility check**	H.3.18.13
			rq	Comparison of redundant CPUs by either:	
				– **reciprocal comparison**	H.3.18.15
				– **independent** hardware **comparator**, or	H.3.18.3
				input comparison or	H.3.18.8
				testing pattern	H.3.18.22

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Component [b]	Fault/error	Software class		Example of acceptable measures [c d e]	Definitions
		B	C		
8. Monitoring devices and **comparators**	Any output outside the static and dynamic functional specification		rq	**Tested monitoring**, or **redundant monitoring** and comparison, or **error recognizing means**	H.3.18.21 H.3.18.17 H.3.18.6
9. Custom chips [f] for example, ASIC, GAL, Gate array	Any output outside the static and dynamic functional specification	rq	rq	Periodic self-test Periodic self-test and monitoring, or **dual channel (diverse) with comparison**, or **error recognizing means**	H.3.16.6 H.3.16.7 H.3.16.2 H.3.18.6

CPU: Central programmation unit

rq: Coverage of the **fault** is required for the indicated software class.

[a] Table H.2 is applied according to the requirements of H.9.12 to H.9.12.2.11 inclusive.

[b] For **fault**/error assessment, some components are divided into their subfunctions.

[c] For each subfunction in the table, the software class C measure will cover the software class B **fault**/error.

[d] It is recognized that some of the acceptable measures provide a higher level of assurance than is required by this document.

[e] Where more than one measure is given for a subfunction, these are alternatives.

[f] To be divided as necessary by the manufacturer into subfunctions.

H.9.12.2.5 Measures others than those specified in H.9.12.2.4 are permitted if they can be shown to satisfy the requirements listed in Table H.2.

H.9.12.2.6 Software **fault**/error detection shall occur not later than the time declared in Table H.1, requirement H.8. The acceptability of the declared time(s) is evaluated during the **fault** analysis of the control.

Part 2 standards may limit this declaration.

H.9.12.2.7 For controls with functions, classified as Class B or C, detection of a **fault**/error shall result in the response declared in Table H.1, requirement H.9. For controls with functions declared as class C, independent means capable of performing this response shall be provided.

H.9.12.2.8 The loss of dual channel capability is deemed to be an error in a control function using a dual channel structure with software class C.

H.9.12.2.9 The software shall be referenced to relevant parts of the operating sequence and the associated hardware functions.

H.9.12.2.10 The software shall be protected from user alteration of safety-related segments and data.

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H.9.12.2.11 The software and safety-related hardware under its control shall be initialized to, and terminate at, as stated in Table H.1, requirement H.4.

H.9.12.3 Measures to avoid errors

H.9.12.3.1 General

For **controls** with software class B or C the measures shown in Figure H.1 to avoid systematic **faults** shall be applied.

Measures used for software class C are inherently acceptable for software class B.

The content of this is extracted from IEC 61508-3 and adapted to the needs of this document.

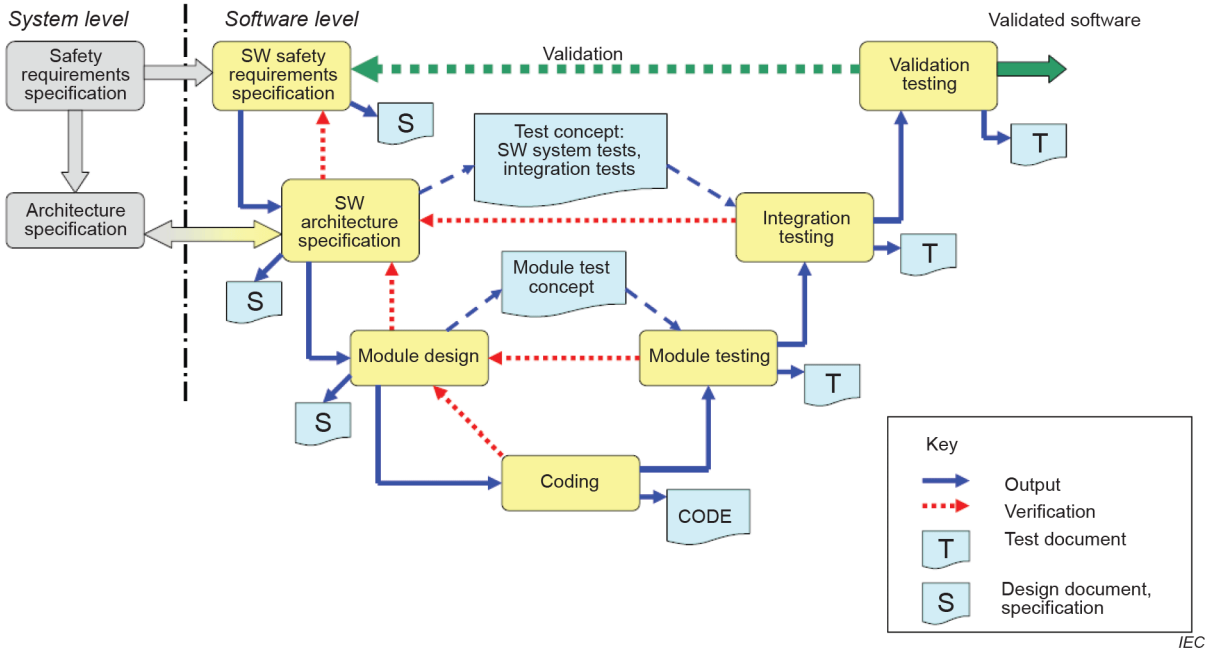


Figure H.1 – V-Model for the software life cycle

Other software lifecycle models are permitted if they incorporate disciplined and structured processes including design and test phases.

H.9.12.3.2 Specification

H.9.12.3.2.1 Software safety requirements

H.9.12.3.2.1.1 The specification of the software safety requirements shall include

– a description of each safety related function to be implemented, including its response time(s):
  - functions related to the application, including their related software classes;
  - functions related to the detection, annunciation and management of software or hardware **faults**;
– a description of interfaces between software and hardware;
– a description of interfaces between any safety and non-safety related functions.

Examples of techniques/measures can be found in Table H.3.

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Table H.3 – Examples of techniques/measures for semi-formal methods

Technique/Measure	References (informative)
Standards identification	
Semi-formal methods	
– Logical/functional block diagrams	
– Sequence diagrams	
– Finite state machines/state transition diagrams	IEC 61508-7:2010, B.2.3.2
– Decision/truth tables	IEC 61508-7:2010, C.6.1

H.9.12.3.2.2 Software architecture

H.9.12.3.2.2.1 The description of software architecture shall include the following aspects:

– techniques and measures to control software **faults**/errors (refer to H.9.12.2);
– interactions between hardware and software;
– partitioning into modules and their allocation to the specified safety functions;
– hierarchy and call structure of the modules (**control** flow);
– interrupt handling;
– data flow and restrictions on data access;
– architecture and storage of data;
– time based dependencies of sequences and data.

Examples of techniques/measures can be found in Table H.4.

Table H.4 – Examples of techniques/measures for software architecture specification

Technique/Measure	References (informative)
Fault detection and diagnosis	IEC 61508-7:2010, C.3.1
Semi-formal methods:	
− Logic/function block diagrams	
− Sequence diagrams	
− Finite state machines/state transition diagrams	IEC 61508-7:2010, B.2.3.2
− Data flow diagrams	IEC 61508-7:2010, C.2.2

H.9.12.3.2.2.2 The architecture specification shall be verified against the specification of the software safety requirements by static analysis.

NOTE Acceptable methods for **static analysis** are

– **control** flow analysis;
– data flow analysis;
– **walk-throughs**/design reviews.

H.9.12.3.2.3 Module design and coding

NOTE 1 The use of computer aided design tools is accepted.

NOTE 2 For defensive programming (for example, range checks, check for division by 0, **plausibility checks**), see IEC 61508-7:2010, C.2.5.

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H.9.12.3.2.3.1 Based on the architecture design, software shall be suitably refined into modules. Software module design and coding shall be implemented in a way that is traceable to the software architecture and requirements.

The module design shall specify

– function(s),
– interfaces to other modules,
– data.

Examples of techniques/measures can be found in Table H.5.

Table H.5 – Examples of techniques/measures for module design specification

Technique/Measure	References (informative)
Limited size of software modules	IEC 61508-7:2010, C.2.9
Information hiding/encapsulation	IEC 61508-7:2010, C.2.8
One entry/one exit point in subroutines and functions	IEC 61508-7:2010, C.2.9
Fully defined interface	IEC 61508-7:2010, C.2.9
Semi-formal methods:	
– Logic/function block diagrams	
– Sequence diagrams	
– Finite state machines/state transition diagrams	IEC 61508-7:2010, B.2.3.2
– Data flow diagrams	IEC 61508-7:2010, C.2.2

H.9.12.3.2.3.2 Software code shall be structured.

NOTE Structural complexity can be minimized by applying the following principles:

– keep the number of possible paths through a software module small, and the relation between the input and output parameters as simple as possible;
– avoid complicated branching and, in particular, avoid unconditional jumps (GOTO) in higher level languages;
– where possible, relate loop constraints and branching to input parameters;
– avoid using complex calculations as the basis of branching and loop decisions.

Examples of techniques/measures can be found in Table H.6.

Table H.6 – Examples of techniques/measures for design and coding standards

Technique/Measure	References (informative)
Use of coding standard (see H.9.12.3.2.4)	IEC 61508-7:2010, C.2.6.2
No use of dynamic objects and variables (see Note)	IEC 61508-7:2010, C.2.6.3
Limited use of interrupts	IEC 61508-7:2010, C.2.6.5
Limited use of pointers	IEC 61508-7:2010, C.2.6.6
Limited use of recursion	IEC 61508-7:2010, C.2.6.7
No unconditional jumps in programs in higher level languages	IEC 61508-7:2010, C.2.6.2
Dynamic objects and/or variables are allowed if a compiler is used which ensures that sufficient memory for all dynamic objects and/or variables will be allocated before runtime, or which inserts runtime checks for the correct online allocation of memory.	

H.9.12.3.2.3.3 Coded software shall be verified against the module specification, and the module specification shall be verified against the architecture specification by static analysis.

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NOTE Examples of methods for **static analysis** are

– **control** flow analysis;

– data flow analysis;

– **walk-throughs**/design reviews.

H.9.12.3.2.4 Design and coding standards

Program design and coding standards shall be consequently used during software design and maintenance.

Coding standards shall specify programming practice, proscribe unsafe language features, and specify procedures for source code documentation as well as for data naming conventions.

H.9.12.3.3 Testing

H.9.12.3.3.1 Module design (software system design, software module design and coding)

H.9.12.3.3.1.1 A test concept with suitable test cases shall be defined based on the module design specification.

H.9.12.3.3.1.2 Each software module shall be tested as specified within the test concept.

H.9.12.3.3.1.3 Test cases, test data and test results shall be documented.

H.9.12.3.3.1.3 Code verification of a software module by static means includes such techniques as software **inspections**, **walk-throughs**, **static analysis** and formal proof.

Code verification of a software module by dynamic means includes functional testing, white-box testing and statistical testing.

It is the combination of both types of evidence that provides assurance that each software module satisfies its associated specification.

Examples of techniques/measures can be found in Table H.7.

Table H.7 – Examples of techniques/measures for software module testing

Technique/Measure	References (informative)
Dynamic analysis and testing:	IEC 61508-7:2010, B.6.5
– Test case execution from boundary value analysis	IEC 61508-7:2010, C.5.4
– Structure-based testing	IEC 61508-7:2010, C.5.8
Data recording and analysis	IEC 61508-7:2010, C.5.2
Functional and black-box testing:	IEC 61508-7:2010, B.5.1, B.5.2
– Boundary value analysis	IEC 61508-7:2010, C.5.4
– Process simulation	IEC 61508-7:2010, C.5.18
Performance testing:	IEC 61508-7:2010, C.5.20
– Avalanche/stress testing	IEC 61508-7:2010, C.5.21
– Response timings and memory constraints	IEC 61508-7:2010, C.5.22
Interface testing	IEC 61508-7:2010, C.5.3

NOTE Software module testing is a verification activity.

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H.9.12.3.3.2 Software integration testing

H.9.12.3.3.2.1 A test concept with suitable test cases shall be defined based on the architecture design specification.

H.9.12.3.3.2.2 The software shall be tested as specified within the test concept.

H.9.12.3.3.2.3 Test cases, test data and test results shall be documented.

Examples of techniques/measures can be found Table H.8.

Table H.8 – Examples of techniques/measures for software integration testing

Technique/Measure	References (informative)
Functional and black-box testing:	IEC 61508-7:2010, B.5.1, B.5.2
– Boundary value analysis	IEC 61508-7:2010, C.5.4
– Process simulation	IEC 61508-7, C.5.18
Performance testing:	IEC 61508-7:2010, C.5.20
– Avalanche/stress testing	IEC 61508-7:2010, C.5.21
– Response timings and memory constraints	IEC 61508-7:2010, C.5.22

NOTE Software integration testing is a verification activity.

H.9.12.3.3.3 Software validation

H.9.12.3.3.3.1 A validation concept with suitable test cases shall be defined based on the software safety requirements specification.

H.9.12.3.3.3.2 The software shall be validated with reference to the requirements of the software safety requirements specification as specified within the validation concept.

The software shall be exercised by simulation or stimulation of

– input signals present during normal **operation**,
– anticipated occurrences,
– undesired conditions requiring **system** action.

H.9.12.3.3.3.3 Test cases, test data and test results shall be documented.

Examples of techniques/measures can be found in Table H.9.

Table H.9 – Examples of techniques/measures for software safety validation

Technique/Measure	References (informative)
Functional and black-box testing:	IEC 61508-7:2010, B.5.1, B.5.2
– Boundary value analysis	IEC 61508-7:2010, C.5.4
– Process simulation	IEC 61508-7:2010, C.5.18
Simulation, modeling:	
– Finite state machines	IEC 61508-7:2010, B.2.3.2
– Performance modeling	IEC 61508-7:2010, C.5.20

NOTE Testing is the main validation method for software; modelling can be used to supplement the validation activities.

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H.9.12.3.4 Other Items

H.9.12.3.4.1 Tools, programming languages

Equipment used for software design, verification and maintenance, such as design tools, programming languages, translators and test tools, shall be qualified appropriately, and shall be shown to be suitable for purpose in manifold applications.

They are assumed to be suitable if they comply with "increased confidence from use" according to IEC 61508-7:2010, C.4.4.

H.9.12.3.4.2 Management of software versions

A software version management **system** at the module level shall be put in place. All versions shall be uniquely identified for traceability.

H.9.12.3.4.3 Software modification

H.9.12.3.4.3.1 Software modifications shall be based on a modification request which details the following:

– the **hazards** affected,

– the proposed change,

– the reasons for change.

H.9.12.3.4.3.2 An analysis shall be carried out to determine the impact of the proposed modification on functional safety.

H.9.12.3.4.3.3 A detailed specification for the modification shall be generated including the necessary activities for verification and validation, such as a definition of suitable test cases.

H.9.12.3.4.3.4 The modification shall be carried out as planned.

H.9.12.3.4.3.5 The assessment of the modification shall be carried out based on the specified verification and validation activities. This can include:

– a reverification of changed software modules;

– a reverification of affected software modules;

– a revalidation of the complete **system**.

H.9.12.3.4.3.6 All details of modification activities shall be documented.

H.9.12.3.5 For **class C control functions**, the manufacturer shall have used one of the combinations (a–p) of analytical measures given in the columns of Table H.10 during hardware development.

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Table H.10 – Combinations of analytical measures during hardware development

Hardware development stage		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
H.3.17.5	**Inspection**	x		x		x		x		x		x		x		x	
H.3.17.9	**Walk-through**				x		x		x		x		x		x		x
H.3.17.7.1	**Static analysis**	x	x							x	x						
H.3.17.1	**Dynamic analysis**			x	x							x	x				
H.3.17.3	**Hardware analysis**					x	x							x	x		
H.3.17.4	**Hardware simulation**							x	x							x	x
H.3.17.2	**Failure rate calculation**	x	x	x	x	x	x	x	x								
H.3.20.3	**FMEA**									x	x	x	x	x	x	x	x
H.3.17.6	**Operational test**	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

H.9.12.4 Remotely actuated control functions

H.9.12.4.2.3 Communication of safety related data

H.9.12.4.2.3.1 Transmission

Safety relevant data shall be transmitted authentically concerning:

– data corruption;
– address corruption;
– wrong timing or sequence.

Data variation or corrupted data shall not lead to an unsafe state. Before the use of transmitted data, it shall be ensured that the above items are addressed using the measures as given in Annex H of the same or higher software class used by that function.

Compliance is checked by assessment according to Table H.11 that provides threats to be considered and examples of defences against unauthorised access and transmission failure modes.

NOTE Special attention is drawn to Table H.2, item "6. External communication", with regard to the following items:

- data deletion from the original message;
- data insertion into the original message;
- corruption of the data in the original message;
- change in sequence of data in the original message;
- make a non-authentic message look like an authentic message;
- incomplete address;
- corruption of the address of the original message;
- wrong address;
- more addresses;
- receive message more than once;
- delay in transmitting or receiving the message;
- wrong sequence of sending/receiving.
- permanent "auto-sending" or repetition,
- interruption of data transfer.

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H.9.12.4.2.3.2 Access to data exchange

For **class B control function** or **class C control function** related operating data, configuration parameters and/or software modules are allowed to be transmitted via communication, if adequate hardware/software measures are taken to prevent unauthorized access to the **control** function. Examples are given in Table H.11.

For access to data exchange of **class B control function** or **class C control function** related operating data through **public networks**, appropriate **cryptographic techniques** shall be implemented. See H.9.12.4.6.

NOTE Aspects concerning security are found under the work of ISO/IEC JTC 1/SC 27 (TC 205).

Table H.11 – Examples of defences against unauthorised access and transmission failure modes

		Defences							
To cover	**Threats**	**Sequence number** [b]	**Time stamp** [c]	**Time-out** [d]	**Feedback message** [e]	**Sourced destination identifier** [f]	**Identification procedure**	**Safety code** [g]	**Cyrpto-graphic techniques**
Transmission failure modes [h]	Repetition of a message	x	x						
	Deletion of message	x							
	Insertion of message	x			x	x	x		
	Re-sequence of data in message	x	x						
	Corrupted, deleted or inserted data in message							x [a]	x
	Delay in sending/receiving the message		x	x					
Unauthorized access	Masquerade [i]				x		x		x

Examples of defences against unauthorized access can also be found in the applications covered by IEC 62280.

[a] See Table H.2, items 6.1 and 6.2.

[b] additional data field containing a number that changes in a predefined way from message to message.

[c] information concerning time of transmission attached to a message by the sender.

[d] delay between two messages exceeding a predefined allowed maximum time.

NOTE 1 If this is the case, an error can be assumed.

[e] response from a receiver to a sender, via a return channel.

[f] identifier which is assigned to each entity.

NOTE 2 This identifier can be a name, number or arbitrary bit pattern. This identifier will be used for the safety-related communication. Usually, the identifier is added to the user data.

[g] redundant data included in a safety-related message to permit data corruptions to be detected by the safety-related transmission function.

[h] These failure modes are of random and systematic nature.

[i] Masquerade: Making an inauthentic message look like an authentic message by an unauthorized user.

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H.9.12.4.2.3.3 Revision of class B and class C software

Requirements of H.9.12.3 shall apply to class B and class C software revisions. In addition, hardware configuration management shall be required, and measures shall be taken to ensure the **control** maintains its protective functions in accordance with this document.

NOTE Hardware configuration management is meant to be in addition to software verification in order to maintain the integrity of the **control**. **System** level implications are taken into consideration.

H.9.12.4.5 Software download and installation

H.9.12.4.5.1 Software updates for class B and class C software provided by the manufacturer and transmitted to the control via remote communication shall be checked, at the control, prior to its use:

– against corruption through communication ensuring **Hamming distance** 3 for software class B, or **Hamming distance** 4 for software class C. (Refer to Table H.2 for external communication.);

– if the software version is compatible with the hardware version of the **control** according to the version management documentation.

Additionally, the software which performs the above mentioned checks shall contain measures to control the **fault**/error conditions specified in H.9.12.2.

H.9.12.4.5.2 In case of software download via remote communication, the **cryptographic techniques** in H.9.12.4.6 shall be provided. In addition to the requirements in H.9.12.4.6, identification procedures shall also be provided for the software packages.

The **cryptographic techniques** employed shall be part of the **control**, and not rely upon part of the router or similar data **transmission** device itself, and shall be performed prior to **transmission**.

H.9.12.4.5.3 For each update of software, the **control** shall have provisions for authorization by the user and a version ID number which shall be accessible.

H.9.12.4.5.4 The installation of class B software or class C software is permitted when during and after the software installation process, the **control** remains in compliance with the requirements of this document.

Compliance is checked by software inspection.

H.9.12.4.6 Cryptographic techniques

In cases where **class B control function** or **class C control function** related operating data, configuration parameters and/or software modules are transmitted over a **public network**, and/or where software updates are provided by the manufacturer via remote communication, **cryptographic techniques** shall be employed.

Compliance is checked by software inspection and review of technical documentation which provides adherence to the commonly accepted data integrity protection methods.

NOTE Examples of commonly accepted **cryptographic techniques** are defined and described in ISO/IEC 9796, ISO/IEC 9797, ISO/IEC 9798, ISO/IEC 10118, ISO/IEC 11770, ISO/IEC 14888, ISO/IEC 15946, ISO/IEC 18033, ISO/IEC 29192, as well as ISO/IEC 19772.

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H.13 Fault assessment on electronic circuits

H.13.2 Fault assessment to ensure functional safety

H.13.2.1 Design and construction requirements

H.13.2.1.1 Fault avoidance and fault tolerance

Controls incorporating **control** functions of class B or class C shall be designed according to H.13.2 taking into account the **failure** modes of Table 14 and H.9.12 for software, if applicable.

Failures of **complex electronics** can be caused by either systematic errors (built into the design, see H.9.12.3) or by random **faults** (component **faults**, see H.9.12.2). Therefore, the **system** shall be designed in such a way that systematic errors are avoided and random **faults** shall be dealt with by a proper **system** configuration.

The design of the software and hardware shall be based on the functional analysis of the application-resulting in a structured design explicitly incorporating the **control** flow, data flow and time related functions required by the application. In the case of custom-chips, special attention is required with regard to measures taken to minimize systematic errors.

This shall result in a **system** configuration which is either inherently failsafe or in which components with direct safety-critical functions (e. g. gas valve drivers, microprocessors with their associated circuits, etc.) are guarded by safeguards in accordance with H.9.12 software class B or class C. These safeguards shall be built into hardware (e. g. watch-dog, supply voltage supervision) and can be supplemented by software (e. g. ROM-test, RAM-test, etc.). It is important that these safeguards can cause a completely **independent safety shut-down**.

If time slot monitoring is used, it shall be sensitive to both an upper and a lower limit of the time interval. **Faults** resulting in shift of the upper and/or lower limit shall be taken into account.

In case of a **control** function that is classified as class C, if a single **fault** in a primary safeguard can render the safeguard inoperative, a secondary safeguard shall be provided. The reaction time of the secondary safeguard shall be in accordance with H.13.2.3.

NOTE 1 Reaction times of these safeguards can be equal or smaller than the relevant **fault tolerating time**.

NOTE 2 The secondary guarding can be realized by:

a) a physically separate circuit monitoring the primary safeguard; or

b) mutual action between the circuit being safeguarded and the primary safeguard (e. g. a watch-dog guarded by the microprocessor); or

c) action between primary safeguards (e. g. a ROM-test guarding a RAM-test).

Components shall be dimensioned on the basis of the worst-case conditions which can arise in the **control**, as stated by the manufacturer.

NOTE 3 A component **failure** could cause a **degradation** of safety critical insulation.

H.13.2.1.2 Documentation

The documentation shall be based on H.9.12.3.

H.13.2.2 Class B control function

H.13.2.2.1 Design and construction requirements

A **class B control function** shall be designed such that under single **fault** conditions it remains in or proceeds to the **defined state**. A second **independent fault** is not considered.

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NOTE **Failure** of **class B control function** in the presence of another **fault** in the appliance, or **failure** of **class C control function** alone, could result in a dangerous malfunction, electric shock, fire, mechanical or other **hazards**.

Software shall comply with software class B.

The class of **control** function shall be declared in Table H.1, requirement H.12.

The assessment shall be performed according to H.13.2.2.2 and H.13.2.2.3 and under the test conditions and criteria of H.13.2.5.

H.13.2.2.2 First fault

Any first **fault** (see Table 14) in any one component or any one **fault** together with any other **fault** arising from that first **fault** shall result in either

a) the **control** becoming inoperative with all safety related output terminals de-energized or assuming a status in which they ensure a safe situation;
b) the **control** reacting within the **fault reaction time** (declared in Table H.1, requirement H.11) by proceeding to a **defined state**, provided that subsequent **reset** from the **defined state** under the same **fault** condition results in the **system** returning to the same **defined state**;
c) the **control** continuing to operate, the **fault** being identified during the next start-up sequence, the result being a) or b);
d) the **control** remaining operational in accordance with the safety related functional requirements of the relevant part 2.

The relevant part 2 shall specify the **fault reaction time** as well as the applicability of c).

For **defined state** with a mechanical actuator, a test up to but not including the switching contacts is sufficient. If the test of the **defined state** fails, the **system** shall proceed to **safety shut-down**. Frequency of test is given in the relevant part 2. Internal **faults** on components of the checking circuit are not considered.

H.13.2.2.3 Fault introduced during defined state

Whenever the **control** is in a **defined state** without an internal **fault**, the following requirements apply.

Any first **fault** (together with any other **fault** arising from that **fault**) in any one component (see Table 14), induced while the **control** is staying in a **defined state**, shall result in either

a) the **control** remaining in a **defined state**, safety related output terminals remaining de-energized; or
b) the **control** becoming inoperative with all safety related output terminals remaining de-energized; or
c) the **control** comes again in **operation** resulting in a) or b) as mentioned in this clause under the condition that the safety related output terminals are energized not longer than the **fault reaction time** (declared in Table H.1, requirement H.11). If the cause of the **defined state** condition no longer remains and the **control** comes again in **operation**, it shall operate in accordance with the safety related functional requirements of the relevant part 2.

H.13.2.3 Class C control function

H.13.2.3.1 Design and construction requirements

A **class C control function** shall be designed such that under first and second **fault** conditions, it remains in or proceeds to the **defined state**. A third **independent fault** is not considered.

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NOTE **Failure** of **class B control function** in the presence of another **fault** in the appliance, or **failure** of **class C control function** alone, could result in a dangerous malfunction, electric shock, fire, mechanical or other **hazards**.

Software shall comply with software class C.

The class of **control** function shall be identified in Table H.1, requirement H.12.

The assessment shall be performed according to H.13.2.3.2, H.13.2.3.3 and H.13.2.4 and under the test conditions and criteria of H.13.2.5.

H.13.2.3.2 First fault

Any first **fault** (see Table 14) in any one component or any one **fault** together with any other **fault** arising from that first **fault** shall result in either

a) the **control** becoming inoperative with all safety related output terminals de-energized or assuming a status in which they ensure a safe situation;

b) the **control** reacting within the **fault reaction time** (see Table H.1, requirement H.11) by proceeding to a **defined state**, provided that subsequent reset from the **defined state** condition under the same **fault** condition results in the **system** returning to the **defined state**;

c) the **control** continuing to operate, the **fault** being identified during the next start-up sequence, the result being a) or b);

d) the **control** remaining operational in accordance with the safety related functional requirements of the relevant part 2.

The relevant part 2 shall specify the **fault reaction time** as well as the applicability of c).

H.13.2.3.3 Second fault

If the assessment of the first **fault** results in the **control** remaining operational in accordance with the safety related functional requirements of the relevant part 2 (see H.13.2.3.2 d)), any further **independent fault** considered together with the first **fault** shall result in either H.13.2.3.2 a), b), c) or d).

During assessment, the second **fault** shall only be considered to occur:

a) either when a start-up sequence has been performed between the first and the second **fault**, or

b) 24 h after the first **fault**.

The relevant part 2 shall specify the applicability of a) or b) and the **fault reaction time** (see Table H.1, requirement H.11).

It may also specify a different time span in which the second **fault** does not occur, if different from 24 h.

H.13.2.4 Faults during defined state

H.13.2.4.1 General

Whenever the **control** is in a **defined state** without an internal **fault**, an assessment according to H.13.2.4.2 and H.13.2.4.3 shall be performed.

Whenever the **control** is inoperative with all safety related output terminals de-energized or in a status in which they ensure a safe situation, in a **defined state** with an internal **fault**, an additional single **fault** assessment according to H.13.2.4.3 shall be performed.

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NOTE Safety related output terminal as used in H.13.2.4.2 and H.13.2.4.3 are terminals which are safety related even in the **safety shut-down** or in a **defined state**, for example, gas valve terminal, but not a terminal for an actuator driving the controlling element which does not degrade the safety in the **defined state**.

H.13.2.4.2 First fault introduced during defined state

Any first **fault** (together with any other **fault** arising from that **fault**) in any one component (see Table 14), induced while the **control** is staying in the **safety shut-down** position, shall result in either:

a) the **control** remaining in a **defined state**, safety related output terminals remaining de-energized or in a status in which they ensure a safe situation;

b) the **control** becoming inoperative with all safety related output terminals remaining de-energized or assuming a status in which they ensure a safe situation;

c) the **control** comes again in **operation** resulting in a) or b) as mentioned in H.13.2.4.2 under the condition that the safety related output terminals are energized not longer than the **fault reaction time** (see Table H.1, requirement H.11). If the cause of the original **safety shut-down** condition no longer remains and the **control** comes again in **operation**, it shall operate in accordance with the safety related functional requirements of the relevant part 2 and the second **fault** assessment shall be carried out in accordance with H.13.2.3.3.

H.13.2.4.3 Second fault introduced during defined state

Any second **fault** (together with any other **fault** arising from that **fault**) in any one component (see Table 14), induced while the **control** is staying in the **defined state**, shall result in either H.13.2.4.2 a), b) or c).

During assessment, the second **fault** shall not be considered to occur within 24 h after the first **fault**.

The relevant part 2 shall specify the **fault reaction time**.

It may also specify a different time span in which the second **fault** does not occur, if different from 24 h.

H.13.2.5 Circuit and construction evaluation

H.13.2.5.1 Test conditions

The effect of internal **faults** shall be assessed by simulation and/or by an examination of the circuit design.

The **fault** shall be considered to have occurred at any stage in the **control** programme sequence.

The **control** shall be operated or considered to operate under the following conditions:

a) at the most unfavourable voltage in the range 85 % to 110 % of the rated supply voltage;

b) loaded with the most unfavourable load declared by the manufacturer;

c) in an ambient temperature of (20 ± 5) °C, unless there are significant reasons for conducting the test at another temperature within the manufacturer's declared range;

d) with any **actuating member** placed in the most unfavourable position;

e) with tissue paper placed on the supporting surface(s) of the **control**;

f) with sparks of about 3 mm in length and having an energy of not less than 0,5 J applied to those components which are likely to liberate flammable gases during the test.

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H.13.2.5.2 Test criteria

During the appraisal, it shall be verified that under the conditions described above, the following criteria are satisfied.

a) The **control** shall not emit flames, hot metal or hot plastics, the tissue paper shall not ignite, no explosion shall result from the liberation of flammable gases and any flame produced shall not continue to burn for more than 10 s after switching off the spark generator. When a **control** is incorporated with any appliance, any enclosure afforded by the appliance is taken into consideration.

b) If the **control** continues to function, it shall comply with Clauses 6 and 15. If it ceases to function, it shall still continue to comply with Clause 6.

c) There shall be no loss of protective function.

After the tests, there shall be no deterioration of the various parts of the **control** that would result in failure to comply with Clause 11 .

H.13.2.5.3 Assessment

A thorough appraisal of the circuit shall be carried out to determine its performance under the specified **fault** conditions. This appraisal shall take the form of a theoretical analysis and a component **failure** simulation test. **Fault** simulations can also be carried out to simulate **faults** within complex devices, for example, EPROM emulation tests.

Only the safety related software (software class B and C) as identified according to H.13.2.1.2 shall be subjected to further assessment. For the identification of the class, a **fault** tree analysis may be used.

H.17 Manufacturing deviation and drift

H.17.1 Those parts of controls providing a **type 2 action** shall have adequate consistency of manufacture with regard to their declared operating value, operating time, or operating sequence.

H.17.2 *Compliance is checked by the appropriate tests of this clause.*

H.17.3 For those controls which are completely or partially destroyed during their intended normal operation (e.g. single operating device), the tests of the appropriate subclauses of Clause 19 are deemed to be sufficient.

H.17.4 For those controls which are dependent on the method of mounting on, or incorporation in an equipment for their operation, the manufacturing deviation and the drift shall be declared separately and be comparative values. The declared manufacturing deviation should be expressed as a bandwidth or spread (for example, 10 K) and the drift by an alteration of value (for example, ±10 K or +5 K, −10 K).

H.17.5 The consistency shall be determined by testing three samples as follows:

H.17.5.1 Test apparatus used shall be such that the control is mounted in the manner declared by the manufacturer.

H.17.5.2 For sensing controls, the apparatus shall preferably be such that the normal operation of the control is used to control the apparatus.

H.17.5.3 However, because this test is made to determine comparative values rather than response values, the form of the apparatus is not critical. It should, however, simulate as nearly as is practicable the conditions of service.

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H.17.5.4 The electrical conditions of the test shall normally be $V_{R\ max}$ and $I_{R\ max}$ unless different conditions have been declared in Table 1, requirement 35.

H.17.5.5 For sensing controls, the rate of change of activating quantity shall be any suitable value unless specific values have been declared in Table 1, requirement 31.

H.17.5.6 The appropriate operating value, operating time or operating sequence shall be recorded for each sample. No two samples shall differ from each other by an amount exceeding the declared manufacturing deviation.

H.17.5.7 The recorded values are also used as reference values for each sample, so that the repeat tests after the environmental tests of Clause 18 and the endurance test of Clause 19 will enable drift to be determined.

H.17.6 For those controls which are not dependent for their operation on the method of mounting on, or incorporation in, an equipment (for example, timers, current sensing controls, voltage sensing controls, energy regulators or the drop-out current of electrically operated controls), the determination of consistency shall be as follows.

H.17.6.1 The manufacturing deviation, and/or the drift may be an absolute value. In this case, a single declaration combining both the manufacturing deviation and the drift can be made.

H.17.6.2 The appropriate operating value, operating time or operating sequence shall be initially measured for all samples and be within the limits declared by the manufacturer.

H.17.6.3 Test apparatus shall be such as to simulate the most arduous conditions of normal use declared.

H.17.6.4 If a drift value has been declared separately in Table 1, requirement 36, the measured values for each sample shall be recorded as a reference value, so that the repeat tests after the environmental tests of Clause 18 and the endurance tests of Clause 19 will enable the drift to be determined.

H.17.7 Calibration tests for PTC thermistors

See J.17.1.

H.17.8 Calibration tests for NTC thermistors

See J.17.2.

H.19 Endurance

H.19.1 General requirements

H.19.1.3.3 Thermal cycling test

The purpose of the test is to cycle components of an electronic circuit between the extremes of temperature likely to occur during **normal use** and which can result from ambient temperature variation, mounting surface temperature variation, supply voltage variation, or the change from an operating condition to a non-operating condition and vice versa.

The tests necessary to achieve the above conditions will depend to a large extent on the particular type of **control** and will be expanded upon, if necessary, in the appropriate part 2 of this document.

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The following conditions shall form the basis of the test:

a) *Duration*

*14 days, or any duration specified in the relevant part 2, whichever is the greater. For **controls** providing **electronic disconnection** (type 2.Y), 14 days, or the number of cycles declared in Table 1, requirements 19 and 20, whichever produces the longer duration of test.*

b) *Electrical conditions*

*The **control** shall be loaded according to the ratings declared by the manufacturer, the voltage then being increased to 1,1 V_R except for 30 min of each 24 h period of the test when the voltage is reduced to 0,9 V_R. The change of voltage shall not be synchronized with the change of temperature. Each 24 h period shall also include at least one period in the order of 30 s during which the supply voltage is switched off.*

c) *Thermal conditions*

The ambient temperature and/or the mounting surface temperature are varied between T_{max} ($T_{s\ max}$) and T_{min} ($T_{s\ min}$) to cause the temperature of the components of the electronic circuit to be cycled between the resulting extremes. The rate of ambient and/or mounting surface temperature change shall be in the order of 1 K/min and the extremes of temperature maintained for approximately 1 h.

d) *Rate of **operation***

*During the test, the **control** shall be cycled through its operational modes at the fastest rate possible up to a maximum of six cycles per minute, subject to the need to cycle components between their temperature extremes.*

*If an operational mode, such as speed control, can be set by the **user**, the test period shall be divided into three periods, one period being at the maximum, one at the minimum and one at an intermediate **setting**.*

*For **controls** providing **electronic disconnection** (type 2.Y), the test also includes the declared number of **operations** from the conducting to the non-conducting state and vice versa.*

H.25 Electromagnetic compatibility (EMC) requirements – Immunity

H.25.1 General requirements

Electronic controls shall be so constructed as to withstand the effects of mains-borne perturbations and electromagnetic phenomena which can occur in normal use (see NOTE 3 to entry of 3.13.4). For controls with **type 2 action** the tests of Clause H.25 are also carried out after the control has performed its safety function.

Evaluation criteria for the **control** appropriate to test level 2 and/or 3 and/or 4 shall be given by the appropriate part 2. Refer to all subclauses in Clause H.25 for additional details. If no part 2 is applicable, Table H.12 or H.25.2 applies. These test levels correspond with test levels specified by the relevant parts of IEC 61000. The part 2 shall provide acceptable effects, assessment criteria, on the **control** as a result of tests using test levels 2 and/or 3, such as normal **operation** after test level 2 test and safe **operation** of appliance/safe shut-down after test level 3 test. Parts 2 may specify higher test levels.

The part 2 shall specify test levels for Clause H.25 tests. As a minimum, test level 3 is applicable to **protective controls** intended to prevent unsafe **operation** of the controlled equipment, such as cut-outs and door-locks for laundry equipment.

The tests of Clause H.25 are not applicable to non-**electronic controls** because of their tolerance to such perturbations. The appropriate tests for specific types of non-**electronic controls** are included in other clauses of the appropriate part 2.

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Compliance is checked at test levels as indicated by the following Table H.12. The controls shall comply with H.25.14.

Table H.12 – Applicable test levels in addition to Clause 25

Control type	Type of action/Class of control function	Applicable Clause H.25 tests	Applicable test levels corresponding to H.25.14.3 [a]
Operating control [b]	**Type 2, class B, class C**	H.25.4 to H.25.13	2, 3, or 4 as specified
Protective control	**Type 2, class B, class C**	H.25.4 to H.25.13	3
Protective controls [c] declared in Table 1, requirement 66 intended for use in accordance with IEC 60335-1:2020	**Type 2, class B, class C**	H.25.4 to H.25.13	Applicable test levels according to IEC 60335-1:2020, 19.11.4

[a] Lower test levels shall be considered in accordance with the relevant parts of IEC 61000-4.

[b] Example of an operating **control** with **class C control function** is the automatic burner control **system** (IEC 60730-2-5). For such **controls,** the applicable test levels are given in the part 2.

[c] According to the language of IEC 60335-1:2020, an **operating control** of **class B control function** or **class C control function** is a protective electronic circuit.

H.25.2 Particular requirements for integrated and incorporated controls with type 2 action

For integrated and incorporated controls with **type 2 action**, compliance is checked by H.25.5 and any other tests of Clause H.25 which are declared in Table H.1, requirement H.1.

NOTE The suitability of each test in Clause H.25 to a given **control** can be determined by reference to the appropriate appliance standard(s) or to the manufacturer's declaration of the intended use of the **control**.

This determination of suitability includes an assessment:

– whether the control will be exposed to a particular type of disturbance in its application;

– whether the response of the control to the particular type of disturbance is relevant to safety in its application.

H.25.3 Sample requirement

A separate sample, as submitted, may be used for each test. At the option of the control manufacturer, multiple tests can be performed on a single sample.

H.25.4 Harmonics and interharmonics including mains signalling at AC power port, low frequency immunity tests

*For protective **controls** declared in Table 1, requirement 66, the following test applies:*

*The **control** is subjected to mains signals in accordance with IEC 61000-4-13, test level class 2 being applicable.*

*During the test, the **control** is supplied with rated voltage. The test levels for Class 2 environment according to IEC 61000-4-13:2002, IEC 61000-4-13/AMD1:2009 and IEC 61000-4-13/AMD2:2015, Tables 1 to 4 shall be applied at the AC power port of the EUT. The **control** is tested under the test conditions as specified in the specific **control** standard.*

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The following tests are performed in accordance with IEC 61000-4-13:2002, IEC 61000-4-13/AMD1:2009 and IEC 61000-4-13/AMD2:2015, Figure 1a for Class 2 environment:

– "Harmonic combination" (IEC 61000-4-13:2002, IEC 61000-4-13/AMD1:2009 and IEC 61000-4-13/AMD2:2015, 8.2.1);

– "Meister curve" (IEC 61000-4-13:2002, IEC 61000-4-13/AMD1:2009 and IEC 61000-4-13/AMD2:2015, 8.2.4).

H.25.5 Voltage dips, voltage interruptions and voltage variations in the power supply network

The **control** shall tolerate voltage dips voltage interruptions and voltage variations in the power supply network.

Compliance is checked by the tests of H.25.5.1.

H.25.5.1 Voltage dips and interruptions

The purpose of the test is to verify the immunity of the equipment against voltage dips and voltage interruptions. Voltage dips and interruptions are caused by **faults** in the LV, MV, HV networks (short-circuit or ground **faults**).

H.25.5.1.1 Test levels for voltage dips and interruptions

The test values in Table H.13 shall be applied to all the test levels.

Table H.13 – Voltage dips, short interruptions and voltage variations

Duration (50 Hz/60 Hz)	ΔU		
	30 %	60 %	100 %
Half-cycle of supply waveform			X
One cycle of supply waveform			X
2,5/3 cycles of supply waveform	X	X	X
25/30 cycles of supply waveform	X	X	X
50/60 cycles of supply waveform	X	X	X
NOTE Where intermediate durations of voltage interruption may affect either the inherent safety of the **control** or the output of a **control** with **type 2 action**, parts 2 may indicate voltage interruptions at other points.			

H.25.5.1.2 Test procedure for voltage dips and interruptions

The test apparatus and procedures shall be as described in IEC 61000-4-11. During the test, the **control** shall be initially operated at its rated voltage.

The voltage dips and interruptions, at random phase with respect to the mains frequency, shall be performed at least three times in the relevant operating modes.

Attention should be given to the operating modes in which the **control** may be particularly sensitive to voltage dips and interruptions.

Between the voltage dips and interruptions a waiting time of at least 10 s shall be observed.

In the case of three-phase equipment, it may be necessary to apply voltage dips and interruptions either on the three phases simultaneously or on one or two phases only.

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Protective **controls** as declared in Table 1, requirement 66, shall be subjected to voltage dips and interruptions at random phase angles with respect to the mains frequency as well as at the zero crossing of the supply voltage.

H.25.5.2 Voltage variation test

The purpose of the test is to verify the immunity of the **control** against voltage change taking place over a short period which can occur due to a change of load or stored energy in local power networks.

H.25.5.2.1 Test levels for voltage variations

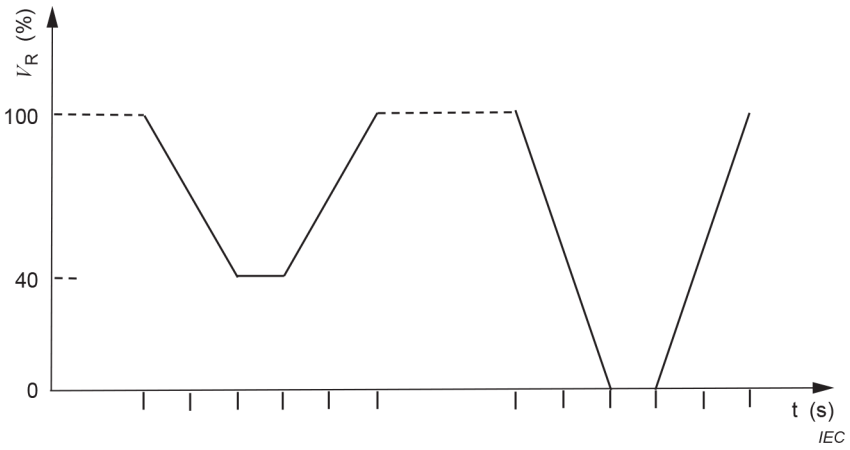
The test values in Table H.14 shall be applied to all the test levels.

H.25.5.2.2 Test procedure

The test apparatus and procedures shall be as described in IEC 61000-4-11.The duration of the voltage changes and the time for which the reduced voltages are to be maintained are given in Table H.14 and illustrated in Figure H.2. The rate of change of voltage shall be constant; however, the voltage is able to be stepped. The steps shall be positioned at 0 crossing and shall be not larger than 10 % of V_R. Steps under 1 % of V_R are evaluated as constant rate of change of voltage.

Table H.14 – Test values for voltage variations

Voltage test level	Time for decreasing voltage	Time at reduced voltage	Time for increasing voltage
40 % V_R	2 s ± 20 %	1 s ± 20 %	2 s ± 20 %
0 % V_R	2 s ± 20 %	1 s ± 20 %	2 s ± 20 %
	x	*x*	*x*
NOTE *x* represents an open set of durations and is able to be specified in part 2.			



NOTE The voltage gradually decreases.

Figure H.2 – Voltage variation test

The **control** is subjected to each of the specified voltage test cycles three times with 10 s intervals between each test cycle for the most representative modes of **operation**. Additional voltage test levels may be specified in part 2.

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H.25.6 Test of influence of voltage unbalance

H.25.6.1 Purpose of the test – Range of application

This test applies only to three-phase equipment.

The purpose of the test is to investigate the influence of unbalance in a three-phase voltage **system** on equipment sensitive to this kind of interference, such as:

– overheating of AC rotating machines;

– generation of non-characteristic harmonics in electronic power converters.

The degree of unbalance is defined by the unbalance factor

$$T_{\mathrm{i}} = \frac{U_{\mathrm{i}}}{U_{\mathrm{d}}} = \frac{\text{negative sequence voltage}}{\text{positive sequence voltage}}$$

H.25.6.2 Test voltage characteristics

A power frequency three-phase voltage shall be applied to the **control** with the specified unbalance factor.

NOTE In order to obtain accurate results, a voltage with very small harmonics content can be used.

H.25.6.3 Test equipment/test generator

The test arrangement shall consist of three single-phase auto-transformers, whose outputs are regulated individually, or the like.

H.25.6.4 Test level

The test shall be carried out with an unbalance factor of 2 %.

H.25.7 Test of the influence of DC in AC networks

NOTE Requirements and tests are under consideration.

H.25.8 Surge immunity test

The **control** shall tolerate voltage surges on the mains supply and relevant signal terminals.

Compliance is checked by the tests of H.25.8.2 to H.25.8.3 inclusive.

H.25.8.1 Purpose of the test

*This test applies to the power supply terminals and in specific cases to the **control** terminals (see H.25.8.2).*

***Controls** providing **electronic disconnection** are loaded as indicated in 19.2 and subjected to the test levels for the installation class specified for the **control** by the manufacturer (declared in Table 1, requirement 43), when the **control** is providing **electronic disconnection**. During and after the test, the **control** shall continue to provide **electronic disconnection**, as determined by the test of 9.4.16.3. If, during the test, the **electronic disconnection** is caused to be conductive for one-half cycle of the supply frequency after application of one surge, this is not considered to be a **fault**.*

The purpose of this test is to verify the immunity of the **control** against unidirectional surges caused by different phenomena:

– switching phenomena in the power network (for example, switching of capacitor banks);

– **faults** in the power network;

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– lightning strikes.

The induced voltage surge can have different effects, depending on the relative impedance of the source and of the **control**:

– if the **system** has a high impedance relative to the source, the surge will produce a voltage surge;
– if the **control** has a relative low impedance, the surge will produce a current pulse.

This behaviour can be illustrated by an input circuit protected by an overvoltage suppressor: as soon as the latter breaks down, the input impedance becomes very low. A realistic test shall correspond to this behaviour and the test generator shall be able to deliver a voltage pulse on a high impedance as well as a current pulse on a low impedance (hybrid generator).

H.25.8.2 Test values

The tests as detailed in Table H.15 shall be applied.

*The tests on the terminals for signal, data, **control** and other input lines shall only be performed if these terminals are designed to make an interconnection with cables longer than 10 m, according to the manufacturer's specifications.*

*For **protective controls** as declared in Table 1, requirement 66, the following additional test applies:*

*The power supply terminals of the **control** are subjected to an open-circuit test voltage of 4 kV (applicable for the line-to-earth coupling mode) with a generator having a source impedance of 12 Ω being used, and to an open-circuit test voltage of 2 kV (applicable for the line-to-line coupling mode) with a generator having a source impedance of 2 Ω being used.*

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Table H.15 – Test voltages for test level 2 (depending on the installation class conditions)

Test values peak kV										
IEC 61000-4-5 installation class	AC power supply and AC I/O		DC power supply and DC I/O		Unsymmetrical operated circuits and lines		Symmetrical operated circuits and lines		Shielded circuits/lines	
	Coupling mode		Coupling mode		Coupling mode		Coupling mode		Coupling mode	
	Line-to-line	Line-to-ground	Line-to-line	Line-to-ground	Line-to-line[a]	Line-to-ground	Line-to-line	Line-to-ground	Line-to-line	Shield-to-ground
2	0,5	1,0	No test	No test	0,5	1,0	No test	1,0	No test	0.5
3	1,0	2,0	No test	No test	1,0	2,0	No test	2,0	No test	2,0
4	2,0	4,0	2,0	4,0	2,0	4,0	No test	4,0	No test	4,0

NOTE 1 For test level 3 requirements, apply the next higher installation class. For test level 4 requirements, apply installation class 4 values.

NOTE 2 Tests are performed with any intended surge suppression properly installed.

NOTE 3 In a **control**, a lower category may follow any higher category when appropriate **transient overvoltage** control means are provided.

NOTE 4 See Annex N for a description of installation class and further explanatory notes.

NOTE 5 Symmetrical lines are a pair of symmetrically driven conductors with a conversion loss from differential to common mode of greater than 20 dB. [SOURCE: IEC 61000-4-5:2014, 3.1.21].

[a] In “Unsymetrical operated circuits and lines”, coupling mode “Line-to-line” that these tests are only required in case of long distance lines according 3.24.9.

At test level 2) and 3), after the tests of H.25.8.2, the surge protective components shall not be destroyed.

H.25.8.3 Test procedure

The test apparatus and procedure shall be as described in IEC 61000-4-5. In accordance with this document, the **control** is connected to an appropriate source of supply operating at the rated voltage with the impulse generator connected across the terminals.

If the **system** has more than one relevant operating mode, the impulses can be distributed over the relevant operating modes (declared in Table 1, requirement 43) provided that, for each operating mode, a minimum of one impulse of each polarity (+, −) and each phase angle described in IEC 61000-4-5, shall be applied.

For **controls** having surge protective device arresters incorporating spark gaps, the test is repeated at a test level that is 95 % of the flashover voltage.

The **control** is tested and assessed in each of the relevant operating modes (, as specified in the relevant part 2.

H.25.9 Electrical fast transient/burst immunity test

The **control** shall tolerate fast transient bursts on the mains supply and on the signal lines.

Compliance is checked by the test of H.25.9.2 to H.25.9.3 inclusive.

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H.25.9.1 Purpose of the test

This test applies to the power supply terminals and in specific cases to the control terminals (see H.25.9.2).

The purpose of this test is to demonstrate the immunity of the control to bursts of fast low energy transients which can be produced by relays, contactors, etc., switch inductive loads and which can be induced into signal and data circuits.

H.25.9.2 Test levels

The tests shall be applied as specified in Table H.16.

The tests on the terminals for interface cables shall only be performed if these terminals are designed to make an interconnection with cables longer than 3 m, according to the manufacturer's specifications.

Generator drive:	*internal*
Duration:	*1 min each positive (+) and also negative (−) polarity*
Operating conditions:	*as in the relevant part 2, or in the absence of a part 2, the relevant operating modes.*

The test voltage on power supply port shall be applied simultaneously between the ground reference plane and all of the power supply terminals (common mode).

Table H.16 – Test level for electrical fast transient burst test

		Open-circuit output test voltage and repetition rate of the impulses			
		On power port, PE		On I/O (Input/Output) signal, data and control ports	
Applicable test levels corresponding to H.25.14.3	**Test level in accordance with IEC 61000-4-4**	**Voltage peak kV**	**Repetition rate kHz**	**Voltage peak kV**	**Repetition rate kHz**
2	2	1	5	0,5	5
3	3	2	5	1	5
Protective controls declared in Table 1, requirement 66 intended for use in accordance with IEC 60335-1:2020	4	4	5	-	-

H.25.9.3 Test procedure

The test apparatus and test procedures shall be as described in IEC 61000-4-4.

The **control** is tested in each of the relevant operating modes, as specified in the relevant part 2.

H.25.10 Electrostatic discharge test

This test is carried out in accordance with IEC 61000-4-2.

The test values shall be applied to test level 3.

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*Direct application of discharge: Contact discharges at 6 kV to accessible metal parts, or air discharges at 8 kV to **accessible parts** of insulating material shall apply.*

Indirect application of discharge: Contact discharges at 6 kV to horizontal or vertical couple plate shall apply.

For **protective controls** as declared in Table 1, requirement 66, the following additional test applies: This test is carried out in accordance with IEC 61000-4-2:2008, Clause 5, test level 4. Contact discharges at 8 kV to accessible metal parts, or air discharges at 15 kV to **accessible parts** of insulating material shall apply.

H.25.11 Radio-frequency electromagnetic field immunity

H.25.11.1 Purpose of the test

The purpose of the test is to verify the immunity of **controls** against electromagnetic fields generated by radio transmitters or any other device emitting continuous wave radiated electromagnetic energy. The immunity of **controls** to the radiation of hand-held transceivers (walkie-talkies) is the main concern but other sources of electromagnetic radiation are involved, such as fixed station radio and television transmitters, vehicle radio transmitters and various industrial electro-magnetic sources of intermittent sources.

H.25.11.1.1 If the criticality of test level 2 testing is not affected after test level 3 testing, the testing of test level 2 need not be carried out.

H.25.11.2 Immunity to conducted disturbances

*The **control** shall tolerate high frequency signals on the mains supply and relevant signal terminals.*

Compliance is checked with the tests of H.25.11.2.1 to H.25.11.2.2, inclusive.

H.25.11.2.1 Test levels for conducted disturbances

At minimum, the test levels in Table H.17 shall be applied.

The tests shall only be applied to interface cables which, according to the manufacturer's specification, may be longer than 1 m.

Table H.17 – Test levels for conducted disturbances on mains and I/O lines

Test frequency range: 150 kHz to 80 MHz		
Test level	Voltage level (RMS)	
	U_0 dBµV	U_0 V
2	130	3
3	140	10
NOTE The test levels in the ISM- and CB-bands are chosen to be 6 dB higher. (ISM: Industrial, scientific and medical radio-frequency equipment: 13,56 MHz ± 0,007 MHz and 40,68 MHz ± 0,02 MHz, CB: Citizen band: 27, 125 MHz ± 1,5 MHz).		

H.25.11.2.2 Test procedure

This test shall be carried out in accordance with IEC 61000-4-6.

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*Test the **control** by sweeping through the complete test frequency range at least once with the **system** in each of its relevant operating modes. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value with linear interpolation between calibration points. The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the **control** to be exercised and be able to respond, but in no case be less than 0,5 s.The ISM and CB bands shall be tested with those test frequencies that have been used by sweeping through the complete test frequency range and cover the ISM and CB bands regarded.*

NOTE The sensitive frequencies or the frequencies of dominant interest can be analyzed separately.

H.25.11.3 Immunity to radiated disturbances

The **control** shall tolerate high-frequency signals on the mains supply and relevant signal terminals.

Compliance is checked by the tests of H.25.11.3.1 to H.25.11.3.2 inclusive.

H.25.11.3.1 Test level for radiated electromagnetic fields

Test levels for immunity to radiated electromagnetic fields shall be applied in accordance with Table H.18.

Increased test levels for radiated immunity shall be applied in accordance with Table H.19.

Table H.18 – Test level for immunity to radiated electromagnetic fields

	Test frequency ranges/Field strength [c] V/m		
Test level	**80 MHz to 1,0 GHz** 80 % AM (1 kHz) [d]	**1,4 GHz to 2,0 GHz** 80 % AM (1 kHz) [d]	**2,0 GHz to 6,0 GHz** 80 % AM (1 kHz) [d]
2	3 [b] 6 [a, b]	3 [b] 6 [a, b]	3 [a, b]
3	10 [b] 20 [a, b]	3 [b] 10 [a, b]	3 [a, b]

[a] These increased values shall be applied in frequency ranges as given in Table H.19.

[b] The test level specified is the RMS value of the unmodulated carrier.

[c] If hand held radio transmitters could be used closer than 20 cm a warning shall be given in the safety manual that the equipment concerned could be disturbed.

[d] IEC 61000-4-3 requires the test to be performed with 80 % 1 kHz AM modulation. However, the test may be extended to other modulation schemes.

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Table H.19 – Increased test level for radiated immunity

Test frequency/range MHz
84,000
137 to 174
219,500
380 to 400
420 to 470
698 to 960
1 240 to 1 300
1 428 to 2 700
3 300 to 3 600
5 150 to 5 925
Information about frequency can be found in IEC 61000-6-7:2014.
NOTE 1 For those frequency/range where a single test frequency is indicated, the test is performed at that frequency only. NOTE 2 For the tests, the modulation scheme as given in the basic standard is applied. Other modulation parameters are possible. NOTE 3 For more information about frequency allocation per region, see IEC TR 61000-2-5 or ITU publications.

H.25.11.3.2 Test procedure

This test shall be carried out in accordance with IEC 61000-4-3.

*Test the **control** by sweeping through the complete test frequency ranges in both the horizontal and the vertical antenna orientation in each of its relevant operating modes. Where the frequency range is swept incrementally, the step size shall not exceed 1 % of the preceding frequency value with linear interpolation between calibration points. The dwell time at each frequency shall not be less than the time necessary for the **control** to be exercised and to respond, but shall in no case be less than 0,5 s.*

*The test shall normally be performed with the generating antenna facing each side of the **control**. When equipment can be used in different orientations (i.e. vertical or horizontal), all sides shall be exposed to the field during the test. When technically justified, some **controls** can be tested by exposing fewer faces to the generating antenna. In other cases, as determined for example, by the type and size of **control** or the frequencies of test, more than four azimuths may need to be exposed.*

NOTE The sensitive frequencies or the frequencies of dominant interest can be analyzed separately.

H.25.12 Test of influence of supply frequency variations

Micro-processor based **controls** declared as **class B control function** and/or **class C control function** which rely on the mains supply frequency for the correct **operation** shall tolerate frequency variations of the mains supply frequency, if declared in Table H.1.

H.25.12.1 Purpose of the test

The purpose of this test is to verify the effect on the **control** from frequency deviation on the mains.

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H.25.12.2 Test levels

The test values in Table H.20 shall be applied.

Table H.20 – Test level for supply frequency variations

Test level	Variations in supply frequency % [a]
2	±1 and ±2
3	±3, ±4 and ±5
[a] Other values may be specified in part 2.	

H.25.12.3 Test procedure

The test apparatus and procedures shall be as described in IEC 61000-4-28.

The **control** shall be initially operated at its rated voltage and shall then be subjected to the frequency variations as detailed in H.25.12.2.

H.25.13 Power frequency magnetic field immunity test

The **controls** which are susceptible to magnetic field such as **controls** which use Hall-effect devices shall tolerate power-frequency magnetic fields.

Compliance is checked by the tests of H.25.13.2 and H.25.13.3.

NOTE Examples of such **controls** include pressure sensors which use Hall-effect devices, **controls** incorporating reed relays and **controls** utilizing bistable relays.

H.25.13.1 Purpose of the test

The purpose of the test is to demonstrate the immunity of **controls** which may be affected by power-frequency magnetic fields related to the specific location and installation conditions of the **control** (for example, proximity of the equipment to the disturbance source).

The power-frequency magnetic field is generated by power-frequency currents in conductors or from other devices (for example, leakage of transformers) in the proximity of equipment.

Only the influences of nearby conductors should be considered, where the current under normal operating conditions produces a steady (continuous) magnetic field, with a comparatively small magnitude.

H.25.13.2 Test levels

The test levels shall be applied in accordance with Table H.21.

Table H.21 – Test level for continuous fields

Test level	Continuous field strength A/m
2	3
3	10

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H.25.13.3 Test procedure

The **control** is supplied at rated voltage. Test equipment, test set-up and test procedure shall be in accordance with IEC 61000-4-8. The **control** is tested under the test conditions as specified in the relevant part 2.

H.25.14 Evaluation of compliance

H.25.14.1 After completion of all the tests of H.25.4 through H.25.13, the sample(s) shall meet the requirements of Clause 6, Clause 11 and 19.5.

H.25.14.2 In addition, the control shall meet the following:

– the requirements of 19.14 or

– the output(s) and functions shall be as declared in Table H.1, requirements H.1 and H.2.

Compliance with the second alternative of H.25.14.2 may make the control unacceptable for some applications.

Parts 2 may contain restrictions on the allowable effects on controlled output(s) for particular types of **controls** or **control** functions for test levels.

H.25.14.3 Different outputs and functions can be declared by the manufacturer after testing at test level 2, or test level 3, if relevant. Part 2 may specify particular criteria after each of these tests.

H.25.14.4 The compliance criteria shall be given in part 2 or the end equipment standard and shall be based on the operating output conditions and the functional specifications of the control under test. However, in cases where the compliance criteria is not specified for the control, the control shall comply with one of the following criteria:

a) normal performance with no loss of protective functions and **control** is within specification or declared limits;

b) loss of protective function within declared limits;

c) loss of protective function with **safety shut-down**.

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Annex I
(normative)

Requirements for certain types of DC supplied controls

Annex I supplements or modifies the corresponding clauses of this document.

I.1 Scope

This annex is additionally applicable for DC supplied controls for non-stationary applications as declared in Table 1, requirement 87 (e.g. road vehicles, recreational vehicles, caravans with 12 V DC or 24 V DC power supply).

This annex is not applicable for controls with a DC power input port intended only for use with an AC-DC power adaptor.

NOTE Such a control is tested as an AC power supplied control.

DC supplied controls for non-stationary applications where the power can be derived from a 12 V DC or 24 V DC power supply and an AC-DC power adaptor shall be evaluated to the requirements of this annex and relevant requirements of Clause H.25.

I.25.8 Surge immunity tests

Shall be according to H.25.8 with the following modification:

This test is not applicable.

I.25.9 Electrical fast transient/burst

Shall be according to H.25.9 with the following modification:

This test is not applicable.

I.25.11.2 Immunity to conducted disturbances

Shall be according to H.25.11.2 with the following addition:

The control shall be tested in accordance with ISO 7637-2 and ISO 7637-3 with the test pulse durations, polarity and voltage according to the amplitudes specified in Table I.1 and Table I.2.

Table I.1 – Electrical transient conduction immunity in accordance with ISO 7637-2

Assessment criteria	Test levels	Test pulses V				
		1	2a	2b	3a	3b
I	Level III					
	(12 V **systems**)	−112	+55	+10	−165	+112
	(24 V **systems**)	−450	+55	+20	−220	+220
II	Level IV					
	(12 V **systems**)	−150	+112	+10	−220	+150
	(24 V **systems**)	−600	+112	+20	−300	+300

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Table I.2 – Electrical transient conduction immunity in accordance with ISO 7637-3

Assessment criteria	Test levels	Test pulses V	
		a	b
I	Level III (12 V **systems**) (24 V **systems**)	 −80 −110	 +60 +110
II	Level IV (12 V **systems**) (24 V **systems**)	 −110 −150	 +75 +150

Tests:

For values in Table I.1, the **system** is tested in accordance with ISO 7637-2 and for values in Table I.2 the **system** is tested in accordance with ISO 7637-3.

For **systems** with different power supply voltage levels, the values for test pulses shall be adapted according to the required test levels.

I.25.12 Supply frequency variations

Shall be according to H.25.12 with the following modification:

This test is not applicable.

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Annex J
(normative)

Requirements for thermistor elements and controls using thermistors

Annex J supplements or modifies the corresponding clauses of this document.

NOTE The subclause numbers in this annex show the additions/modifications to the same subclause number as used in the main part of this document.

J.1 Scope

Addition:

Annex J applies to

– **PTC thermistors** and **NTC thermistors** type devices,
– discrete **thermistor**-type devices and to **controls** using **thermistors** constructed of doped ceramic or polymeric semiconductor materials,
– inherent safety, the operating temperature values and testing of **controls** using **thermistors** either within the **control** or remote from it.

NOTE These **thermistors** can be used
– in a self-heating mode as **self-controlled heaters** and in similar applications;
– as **thermistor control elements**; or
– as **sensing elements**.

Control thermistors, such as current limiters, are not intended to replace current interrupting devices such as fuses, but are intended to provide a level of overcurrent protection complying with the end-use equipment requirements.

Part 2 standards may contain additional requirements for **thermistors** used as complete controls.

J.3 Terms and definitions

J.3.15 Definitions pertaining to thermistors

J.3.15.1
thermistor
thermally sensitive semiconductor resistor, which shows over at least part of its resistance/temperature (R/T) characteristic a significant non-linear change in its electrical resistance with a change in temperature

Note 1 to entry: The change in temperature can occur either due to flow of current through the **thermistor**, as a result of a change in the ambient temperature, or by a combination of both of these occurrences.

J.3.15.2
PTC thermistor
thermistor that exhibits an increase in resistance with increasing temperature over the useful portion of the resistance/temperature (R/T) characteristic

Note 1 to entry: PTC – positive temperature coefficient. **PTC thermistors** also exhibit a decreasing resistance with applied voltage as a secondary effect.

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Note 2 to entry: For a **PTC thermistor**, the significant portion of the resistance/temperature characteristic is usually the portion in which a step-like increase in resistance occurs in a temperature increment, usually preceded by a gradual change in resistance at lower temperatures, and a similar gradual change at temperatures above the step-like increase. The resistance/temperature characteristic of some **PTC thermistors** can take on a negative slope after a slight gradual increase following the step-like increase.

J.3.15.3
NTC thermistor
thermistor that exhibits a decrease in resistance with increasing temperature over the useful portion of the resistance/temperature characteristic

Note 1 to entry: NTC – negative temperature coefficient.

J.3.15.4
thermistor control element
PTC thermistor or **NTC thermistor** which directly controls a load by being connected in series with it

Note 1 to entry: A **thermistor control element** is not intended to be connected across the mains.

Note 2 to entry: Typical uses are current limiters, **inrush-current** limiters, degaussing coil-current limiters, and motor starting-current limiters.

J.3.15.5
self-controlled heater
PTC thermistor which has no additional **temperature limiter** and which is used as a heater element because of its self-heating effect

Note 1 to entry: It is typically used across-the-line.

Note 2 to entry: Normally a **self-controlled heater** will provide a **type 2 action**.

J.3.15.6
thermistor sensing element
PTC thermistor or **NTC thermistor** used as a sensor and which does not carry load current

J.3.15.7
B value
NTC thermistor's index, which expresses the degree of resistance change when calculated from any two points specified by the manufacturer on the resistance/temperature (R/T) curve

J.3.15.8
hold current
I_h
maximum current a current limiting **PTC thermistor** is able to maintain in a low resistance "on" state at rated ambient for a period of time specified by the manufacturer

J.3.15.9
inrush current
I_n
peak current measured following energization at rated voltage and at 25 °C ± 2 K or at the manufacturer's specified ambient temperature

J.3.15.10
trip current
I_t
for a current-limiting **PTC thermistor**, minimum current value declared by the manufacturer at which a **PTC thermistor** switches from low to high resistance at a specified temperature or temperature range

Note 1 to entry: $I_t = Y \times I_h$, where Y is the **trip current** multiplier declared by the manufacturer.

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J.3.15.11
maximum current
I_{max}
current value assigned by the manufacturer that complies with all the requirements of this document

Note 1 to entry: For the various devices, the associated current designated as I_{max} is shown in Table J.1.

Table J.1 – Maximum current

Device	Associated current designated I_{max}
PTC **self-controlled heater**	Maximum **steady-state current** [a]
PTC motor starter	Maximum start winding current
PTC current limiter, degausser	Maximum **trip current** [b]
NTC **inrush current** limiter	Maximum **steady-state current**
PTC or NTC sensor	Not applicable

[a] For devices rated in watts by the manufacturer, I_{max} is calculated. This current does not mean **inrush current**.

[b] For devices assigned a **time-to-trip** versus current curve by the manufacturer, the **maximum current** (I_{max}) shall be identified.

J.3.15.12
short-circuit current
I_{sc}
maximum current available from the impedance limited source (such as a power supply)

J.3.15.13
steady-state current
I_{ss}
current measured after a **thermistor's** temperature stabilizes in air at 25 °C ± 2 K ambient temperature, or at an ambient temperature specified by the manufacturer while connected to rated voltage and while operating in its high-resistance state for **PTC thermistors** or low-resistance state for **NTC thermistors**

Note 1 to entry: For some **NTC thermistors**, I_{ss} is the same as I_{max}.

J.3.15.14
resistance
R_{min}
for a ceramic **PTC thermistor**, point of minimum resistance on the R/T curve

J.3.15.15
resistance
R_x **or** R_{25}
rated **resistance** at a temperature specified by the manufacturer for R_x or at 25 °C ± 2 K for R_{25}

J.3.15.16
switching resistance
R_{sw}
for a ceramic **PTC thermistor**, **resistance** value at which the **resistance** begins to increase sharply with temperature increase

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Note 1 to entry: For this document, R_{sw} is the value where the **resistance** is twice R_{min}; unless the manufacturer specifies R_{sw} with reference to R_{min} with a multiplying factor other than two, or with reference to R_x.

J.3.15.17
tripped resistance
R_{tr}
for a PTC control **thermistor**, **resistance** value of the **thermistor** in its tripped state at maximum voltage (V_{max})

Note 1 to entry: R_{tr} is calculated by dividing the voltage drop across the **thermistor** by the **steady-state current** (I_{ss}) flowing through the **thermistor**.

J.3.15.18
switching temperature
T_{sw}
for a ceramic **PTC thermistor**, temperature at which the **resistance** is at R_{sw}

J.3.15.19
surface temperature
T_{surf}
temperature of the surface of a **thermistor** while the **thermistor** is energized under normal operating conditions

Note 1 to entry: Typical normal operating conditions for **thermistors** are specified in Table J.2.

Table J.2 – Normal operating conditions

Type of thermistor	Voltage	Current
PTC **self-controlled heater**	V_{max}	I_{ss}
PTC motor starter	V_{max}	I_{ss}
PTC degausser	V_{max}	I_{ss}
PTC current-limiter	V_{max}	I_h and I_{ss} [a]
NTC **inrush current** limiter	V_{max}	I_{max}

[a] Surface temperature measured at I_{ss} reflects the conditions in the tripped state of the **thermistor** (normal operating conditions for the PTC, abnormal operating condition for the circuit/application controlled by the PTC).

J.3.15.20
time-to-trip
time required for a **PTC thermistor** to limit the manufacturer's declared **trip current** (I_t) to 50 % of its value when energized at the rated voltage and ambient temperature

J.3.15.21
thermal runaway temperature
T_R
high temperature point on the R/T curve at which a **PTC thermistor's resistance** no longer increases with increasing temperature

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J.3.15.22
maximum voltage
V_{max}
maximum voltage of a **thermistor** as declared by the manufacturer

Note 1 to entry: V_{max} is higher than rated voltage (V_r) when a higher operating voltage occurs under certain conditions in the end-use equipment such as for motor starting-coil limiters.

J.4 General

J.4.3 General notes on tests

J.4.3.3 Samples required

Addition:

J.4.3.3.1 Unless otherwise specified, representative samples as indicated in Table J.3 shall be subjected to the tests specified in J.19.17. New samples shall be used for all tests other than the overload and endurance tests.

Table J.3 – Samples for the test (clause reference)

		Thermal condition-ing	**Heat-cold-humidity cycling**	**Overload**	**Endurance**	**Cold operational cycling**	**Cold thermal cycling**	**Thermal runaway**
		(J.19.17.3)	(J.19.17.1)	(J.19.17.2.1, J.19.17.7.1)	(J.19.17.2.2, J.19.17.7.2)	(J.19.17.4, J.19.17.8)	(J.19.17.6)	(J.19.17.5)
Number of samples per test		3	3	3 [a]	3 [a]	3	3	3
Thermis-tor appli-cation	PTC **self-controlled heater**	X	X	X	X	X	-	X
	PTC thermistor control element	X	X	X	X	X	-	X
	PTC sensor	X	X	X	X	-	X	-
	NTC thermistor control element	X	X	X	X	X	-	-
	NTC sensor	X	X	X	X	-	X	-
The calibration tests of J.17.1 and J.17.2 shall be conducted before and after each of the above tests (except thermal runaway).								
[a] The same three samples shall be used for both the overload and endurance tests.								

J.4.3.4.2 According to rating

Additional paragraph:

For the purposes of this document, the rated voltage (V_r) of a **thermistor** is the input voltage of a **thermistor** as declared by the manufacturer.

NOTE V_r is typically equal to the supply source voltage.

J.4.3.4.2.11 *Additional subclause:*

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The electrical and thermal ratings of a **thermistor** shall be in accordance with Table J.4 and based on its intended application.

Table J.4 – Electrical and thermal ratings of a thermistor

Characteristic	Thermistor type						
	PTC					NTC	
	Self-controlled heater	Motor starter	Current limiter [a]	Sensor [a]	Degausser	Sensor [a]	Inrush-current limiter
Beta value (B)	-	-	-	-	-	R	-
Calibration class number	-	-	-	R	-	R	-
Capacitance – load, or Joule rating	-	-	-	-	-	-	R
Trip current – (I_t)	-	-	R	-	-	-	-
Inrush current (I_n)	R	R	-	-	R	-	R
Hold current (I_h)	-	-	R	-	-	-	-
Maximum current (I_{max})	-	R	R	-	R	-	R
Steady-state current (I_{ss})	R	R	R	-	R	-	R
Coil impedance	-	-	-	-	R	-	-
Resistance – R_{25} and tolerance	R	R	R	R	R	R	R
Maximum operating ambient temperature	-	R	R	R	R	R	R
Switching temperature (T_{sw})	R	R	R	R	R	-	-
Maximum surface temperature (T_{surf})	R	R	R	-	R	-	R
Time-to-trip	-	-	R	-	-	-	-
Maximum voltage (V_{max})	R	R	R	-	R	-	R
Rated voltage (V_r)	R	R	R	-	R	-	R
The "R" designation indicates ratings for the device that are required to be provided by the manufacturer.							
[a] The range of operating ambient temperature shall be specified.							

J.4.3.4.5 According to purpose

Additional subclauses:

J.4.3.4.5.4 Based on the type of **thermistor** and the particular application, **thermistors** shall be subjected to the tests noted in Table J.3 and the calibration tests of J.17.1 or J.17.2, whichever applies.

However, **thermistors** used in **type 1 action controls** that comply with IEC 60539 series, IEC 60738 series or IEC 62319 series shall only be subjected to the thermal runaway test of J.19.17.5 provided that it complies with the applicable declaration of Table J.5 for the control. Compliance with IEC 60539 series, IEC 60738 series or IEC 62319 series is not required if the **thermistors** comply with the requirements of Annex J.

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J.5 Information

Table J.5 provides additional requirements to Table 1.

Table J.5 – Additional items to Table 1

	Information	Clause or subclause	Method
J.1	According to the construction and use of a **thermistor**	J.3.15.4, J.3.15.5, J.3.15.6	X
J.2	R/T characteristics, calibration specifications [a]	J.17.1, J.17.2	X
J.3	R/T characteristics, calibration specifications, **drift** [b]	J.17.1, J.17.2, J.19.16.2	X
J.4	Number of cycles	J.19.17.2	X
J.5	Method of R/T measurement	J.17.1.4, J.17.2.3	X
J.6	PTC current limiters where the maximum current is reduced to less than or equal to 8 A in ≤ 5 s.	J.17.1.6.1.1	X

[a] The R/T characteristics shall be expressed in the form of a curve, a table or various operating points and shall include the declared deviation.

[b] Additional declarations may be made at intermediate numbers of cycles for the test of J.19.17.2.

J.9 Constructional requirements

Additional subclauses:

J.9.3.10 **Thermistors** used in controls to provide functional safety or as controls to provide functional safety for a controlled application shall provide **type 2 action**, for other applications at least **type 1 action**.

NOTE Examples of **thermistors** used to provide **functional safety** of a controlled application are temperature sensors for temperature cut-out applications or current limiting PTC devices in non-limited energy circuits.

J.9.4.17 Type 1.YJ or 2.YJ action

A type 1.YJ or type 2.YJ action of a **thermistor** shall operate to provide an inherent change in resistance.

For the purpose of this document, a **PTC thermistor** that is in the switched mode (high resistance) or an **NTC thermistor** in the unswitched mode (high resistance), are considered to provide the equivalent of **electronic disconnection** and are classified as type 1.YJ action or 2.YJ action.

Compliance is checked by the tests of relevant requirements of this Annex J.

J.12 Components

J.12.8.2 *Add the following:*

Subclause 12.8.2 is applicable to **thermistors** previously tested under IEC 60539 or IEC 60738.

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J.15 Electric strength and insulation resistance

J.15.2 Electric strength

Modification to footnote b of Table 16:

Add the word "thermistors," *after* "electronic parts".

J.17 Manufacturing deviation and drift

J.17.1 Calibration tests for PTC thermistors

J.17.1.1 Ceramic **thermistors** are not influenced by the sequence in which the calibration tests of J.17.1.4 to J.17.1.8 are conducted on the samples. However, polymeric types can be influenced due to the nature of the material. Hence, for polymeric types of **thermistors**, it is recommended to perform the test of J.17.1.4 at the end of all the calibration tests.

J.17.1.2 In the "as-received" condition, each **PTC thermistor** sample shall be subjected to the tests specified in Table J.6 and shall comply with the criteria for each test as specified in Table J.6.

J.17.1.3 Following the tests described in J.19.16 a), the same **PTC thermistor** samples shall be subjected to the tests specified in Table J.6 and shall comply with the criteria for each test as specified in Table J.6. For PTC sensors, the test results shall comply with the criteria for each test as specified in Table J.7.

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Table J.6 – Sequence of calibration and conditioning tests for PTC thermistors

Type of PTC thermistor	Calibration tests performed on samples before the conditioning tests specified in J.19.17 [a]	Compliance criteria designation (before conditioning) [b]	Calibration tests performed on thermistor samples after conditioning tests specified in J.19.17 [a]	Compliance criteria designation (after conditioning) [b]
Self-controlled heater	R/T	A	T_{surf}	D
	T_{surf}		I_n	
	I_n			
Motor starter	R/T	A	T_{surf}	D
	T_{surf}		I_n	
	I_n			
Degausser	R/T	A	T_{surf}	D
	T_{surf}		I_n	
	I_n			
Current limiter	R/T	B	TT	E
	T_{surf}			
	TT			
	I_{ss}			
	I_h			
Sensor	R/T	C	R/T	F

R/T R/T measurement for **PTC thermistors** – all types (J.17.1.4)

I_h Hold current test for PTC current limiters (J.17.1.5)

TT Time-to-trip test for PTC current limiters (J.17.1.6)

T_{surf} Surface temperature test (J.17.1.7)

I_n **Inrush current** (compliance is determined by measurement, J.17.1.8)

I_{ss} Steady-state current (compliance is determined by measurement)

A - **Resistance** at 25 °C, **surface temperature** and **inrush-current** values shall be within the declared deviation tolerance specified by the manufacturer.

B - **Resistance** at 25 °C, **surface temperature**, **steady-state current** and **time-to-trip** values shall be within the declared deviation tolerance specified by the manufacturer. The **thermistor** shall maintain the **hold current** for the time at the ambient temperature specified by the manufacturer, without tripping.

C - The temperatures corresponding to the **switching resistance** (R_{sw}) and two additional points, located above and below R_{sw} on the R/T curve shall be within the declared deviation tolerance specified by the manufacturer.

D - The **surface temperature** and **inrush-current** values shall be within the declared **drift** tolerance specified by the manufacturer.

E - Time-to-trip values shall be within the declared **drift** tolerance specified by the manufacturer.

F - The temperatures corresponding to the **switching resistance** (R_{sw}) and two additional points, located above and below R_{sw} on the R/T curve, shall not vary from the corresponding as-received values by more than indicated in Table J.7.

[a] Test abbreviations

[b] Compliance criteria

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Table J.7 – Classes for PTC sensing thermistors

Property	Class No.			
	C_1	C_2	C_3	C_4
Temperature **drift**, K for a given resistance	±0,5	±1,0	±2,0	±5,0
Temperature values should be “normalized” to the Kelvin scale when determining the temperature **drift**.				

J.17.1.4 R/T measurement for PTC thermistors

J.17.1.4.1 **Thermistor** samples shall be placed in a full draft circulating-air oven or fluid medium, such as silicon oil with the temperature maintained within ±1 K of the temperature specified for the test. The test shall be conducted at various temperatures starting at room ambient temperature through the switching temperature (T_{sw}) and not exceeding the thermal runaway temperature (T_R) of the R/T curve. The resistance is measured by an ohmmeter at as many temperatures as required to create a complete R/T curve.

J.17.1.5 Hold current (I_h) test for PTC current limiters

J.17.1.5.1 A current limiting **thermistor** shall maintain the specified hold current (I_h) for the time specified by the manufacturer at the ambient temperature specified by the manufacturer without tripping.

J.17.1.6 Time-to-trip test for PTC current limiters

J.17.1.6.1 A current limiting **thermistor** with a time-to-trip specification shall trip at the specified trip current (I_t) and corresponding rated voltage (V_r) within the specified time-to-trip. A **thermistor** with multiple trip currents and times shall be tested at the maximum and minimum specified currents. The current is not to exceed the maximum current ($\boldsymbol{I_{max}}$) point on the time-to-trip versus current curve.

J.17.1.6.1.1 A current limiting **thermistor**, as declared in item J.5 of Table J.5, shall trip at the declared trip current (I_t) and corresponding rated voltage (V_r) within the specified time-to-trip.

J.17.1.7 Surface temperature test

J.17.1.7.1 The surface temperature ($\boldsymbol{T_{surf}}$) of a **PTC thermistor** shall be measured using thermocouples or equivalent devices. For a **PTC thermistor** other than a current limiter, the surface temperature ($\boldsymbol{T_{surf}}$) shall be measured while the **thermistor** is operating at maximum voltage ($\boldsymbol{V_{max}}$) and steady-state current. For a PTC current limiter, the surface temperature ($\boldsymbol{T_{surf}}$) shall be measured under two conditions:

a) *operating condition in hold state where the device shall be operated at its rated **maximum voltage** ($\boldsymbol{V_{max}}$) and rated **hold current** ($\boldsymbol{I_h}$), and*

b) *operating condition in tripped state where the device shall be operated at rated **maximum voltage** ($\boldsymbol{V_{max}}$) and rated **steady-state current** ($\boldsymbol{I_{ss}}$).*

The surface temperature is measured in an ambient temperature of 25 °C.

See Table J.2.

J.17.1.8 Inrush current measurement

J.17.1.8.1 For **PTC thermistors** intended to be used as self-controlled heaters, motor starters or degaussers, the inrush current shall be measured using an oscilloscope while the **thermistor** is operating at maximum voltage under rated load.

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J.17.2 Calibration tests for NTC thermistors

J.17.2.1 In the "as-received" condition, each **NTC thermistor** sample shall be subjected to the tests specified in Table J.8 and shall comply with the criteria for each test as specified in Table J.8.

J.17.2.2 Following the tests described in J.19.16 b), the same **NTC thermistor** samples shall be subjected to the tests specified in Table J.8 and shall comply with the criteria for each test as specified in Table J.8. For NTC sensors, the test results shall comply with the criteria for as specified in Table J.9.

Table J.8 – Sequence of calibration and conditioning tests for NTC thermistors

Type of NTC thermistor	Calibration tests performed on samples before the conditioning tests specified in J.19.17 [a]	Compliance criteria designation (before conditioning) [b]	Calibration tests performed on thermistor samples after conditioning tests specified in J.19.17 [a]	Compliance criteria designation (after conditioning) [b]
Inrush-current limiter	R/T	A	T_{surf}	C
	T_{surf}		I_n	
	I_n			
Sensor	R/T	B	R/T	D
	Beta			

R/T	R/T measurement for **NTC thermistors** (J.17.2.3)
T_{surf}	Surface temperature test (J.17.2.4)
Beta	**Resistance** (R_{25}) and **beta value** (**B**) test for **NTC thermistors** (J.17.2.6)
I_n	**Inrush current** (compliance is determined by measurement (J.17.2.5)
A	**Resistance** at 25 °C, **surface temperature**, and **inrush-current** values shall be within the declared deviation tolerance specified by the manufacturer.
B	The resistance at two or more temperature points on the R/T curve and the beta value (if declared) shall be within the declared deviation tolerance specified by the manufacturer. One of the temperatures shall be at 25 °C.
C	The **surface temperature** and **inrush-current** values shall be within the declared **drift** tolerance specified by the manufacturer.
D	The resistance at two or more temperature points on the R/T curve shall not vary from the respective "as received" temperatures on the "as-received" R/T curve by more than indicted in Table J.9. One of the temperatures shall be 25 °C.

[a] Test abbreviations

[b] Compliance criteria

Table J.9 – Classes for NTC sensing thermistors

Property	Class No.			
	C_1	C_2	C_3	C_4
Temperature **drift** for a given resistance	±0,5	±1,0	±2,0	±5,0
Temperature values should be “normalized” to the Kelvin scale when determining the temperature **drift**.				

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J.17.2.3 R/T measurement for NTC thermistors

J.17.2.3.1 **Thermistor** samples shall be placed in a full draft circulating-air oven or fluid medium, such as silicon oil with the temperature maintained within ±1 K of the temperature specified for the test. The test shall be conducted at various temperatures, starting at room ambient temperature and not exceeding the maximum declared sensing temperature (sensors) or the maximum surface temperature ($\boldsymbol{T_{Surf}}$) determined in accordance with J.17.2.4 (inrush-current limiters). The resistance shall be measured at as many temperatures as required to create a complete R/T curve.

J.17.2.4 Surface temperature test (inrush-current limiting only)

J.17.2.4.1 The surface temperature ($\boldsymbol{T_{Surf}}$) of a NTC inrush-current limiter shall be measured using thermocouples or equivalent devices while the **NTC thermistor** is being operating at maximum voltage ($\boldsymbol{V_{max}}$) and maximum current ($\boldsymbol{I_{max}}$) with the rated capacitance value in parallel with the load. The temperature shall be within the manufacturer's specified limits. See Table J.8.

J.17.2.5 Inrush current measurement (inrush-current limiting only)

J.17.2.5.1 For an NTC inrush-current limiter, the inrush current shall be measured using an oscilloscope while the **thermistor** is operating at maximum voltage ($\boldsymbol{V_{max}}$) and maximum current ($\boldsymbol{I_{max}}$) with the rated capacitance value in parallel with the load.

J.17.2.6 Resistance (R_{25}) and beta value (B) test for NTC thermistors

J.17.2.6.1 The beta value (B) of a **thermistor** with a beta value (B) rating shall be within the limits specified by the manufacturer. The **resistance** (R_{25}) of a **NTC thermistor** shall be measured at 25 °C followed by measurement of resistances R_1 and R_2 at temperatures T_1 and T_2 as specified by the manufacturer. The beta value (B) shall be calculated using the following formula:

$$B = (\boldsymbol{I_n}\, R_1 - \boldsymbol{I_n}\, R_2) \,/\, (1/T_1 - 1/T_2)$$

where

B is the calculated beta value,

R_1 is the resistance *at* T_1,

R_2 is the resistance *at* T_2,

T_1 is a temperature in K on the R/T curve specified by the manufacturer, and

T_2 is a second temperature in K on the R/T curve specified by the manufacturer.

J.19 Endurance

Additional subclauses:

J.19.16 The sequence of tests is as follows:

a) *for **PTC thermistors**:*
   - *Ageing (J.19.17.3.1 or J.19.17.3.2);*
   - *Heat-cold-humidity (J.19.17.1);*
   - *Overload (J.19.17.2.1);*
   - *Endurance (J.19.17.2.2);*
   - *Cold operational cycling (J.19.17.4);*

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- *Cold thermal cycling (J.19.17.6);*
- *Thermal runaway (J.19.17.5).*

b) *for **NTC thermistors**:*

- *Ageing (J.19.17.3.1);*
- *Heat-cold-humidity (J.19.17.1);*
- *Overload (J.19.17.7.1);*
- *Endurance (J.19.17.7.2);*
- *Cold operational cycling (J.19.17.8)*
- *Cold thermal cycling (J.19.17.6).*

J.19.16.1 After the appropriate tests of J.19.17.1 to J.19.17.4 inclusive, the performance of the control shall not be adversely affected and it shall function as intended and declared. Compliance is checked by the tests of J.17.1 or J.17.2, whichever applies.

J.19.16.2 After the appropriate tests of J.19.17, the control shall continue to comply with the requirements of Clauses 6 and 15. During and after the tests, there shall be no emission of flames or expulsion of particles.

J.19.17 Conditioning tests

J.19.17.1 Heat-cold-humidity

Following the test specified below, each **thermistor** shall comply with the requirements in Table J.6, Table J.7, Table J.8 or Table J.9, whichever applies.

Three non-energized samples of a **thermistor** shall be subjected to three complete cycles in the sequence specified in a) or b):

a) *Indoor temperature use:*

1) *24 h at the measured **surface temperature*** ($T_{\mathbf{Surf}}$) *or maximum declared operating temperature. In any case, the temperature shall not be less than 70 °C. The oven temperature shall be maintained within ±5 K of the temperature specified for the test. The temperature shall be monitored within the area of the oven in which the samples are being tested;*
2) *168 h in a non-condensing atmosphere having a relative humidity of 90 % to 95 % at 40 °C; and*
3) *8 h at 0 °C or at the manufacturer's specified ambient temperature, whichever is lower.*

b) *Outdoor temperature use:*

1) *24 h immersed in water at 25 °C;*
2) *8 h at minus 35 °C or at the manufacturer's specified ambient temperature, whichever is lower;*
3) *24 h at the measured **surface temperature*** ($T_{\mathbf{Surf}}$) *or maximum declared operating temperature. In any case, the temperature shall not be less than 70 °C. The oven temperature shall be maintained within ±5 K of the temperature specified for the test. The oven temperature shall be monitored within the area of the oven in which the samples are being tested; and*
4) *168 h in a non-condensing atmosphere having a relative humidity of 90 % to 95 % at 40 °C.*

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J.19.17.2 Extended cycling (PTC)

J.19.17.2.1 Overload

J.19.17.2.1.1 Following the tests specified in J.19.17.2.1.2**,** J.19.17.2.1.3**,** or J.19.17.2.1.4 and J.19.17.2.2, a **thermistor** shall comply with Table J.6 or Table J.7.

J.19.17.2.1.2 For a self-controlled heater, three samples shall be mounted and operated as intended for 50 cycles while connected to 120 % of maximum voltage (V_{max}). Each cycle shall cover that portion of the R/T curve from the lower knee to the high resistance state.

J.19.17.2.1.3 For a control **thermistor**, three samples shall be mounted and operated as intended for 50 cycles while connected to maximum voltage (V_{max}) and the lesser value of:

a) 120 % of rated **maximum current** (I_{max}), or

b) 120 % of rated **short-circuit current** (I_{sc}).

Each cycle shall start with the sample thermally stabilized at 25 °C ± 5 K. Each cycle shall cover that portion of the R/T curve from the lower knee to the high resistance state.

J.19.17.2.1.4 For a sensing **thermistor**, three samples shall be mounted and operated as intended for 50 cycles of operation consisting of starting with the sample thermally stabilized at 25 °C ± 5 K and increasing the temperature to 120 % of the maximum sensing temperature of the **thermistor**.

J.19.17.2.2 Endurance

The three **thermistor** samples that have been subjected to overload test of J.19.17.2.1 shall be operated at the conditions specified in a), b), or c) for the number of cycles specified in Table J.10. Each cycle shall cover a significant portion of the R/T curve.

a) ***Self-controlled heater*** *– A* ***self-controlled heater thermistor*** *or heater assembly shall be mounted and tested at* ***maximum voltage*** *(V_{max}) maximum rated wattage or maximum current (I_{max}). A* ***thermistor****, whose power consumption varies with the amount of heat sinking, air flow, or similar variables provided in the end-use equipment, shall be tested at the maximum rated wattage or* ***maximum current*** *(I_{max}) using the heat sinking, air flow, or other conditions of the end-use equipment.*

b) *Control – A control* ***thermistor*** *shall be tested at* ***maximum voltage*** *(V_{max}) and the following currents:*

   1) *Current limiter – The test current shall not be less than the minimum trip current (I_t).*

   2) *Degausser – The test current shall be* ***maximum current*** (I_{max}).

   3) *Motor starter – The test current shall be* ***maximum current*** (I_{max}).

c) *Sensing – A sensing* ***thermistor*** *shall be cycled between 25 °C ± 5 K and the maximum operating temperature.*

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Table J.10 – Number of cycles for endurance test

Type of thermistor	Number of cycles of operation
Self-controlled heater	100 000
Current limiter intended for use in a **functional safety** circuit	100 000 [a]
Current-limiter not intended for use in a **functional safety** circuit	6 000
Degausser or motor starter	30 000
Sensor not intended for use in a **functional safety** circuit	6 000
Sensor intended for use in a **functional safety** circuit	100 000

[a] The minimum number of cycles is reduced to 6 000 under the following conditions:
– the trip state of the **thermistor** is apparent in the end-use application; and
– manual intervention is required in order to reset the **thermistors**.

J.19.17.3 Thermal conditioning

J.19.17.3.1 Passive ageing

*Following the tests specified below and in J.19.17.3.2, each **thermistor** shall comply with the requirements in Table J.6, Table J.7, Table J.8 or Table J.9, as appropriate.*

Three non-energized samples of a **thermistor** shall be conditioned for 1 000 h at a temperature 30 K above the temperature specified in Table J.11 in an air-circulating oven. In any case, the temperature shall not be less than 70 °C. The oven temperature shall be maintained within ±5 K of the temperature specified for the test. The oven temperature shall be monitored within the area of the oven in which the samples are being tested.

Table J.11 – Ageing test temperature

Thermistor type	Temperature
All types except sensors	Temperature determined in accordance with **surface temperature** test, J.17.1.8 (PTC) and J.17.2.4 (NTC)
Sensing	Highest temperature rating

J.19.17.3.2 Active ageing

In addition to the test described in J.19.17.3.1, a current limiter shall be subjected to this test. Three samples of a current limiting **PTC thermistor** shall be energized and conditioned for 1 000 h while in the tripped state at maximum voltage ($V_{\mathbf{max}}$) and carrying steady-state current ($I_{\mathbf{ss}}$).

J.19.17.4 Cold operational cycling (PTC)

Following the test specified below, a **thermistor** shall comply with Table J.6.

Three samples of a **thermistor** shall be subjected to 1 000 cycles of operation at an ambient temperature of 0 °C or at the manufacturer's specified ambient, whichever is lower. The test conditions shall be as specified in J.19.17.2.2 a) for a self-controlled heater or J.19.17.2.2 b) for a control **thermistor**. The **thermistor** temperature shall be returned to the starting temperature before each cycle.

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J.19.17.5 Thermal runaway

*The **thermistors** are to be energized and operated under maximum rated conditions until thermally stabilized. The voltage is then to be gradually increased until breakdown occurs, or two times the **working voltage** of the **thermistor** is reached, at which time the test can be terminated.*

NOTE Increasing the voltage in steps of 0,1 times the **working voltage** of the **thermistor** every 2 min constitutes an appropriate rate of rise.

J.19.17.6 Cold thermal cycling

Following the test specified below, a **thermistor** shall comply with Table J.7 or Table J.9, whichever applies.

Three samples of a sensing **thermistor** shall be subjected to 1 000 cycles of cold thermal cycling operation. Each cycle shall start at 0 °C or at the manufacturer's specified ambient, whichever is lower, and cover that portion of the R/T curve from the starting temperature to the maximum rated temperature.

J.19.17.7 Extended cycling (NTC)

J.19.17.7.1 Overload

J.19.17.7.1.1 Following the tests specified in J.19.17.7.1.2 or J.19.17.7.1.3 and J.19.17.7.2, a **thermistor** shall comply with Table J.8.

J.19.17.7.1.2 For an inrush-current limiting **thermistor**, three samples shall be mounted and operated as intended for 50 cycles while connected to maximum voltage ($V_{\mathbf{max}}$) and 120 % of the maximum current ($I_{\mathbf{max}}$). Each cycle shall start with the sample thermally stabilized at 25 °C.

J.19.17.7.1.3 For a sensing **thermistor**, three samples shall be mounted and operated as intended for 50 cycles of operation consisting of starting with the sample thermally stabilized at 25 °C ± 5 K and increasing the temperature to 120 % of the maximum sensing temperature of the **thermistor**.

J.19.17.7.2 Endurance

The three **thermistor** samples that have been subjected to the overload test, J.19.17.7.2, shall be operated at the conditions specified in a) or b) for the number of cycles specified in Table J.12. Each cycle shall cover a significant portion of the R/T curve.

a) ***Inrush-current** limiting – An **inrush-current** limiting **thermistor** shall be tested at **maximum voltage** (V_{max}) and maximum current (I_{max}) with the rated capacitance value in parallel with the load. See Figure J.1.*

b) *Sensing – A sensing **thermistor** shall be cycled between 25 °C ± 5 K and the maximum operating temperature.*

Table J.12 – Number of cycles for endurance test

Type of thermistor	Number of cycles of operation
Inrush-current limiter intended for use in a **functional safety** circuit	100 000
Inrush-current limiter not intended for use in a **functional safety** circuit	6 000
Sensor intended for use in a **functional safety** circuit	100 000
Sensor not intended for use in a **functional safety** circuit	6 000

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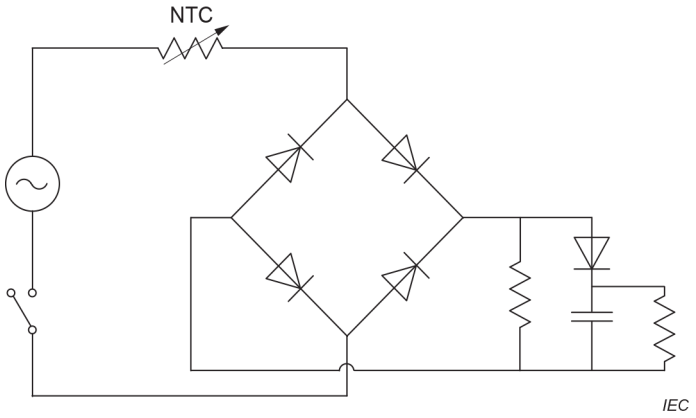


Figure J.1 – Generic test circuit for inrush-current limiting thermistor endurance test

J.19.17.8 Cold operational cycling (for inrush current-limiting NTC thermistors only)

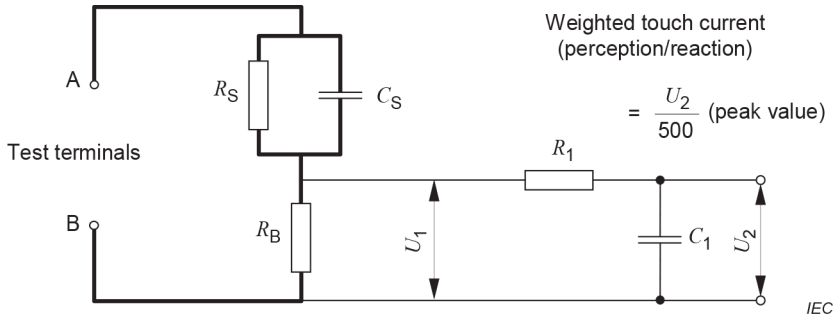
Following the test specified below, a **thermistor** shall comply with Table J.8.

Three samples of a **thermistor** shall be subjected to 1 000 cycles of operation at maximum voltage ($\boldsymbol{V_{max}}$) conducting maximum current ($\boldsymbol{I_{max}}$), at an ambient temperature of 0 °C or at the manufacturer's specified ambient temperature, whichever is lower. Each cycle shall cover that portion of the R/T curve from the starting temperature to steady-state conditions. The **thermistor** temperature shall be stabilized at the start temperature ±2 K before each cycle.

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Annex K
(normative)

Circuit for measuring touch current



R_S 1 500 Ω R_1 10 000 Ω

R_B 500 Ω C_1 0,022 µF

C_S 0,22 µF

NOTE 1 This figure is taken from IEC 60990:2016, Figure 4.

NOTE 2 The value 500 has the dimension in ohms and U_1 and U_2 are given in volts.

Figure K.1 – Circuit for measuring touch currents

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Annex L
(normative)

Printed circuit board coating performance test

L.1 A coating intended to be used on a printed circuit board that has creepage distances in accordance with Clause 11, pollution degree 1, shall comply with the requirements of Annex P.

L.2 A printed circuit board assembly that is used with a coating, including inks, solder resists and assembled components, shall be acceptable for its application in terms of temperature, solder conditions, conductor size and adhesion to the base material as determined by the requirements of IEC 61249 series.

L.3 A coating shall withstand the electric strength test of 13.2 for **functional insulation** at a test voltage determined from Table 16, based on the maximum working voltage supplied to the board assembly, after the conditioning of c) and d).

a) Ten test samples shall be prepared with the minimum applicable creepage distances and the minimum coating thickness using the pattern shown in Figure L.1. The samples are to be prepared by normal production means using the primer or cleaner employed prior to applying the coating to the board. Wiring suitable to the voltages and temperatures involved shall be attached.

b) Ageing test – Five samples of the coated board as described in a) shall be subjected to a temperature of 130 °C ± 2 K for 1 000 h.

c) Humidity conditioning – The five samples of the coated board which were subjected to the ageing test of P.3.2 are to be conditioned for 48 h in a test chamber at a temperature of (35 ± 1) °C and (90 ± 5) % relative humidity. Immediately following removal from the test chamber, each sample shall be subjected to the electric strength test described in e) and f).

d) Environmental cycle conditioning – Five of the samples of the coated board described in a) are to be subjected to three complete cycles of environmental conditioning as described in Table L.1. Immediately following the conditioning, each sample shall be subjected to the electric strength test described in e) and f).

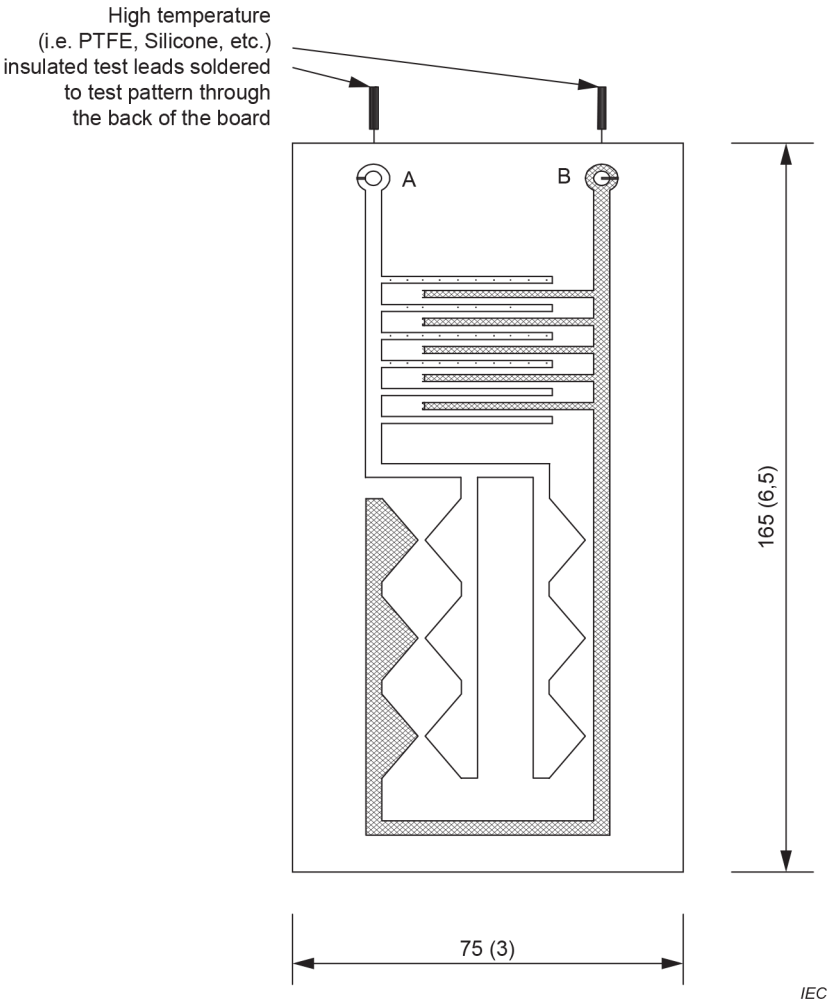
e) After conditioning, the samples of the coated board as described in a) are to be provided with tight-fitting aluminium foil (representing an electrically conductive deposit along the surface of the coating) that covers the test pattern except for the insulated test lead wire and solder points.

f) The voltage stress shall be applied according to Clause L.3 to each conditioned sample between leads A, B, and C individually and the common lead (see Figure L.1). No flashover or breakdown shall occur. Glow discharges without drop in voltage are neglected.

Table L.1 – Environmental cycling conditions

For indoor applications	For outdoor applications
24 h at T_{max}; followed by at least 96 h at (35 ± 2) °C, (90 ± 5) % relative humidity; followed by 8 h at (0 ± 2) °C	A minimum of 24 h immersed at (25 ± 2) °C; followed immediately by at least 96 h at (35 ± 2) °C, (90 ± 5) % relative humidity; followed by 8 h at (–35 ± 2) °C

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NOTE The smallest distance between tracks (point-to-point, point-to-line and line-to-line) represents the minimum distance to be permitted on production assemblies.

Figure L.1 – Test sample

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Annex M
(normative)

Printed circuit board protection

M.1 Printed circuit boards conforming to all of the requirements for type 1 protection (Figure M.1) as specified in IEC 60664-3:2016 shall comply with the minimum creepage distance requirements of Clause 11 of this document, pollution degree 1.

NOTE Type 1 protection improves the microenvironment of the parts under the protection [Source: IEC 60664-3:2016, Clause 1].

M.2 Printed circuit boards conforming to all of the requirements for type 2 protection (Figure M.2) as specified in IEC 60664-3:2016 shall comply with the minimum requirements for solid insulation as specified in 11.4 of this document. The spacing between the conductors before the protection is applied shall not be less than the values as specified in IEC 60664-3:2016, Table 1 but not less than 0,2 mm for functional or **basic insulation** and not less than 0,7 mm for supplementary or **reinforced insulation**.

NOTE Type 2 protection is considered to be similar to solid insulation [Source: IEC 60664-3:2016, Clause 1].

M.3 Six samples of actual printed circuit boards are required for testing:

– for testing of protection:
  - test specimens according to IEC 60664-3:2016, Annex C, which specifically applies for printed circuit boards; the specimen used for testing shall have the same minimum distances as those from production; or
  - specimens from production; or
  - any printed circuit board, as long as the test specimens are representative of those from production;

– for testing mouldings and potting:
  - production specimens shall be used, or they shall be representative of those from production.

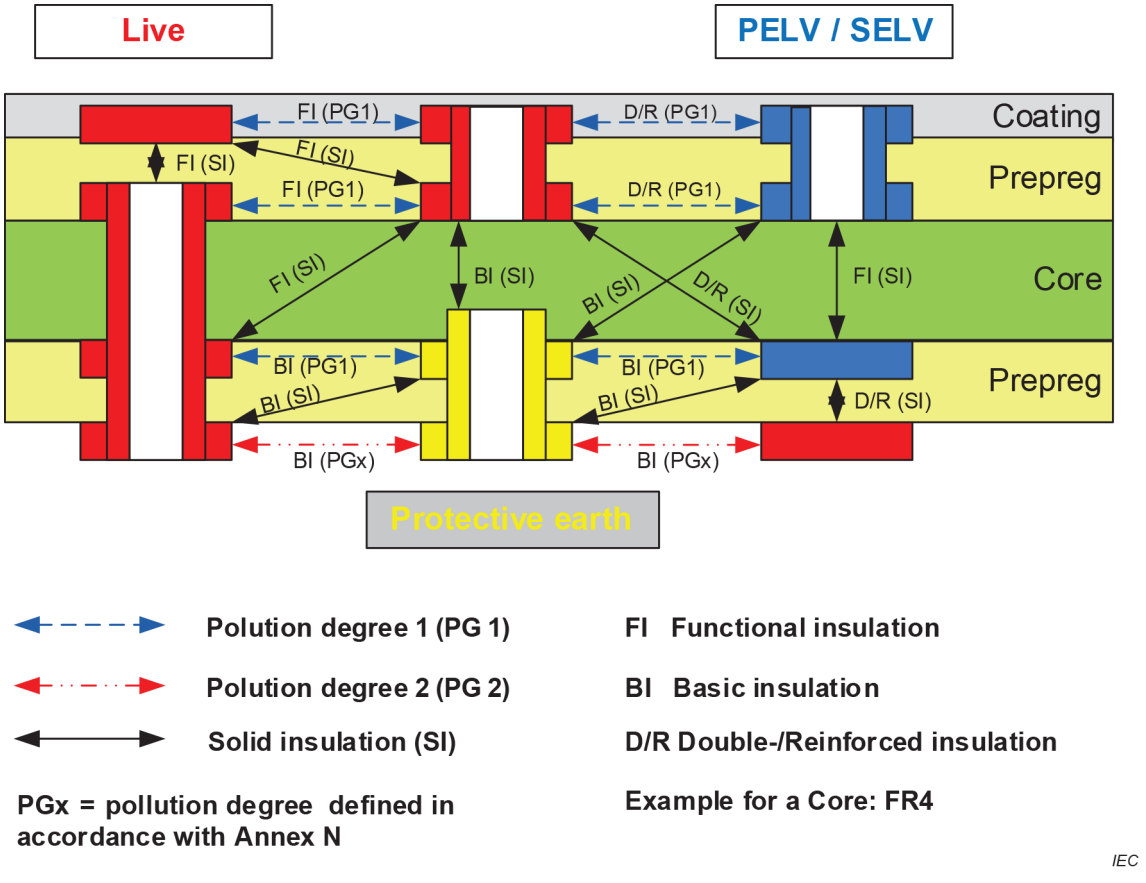
M.4 Compliance with the requirements for type 1 or type 2 protection shall be checked by the tests of IEC 60664-3:2016, Clause 5.

M.5 For the tests of IEC 60664-3:2016, Clause 5, the test levels or conditions given in Table M.1 apply:

Table M.1 – IEC 60664-3 test levels or conditions

IEC 60664-3:2016, subclause		Test level of this document
5.6	Scratch-resistance test	Not relevant for inner layers of multi-layer boards of type 2 protection
5.7.2	Cold conditioning	–25 °C
5.7.3	Dry-heat conditioning	The maximum working surface temperature as given in IEC 60664-3:2016, Table 2 is the printed circuit board's surface temperature during normal operation. This test covers also the test of 11.4.5, second indent.
5.7.4	Rapid change of temperature	Degree of severity 2 (–25 °C to +125 °C)
5.7.5.2	Electromigration	21 days
5.8.2	Adhesion of coating	Not relevant for inner layers of multi-layer boards of type 2 protection
5.8.5	Partial discharge	Only applicable if the peak voltage exceeds 700 V and if the field strength > 1 kV/mm, see IEC 60664-1:2007, 6.1.3.1.
The test sequence shall be according IEC 60664-3:2016, Table A.1.		

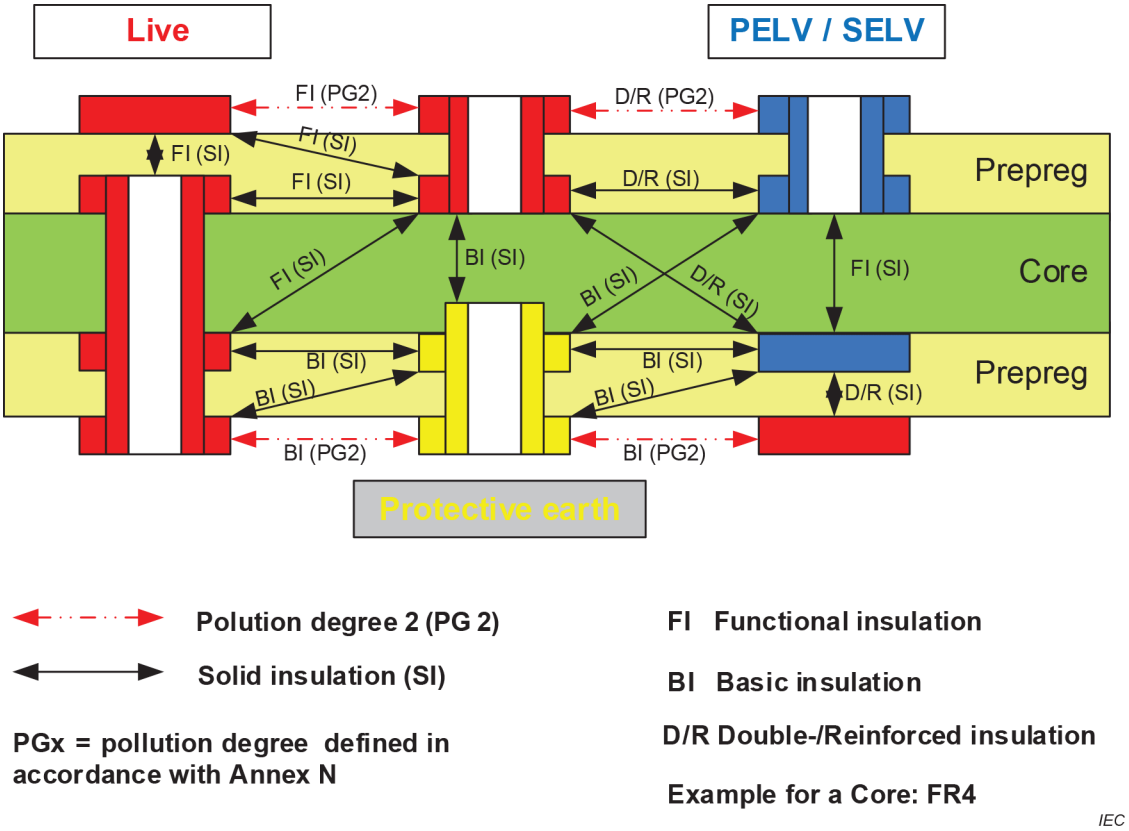
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NOTE For a better legibility, the figure does not show all possible relations. At least one relation is provided for each combination.

Figure M.1 – Example of type 1 protection

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NOTE For a better legibility, the figure does not show all possible relations. At least one relation is provided for each combination.

Figure M.2 – Example of type 2 protection

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Annex N
(informative)

Explanatory notes for surge immunity test

N.1 Different source impedances

The selection of the source impedance of the generator depends on

– the kind of cable/conductor/line (power supply AC, power supply DC, interconnection, etc.);
– the length of the cables/lines;
– indoor/outdoor conditions;
– application of the test voltage (line-to-line or line-to-earth).

The impedance of 2 Ω represents the source impedance of the low voltage power supply network.

The generator with its effective output impedance of 2 Ω is used.

The impedance of 12 Ω (10 Ω + 2 Ω) represents the source impedance of the low voltage power supply network and earth.

The generator with an additional resistor of 10 Ω in series is used.

The impedance of 42 Ω (40 Ω + 2 Ω) represents the source impedance between all other lines and earth.

The generator with an additional resistor of 40 Ω in series is used.

N.2 Application of the tests

N.2.1 General

Two different kinds of tests are to be distinguished: at equipment level and at **system** level.

N.2.2 Equipment level immunity

The test shall be carried out in the laboratory on a single EUT. The immunity of the EUT thus tested is referred to as equipment level immunity.

The test voltage shall not exceed the specified capability of the insulation to withstand high voltage stress.

N.2.3 System level immunity

The test carried out in the laboratory refers to the EUT. The equipment level immunity does not assure the immunity of a **system** in all cases. For that reason, a test on **system** level is advised which simulates the real installation. The simulated installation comprises protection devices (arrestors, varistors, shielded lines, etc.) and the real length and type of the interconnection lines.

This test is aimed at simulating as closely as possible the installation conditions in which the EUT or EUTs are intended to function later on.

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In the case of the immunity under real installation conditions, higher test levels can be applied, but the energy involved will be limited by the protective devices according to their current limiting characteristics.

The test is also intended to show that secondary effects produced by the protective devices (change of waveform, mode, amplitude of voltages or currents) do not cause unacceptable effects on the EUT.

N.3 Installation classification

N.3.1 General

Installation classifications are as follows.

Class 2: Electrical environment where cables are well separated, even on short runs.

The installation is earthed via a separate earth line to the earthing **system** of the power installation, which can be essentially subjected to interference voltages generated by the installation itself or by lightning. The power supply to the electronic equipment is separated from other circuits, mostly by a special transformer for the power supply. Non-protected circuits are in the installation, but well separated and in restricted numbers.

This class applies to category I equipment. Category I normally applies to **controls** connected after category II equipment and which, for example, includes **ELV** electronic logic **systems**, **isolated limited secondary circuits**, **ELV**-circuits, **SELV**-circuits, **PELV**-circuits and circuits on the secondary side of a transformer.

Surge does not exceed 1 kV.

Class 3: Electrical environment where power and signal cables run in parallel.

The installation is earthed to the common earthing **system** of the power installation, which can be essentially subjected to interference voltages generated by the installation itself or by lightning.

Current due to earth **faults**, switching operations and lightning in the power installation may generate interference voltages with relatively high amplitudes in the earthing **system**. Protected electronic equipment and less sensitive electric equipment are connected to the same power supply network. The interconnection cables can be partly routed as outdoor cables but close to the earthing network. Unsuppressed inductive loads are in the installation and usually there is no separation of the different field cables.

This class applies to category III or category II equipment.

Category III normally applies to **controls** intended for connection to **fixed wiring** or for incorporation into equipment intended for permanent connection to **fixed wiring**, unless the **control** or equipment application provides means of suppressing the transient voltage, in which case a lower category will apply.

Category II normally applies to **controls** connected after a socket-outlet or for incorporation into equipment connected after a socket-outlet. **Controls** intended for permanent connection to **fixed wiring** may also come into this category, where methods of suppressing the transient voltage, such as voltage limiting means at the line terminal or **clearances** between conductive parts, are incorporated in the **control** or equipment. Where the contacts of a **control** are designed to allow flashover of the transient voltage and are adequate to withstand the let-through current, this may provide adequate suppression. For example, **controls** for household appliances satisfying the above descriptions.

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Surge does not exceed 2 kV.

Class 4: Electrical environment where the interconnections are running as outdoor cables along with power cables, and cables are used for both electronic and electric circuits.

The installation is connected to the earthing **system** of the power installation which can be subjected to interference voltages generated by the installation itself or by lightning. Currents in the kiloamperes range due to earth **faults**, switching operations and lightning in the power supply installation may generate interference voltages with relatively high amplitudes in the earthing **system**. The power supply network can be the same for both the electronic and the electric equipment. The interconnection cables may run as outdoor cables even to the high voltage equipment.

A special case of this environment is when the electronic equipment is connected to the telecommunication network within a densely populated area. There is no systematically constructed earthing network outside the electronic equipment and the earthing **system** consists of pipes, cables, etc. only.

Surge does not exceed 4 kV.

Examples of the installation of electronic equipment in different areas are given in Figure N.1, Figure N.2 and Figure N.3.

N.3.2 Equipment level immunity of ports connected to the power supply network

The minimum immunity level for connection to public supply network is

Line-to-line coupling: 0,5 kV

Line-to-earth coupling: 1 kV

N.3.3 Equipment level immunity of ports connected to interconnection lines

Surge tests on interconnection circuits are only required for external connections (outside the cabinet/housing). If it is possible to test at the **system** level (EUT with interconnection cables connected) it is not necessary to test at the equipment level (for example, ports of the process-control/signal inputs/outputs) especially in cases where the shield of the interconnection cable is part of protection measures. If the installation of the plant is carried out by someone other than the manufacturers of the equipment, the admissible voltage for the inputs/outputs (especially for the process-control interface) of the EUT should be specified.

The manufacturer should test his equipment on the basis of the specified test levels to confirm the equipment level immunity, for example, with secondary protection at the ports of the EUT for a test level of 0,5 kV. The **user** of the plant or those responsible for the installation should then apply measures (for example, shielding, bonding, earthing, protection) necessary to ensure that the interface voltage caused by, for example, lightning strokes does not exceed the chosen immunity level.

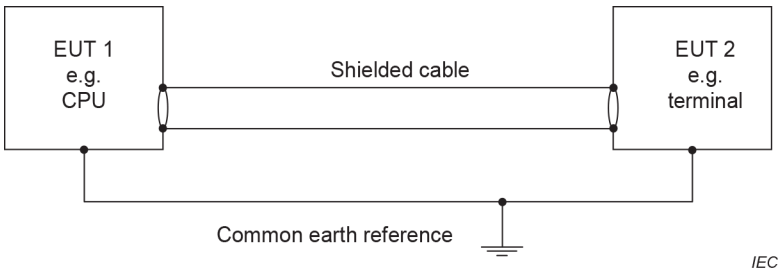


Figure N.1 – Example of surge protection by shielding in buildings with common earth reference systems

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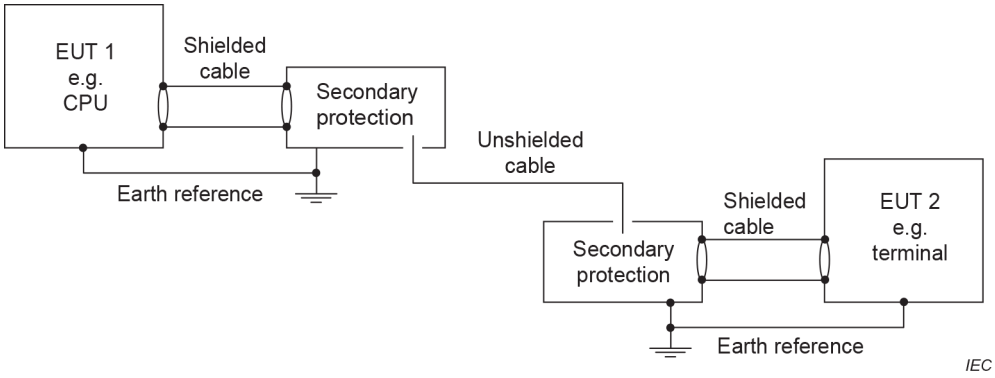


Figure N.2 – Example of secondary surge protection in buildings with separate common earth reference systems

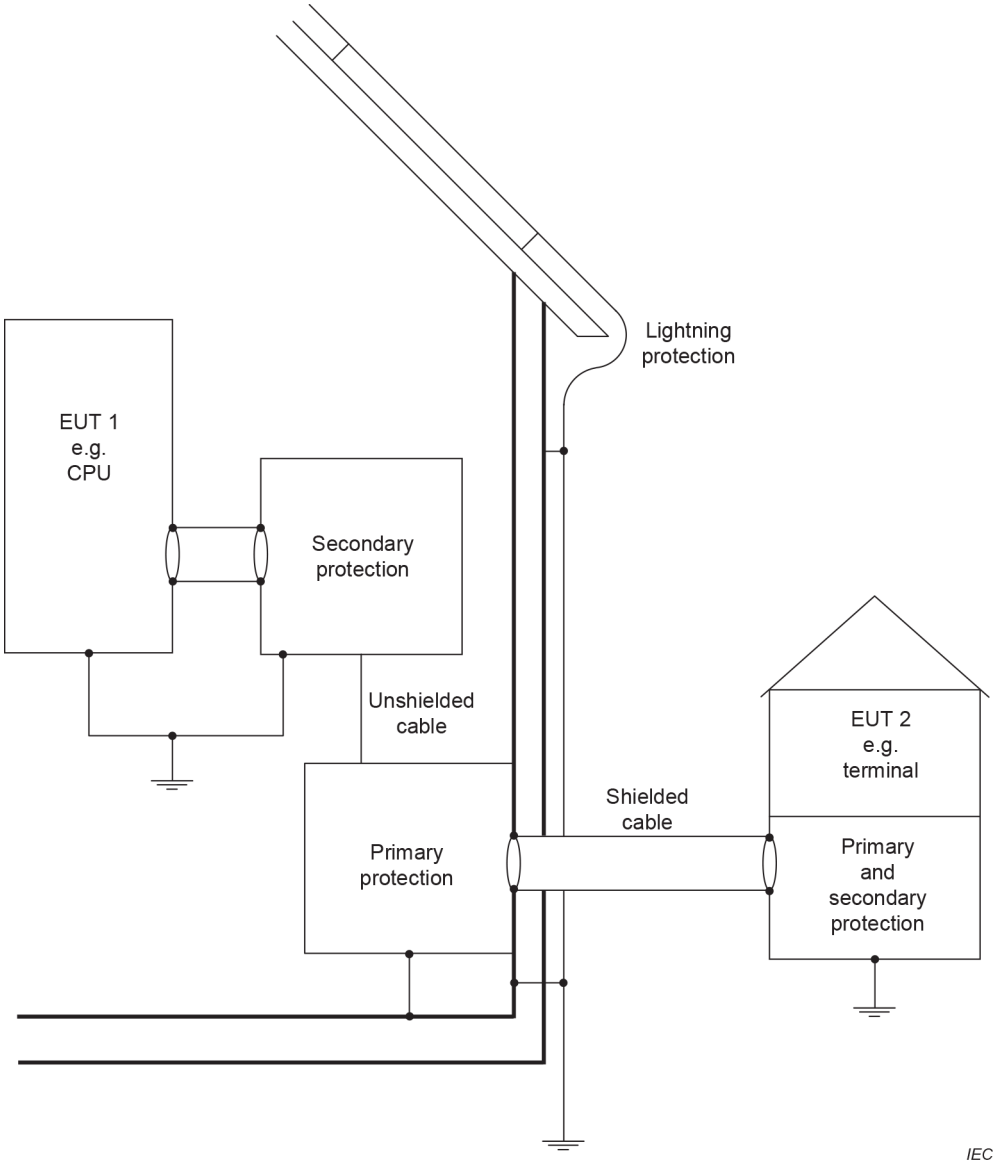


Figure N.3 – Example of primary and secondary surge protection of indoor/outdoor equipment

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Annex O
(informative)

Guidance for applying Clause 11

Guidance for applying Clause 11 is indicated in Figure O.1, Table O.1 and Table O.2.

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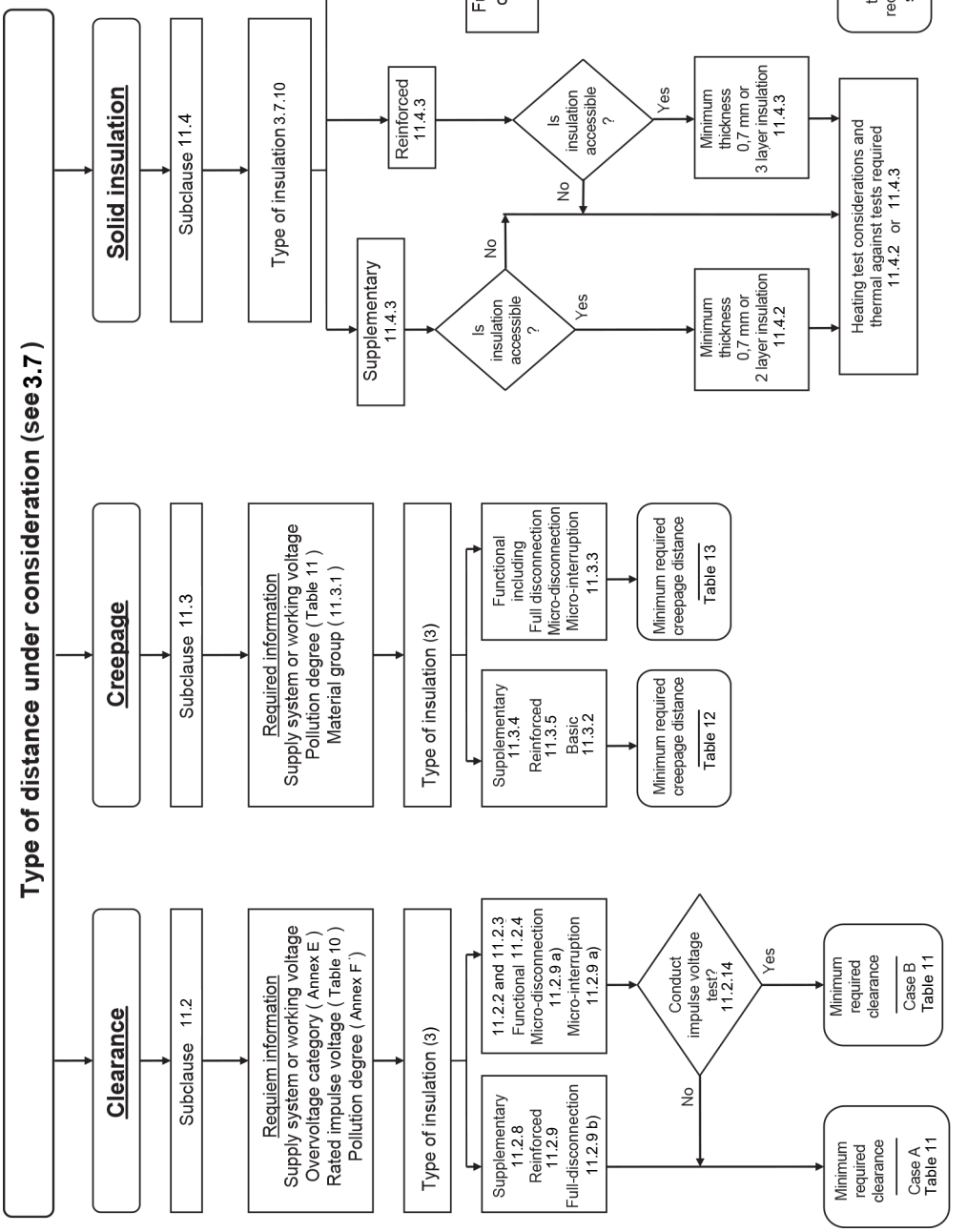


Figure O.1 – Guidance flowchart for application of requirements of Clause 11

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Table O.1 – Example A – Using Annex O guidance for applying Clause 11

Question	Answer	Instruction
Is the distance under consideration through air or across a surface?	Through air	Follow **clearance** path of flow chart
What is the **system** supply voltage, or for **functional insulation**, the **working voltage**?	230 V/400 V, 3-phase, 4 wire	Record as a)
What is the **overvoltage category**? (refer to Annex D)	See category II	Record as b)
What is the **rated impulse voltage**?	Determine from Table 10 using a) and b)	Record as c)
What is the **pollution degree**? (refer to Annex F)	**Pollution degree** 2	Record as d)
What is the type of insulation? (refer to definitions, etc.)	**Reinforced insulation**	Refer to 11.2.11. For reinforced use case A and next higher impulse voltage step from Table 11. Record as e).
What is the limit for this distance?	Refer to Table 11	Determine the limit using d) and e)
	The limit is 3 mm	

Table O.2 – Example B – Using Annex O guidance for applying Clause 11

Question	Answer	Instruction
Is the distance under consideration through air or across a surface?	Across a surface	Follow **creepage distance** path
What is the **system** supply voltage, or for **functional insulation**, the **working voltage**?	230 V	Record as a)
What is the **pollution degree**? (refer to Annex F)	**Pollution degree** 2	Record as b)
What is the material group? (refer to 11.3.1, footnote b of Table 12 and to footnote d of Table 13)	IIIb)	Record as c)
What is the type of insulation? (refer to definitions, etc.)	**Functional insulation**	Refer to 11.3.3
What is the limit for this distance?	Refer to Table 13	Determine the limit using a), b) and c)
	The limit is 2,5 mm	

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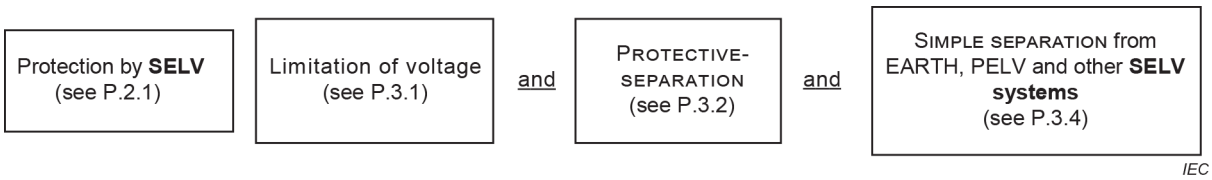
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Annex P
(normative)

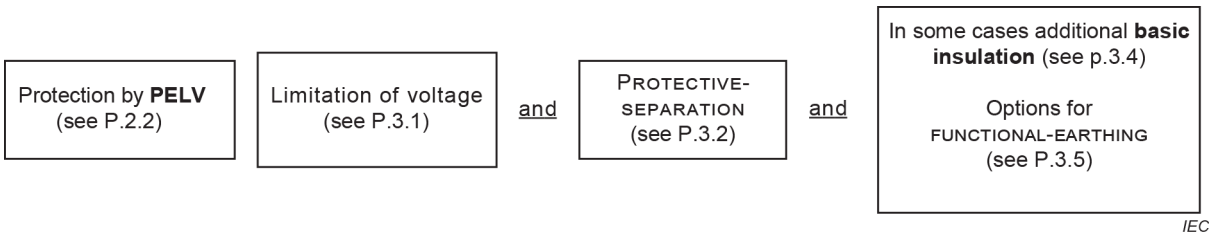
Requirements for SELV and PELV

P.1 Overview of the requirements for SELV and PELV

P.1.1 Protection by SELV



P.1.2 Protection by PELV



(Adapted from IEC 61140)

NOTE The requirements of IEC 61140 for barriers were considered and included in the requirements of this document including, but not limited to, Clauses 6, 9, 11 and 20 of this document.

P.2 Protection against electric shock by SELV system or PELV system

P.2.1 SELV system

Protection against electric shock shall be provided by the following measures:

– limitation of voltage**,** according to P.3.1 in a circuit (the **SELV system**), and

– protective-separation, according to P.3.2, of the **SELV system** from all circuits other than **SELV** and **PELV**, and

– simple-separation, according to P.3.4, of the **SELV system** from other **SELV systems**, from **PELV systems** and from earth.

Intentional connection of **exposed conductive parts** of the **control** to a **protective conductor** or to an earth-conductor is not permitted.

In special locations where **SELV** is required and where **protective screening** according to P.3.3 is applied, the **protective screen** shall be separated from each adjacent circuit by **basic insulation** rated for the highest voltage present.

Requirements for the elements of **SELV system** are given in Clause P.3.

P.2.2 PELV system

Protection against electric shock shall be provided by the following measures:

– limitation of voltage, according to P.3.1 in a circuit which can be earthed and/or the **exposed conductive parts** of which can be earthed (the **PELV system**), and

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– **protective separation** according to P.3.2 of the **PELV system** from all circuits other than **SELV** and **PELV**.

If the **PELV** circuit is earthed and if **protective screening** according to P.3.3 is used, it is not necessary to provide **basic insulation** between the **protective screen** and the **PELV system**.

Where **live parts** of the **PELV system** are accessible (touchable) simultaneously with conductive parts which, in case of a **fault**, could assume the potential of the primary circuit, protection against electric shock depends on **protective equipotential bonding** (7.6) of all such conductive parts. Such parts shall be bonded to the protective earthing terminal or **termination** of the **control**.

Requirements for the elements of **PELV system** are given in Clause P.3.

P.3 Protective measures for SELV system and PELV system

P.3.1 Limitation of voltage

Limitation of voltage shall provide that the voltage between simultaneously accessible parts does not exceed the limits as specified in 3.1.5 and as specified in 6.1.1.

P.3.2 Protective separation

Protective separation between circuits in **SELV systems** or **PELV systems** and other live circuits shall be achieved by means of

– **basic insulation** and **supplementary insulation**, each rated for the highest voltage present, i.e. **double insulation**, or

– **reinforced insulation** rated for the highest voltage present, or

– **protective screening** according to P.3.3 with the **protective screen** being separated from each adjacent circuit by **basic insulation** rated for the highest adjacent circuit voltage (see also P.2.1, last paragraph), or

– a combination of these provisions.

If conductors of the separated circuit are contained together with conductors of other circuits in a multiconductor cable or in another grouping of conductors, they shall be insulated, individually or collectively, for the highest voltage present, so that **double insulation** or **reinforced insulation** is achieved.

If any component is connected between the separated circuits, that component shall comply with the requirements for **protective impedance** as specified in 6.1.10.

Protective separation or an equivalent level of protection required between **SELV** or **PELV** circuits and other circuits is provided by the following sources:

– either be through a safety isolating transformer, or

– a source of current providing a degree of safety equivalent to that of a safety isolating transformer (e.g. motor generator), or

– electrochemical (e. g. battery).

NOTE The voltage limits are based on the assumption that the **safety isolating transformer** is supplied at the upper limit of its rated voltage.

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If a converter is used, and the **control** is declared

– IPX7 and IPX8 as declared in Table 1, requirement 9, the **control** shall be declared to be subjected to second **fault** analysis (see Table H.1, requirement H.10) for the circuits and insulation between windings of the converter and as result of second **fault** the **ELV** value of 0 V shall not be exceeded. The current between the poles of the output shall comply with 6.1.9.

Compliance is checked by inspection, measurement and when performing the appropriate test(s) in the order of this document.

P.3.3 Protective screening

Protective screening shall consist of a conductive screen interposed between **hazardous live parts** of the **control**, installation, or **system** and the part being protected (for example, a **SELV**-circuit or a **PELV** circuit). The **protective screen**:

– shall be permanently and reliably connected to the protective earthing terminal of the **control** and the connection shall comply with the requirements of Clause 7; and

– shall itself comply with the requirements of Clause 7.

P.3.4 Simple-separation

Simple-separation between a **SELV** circuit and other **SELV systems** or **PELV systems** or earth shall comply with the requirements for **basic insulation** throughout, rated for the highest voltage present.

If any component is connected between the separated circuits, that component shall withstand the electric stresses specified for the insulation which it bridges and its impedance shall limit the prospective current flow through the component to the steady-state **touch current** values indicated in 6.1.10 and 9.2.5 for **protective impedance**.

P.3.5 Functional earthing

This document allows the use of **exposed conductive parts** as **internal conductors** of an internal **PELV** circuit for functional earthing under conditions specified in this document and for particular applications in the relevant part 2.

NOTE Functional earthing is the connection of an electrical working circuit to earth for functional purposes as opposed to protective earthing. Depending on the type of installation **system**, different requirements apply and are given in the IEC standards for the installation of buildings. Functional earthing may be necessary for telecommunication equipment for which IEC product standards apply.

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Annex Q
(informative)

Regional differences relevant for the member countries of Cenelec

NOTE This annex provides the regional differences relevant for the member countries of CENELEC, without mentioning them. If a certain requirements, test or Note is only applicable for one or some of these countries, then the relevant countries are mentioned. The subclause numbers in this annex show the additions/modifications to the same subclause number as used in the main part of this document, except for Q.30 and Q.31, which are clause numbers just for this Annex Q. The Annex ZB (see Q.30) in the CENELEC version of this standard is listing “Special national condition: National characteristic or practice that cannot be changed even over a long period, e.g. climatic conditions, electrical earthing conditions.” The Annex ZC (see Q.31) in the CENELEC version of this standard is listing “A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN-CENELEC national member.”

Q.3.7.3 Class 0 control (see 3.7.3)

NOTE See Annex ZB.

Q.3.7.4 Class II control (see 3.7.4)

NOTE See Annex ZB.

Q.3.7.6.3 Class II control (see 3.7.6.3)

NOTE See Annex ZB.

Q.4.2 General requirements (see 4.2)

Add after the 1st paragraph:

The rated voltage of controls, having terminals intended to be directly connected to the supply mains single phase, shall cover usage at 230 V and to the supply mains multiphase, 400 V.

Q.4.3.4.3 According to protection against electric shock (see 4.3.4.3.1)

Q.4.3.4.3.1 (see 4.3.4.3.1)

NOTE See Annex ZB.

Q.4.3.4.3.3 (see 4.3.4.3.3)

NOTE See Annex ZB.

Q.5.4.2 Marking of terminals for external connections (see 5.4.2)

Q.5.4.2.2 (see 5.4.2.2)

NOTE See Annex ZB.

Q.5.4.2.4 (see 5.4.2.4)

NOTE See Annex ZB.

Q.7.1.1 (see 7.1.1)

NOTE See Annex ZB.

Q.7.5.2 Incorporated control (see 7.5.2)

NOTE 7.5.2 does not apply.

Q.14.3 Subclause 14.3 does not apply.

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Q.15.2 Electric strength (see 15.2, Table 16)

NOTE See Annex ZB.

Q.15.3 Subclause 15.3 does not apply.

Q.16 Heating (see Clause 16)

Add after Table 17:

If the maximum permitted temperature of a winding or core lamination exceeds the value specified for the test described in 16.1, six additional samples shall be subjected to the following tests:

Moving parts, if any, are locked and a current is passed individually through each winding, this current being such that the temperature of the relevant winding is equal to the maximum temperature measured under the conditions specified in 16.1. This temperature is increased by whichever value is chosen from Table Q.1. The total time during which the current is passed is as indicated in the table for the temperature increase chosen.

Table Q.1 – Additional aging parameters for windings

Temperature increase	Total time
0 ± 3	p[a]
10 ± 3	0,5 p
20 ± 3	0,25 p
30 ± 3	0,125 p
[a] In general, p equals 8 000 for controls for EN 60335-1 applications.	

The total time is divided into four equal periods, each of them being followed by a period of 48 h during which the control is subjected to a humidity treatment as specified in 14.2. After the final humidity treatment, the insulation shall withstand an electric strength test as specified in 15.2, the test voltage for the electric strength being, however, reduced to 50 % of the values specified in Table 16.

Failure of only one of the six samples during the first of the four periods of the test is ignored. If one of the six samples fails during the second, third or fourth period of the test, the remaining five samples are subjected to an additional fifth period of passing current and humidity treatment, followed by an electric strength and insulation resistance test as specified before.

Failure of any of the remaining five controls will entail a rejection.

The controls are then subjected to the test of 19.8, but only for half the number of cycles specified in that subclause. All controls shall then withstand an electric strength test as specified before.

NOTE Examples of cases where there can be doubt with regard to the classification of the insulating **system** of a winding are those two cases where well-known insulating materials are used in an unconventional way, where combinations of materials of different temperature classes are used at a temperature higher than that allowed for the lowest class used or where materials are used for which no sufficient experience is available, as can be the case for integral core insulation.

If it is desired to establish that the insulation **system** falls within the temperature class claimed by the manufacturer, the winding temperature shall be equal to the temperature limit for the class of insulation claimed, increased by the temperature increase chosen from the table.

The temperature increase chosen from the table should be agreed with the manufacturer.

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Q.18.2.1 The effect of temperature (see 18.2.1) is tested as follows:

NOTE See Annex ZB.

Q.19.3.1 For parts of the **control** other than any temperature **sensing element (see** 19.3.1), the following shall apply:

Add the following as a sub-part to the 3rd dashed item:

– Controls with **type 1 action** – Clauses 18 and 19;
– Controls with **type 2 action** – Clauses 15, 18 and 19.

One additional sample required.

Q.19.7 Overvoltage test or overload test in all countries using an overload test of automatic action at accelerated rate (see 19.7)

Only the overvoltage test is applicable.

Q.19.10 Overvoltage test or overload test in all countries using an overload test of automatic action at accelerated rate (see 19.10)

Only the overvoltage test is applicable.

Q.21.3.1 (see 21.3.1)

Add as a 2nd paragraph the following:

For parts that maintain or retain in position electrical connections, the glow-wire test shall be carried-out at a temperature of 850 °C.

Q.25 Electromagnetic compatibility (EMC) requirements – Immunity (see Clause 25)

Q.25.1 General

Add before Table 25 the following requirement:

Table 25 applies with the following modification: For all class A free standing controls, independently mounted controls and in-line cord controls the tests of 25.5 to 25.10 are applicable, which means, Note [a] in Table 25 is not applicable.

Q.30 – Annex ZB (normative) – Special national conditions

Special national condition: National characteristic or practice that cannot be changed even over a long period, e.g. climatic conditions, electrical earthing conditions.

NOTE If it affects harmonization, it forms part of the European Standard.

For the countries in which the relevant special national conditions apply, these provisions are normative, for other countries they are informative.

Q.30.3.7.3 Class 0 controls as given in 3.7.3 are not allowed in Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom.

Q.30.3.7.4 Class 0I controls as given in 3.7.4 are not allowed in Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom.

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Q.30.3.7.6.3 Class II controls as given in 3.7.6.3 are not allowed in Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom.

Q.30.4.3.4.3.1 Class 0 and Class 0I controls as given in 4.3.4.3.1 are not allowed in Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom are not allowed.

Q.30.4.3.4.3.3 Class 0 and Class 0I controls as given in 4.3.4.3.3 are not allowed Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom.

Q.30.5.4.2.2 United Kingdom

Add to the requirement in 5.4.2.2: Terminals intended exclusively for a live external conductor shall be indicated by the letter ‘L’.

Q.30.5.4.2.4 United Kingdom

Add to the requirement in 5.4.2.4:

The letter "L" shall not be used except as indicated above.

Q.30.7.1.1 Class 0I controls as given in 7.1.1 are not allowed Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom.

Q.30.15.2 Class 0I controls as given in Table 16, footnote [c] are not allowed Austria, Belgium, Denmark, France, Germany, Italy, Norway and United Kingdom.

Q.30.18.2.1 For Finland, Norway and Sweden

In the first dashed paragraph of 18.2.1, replace "(−10 ± 2) °C" by "(−25 ± 2) °C".

Q.31 – Annex ZC (informative) – A-deviations

A-deviation: National deviation due to regulations, the alteration of which is for the time being outside the competence of the CEN-CENELEC national member.

This European Standard falls under Directives LVD (2014/35/EU), EMC (2014/30/EU) and RED (2014/53/EU).

NOTE (from CEN/CENELEC IR Part 2:2011, 2.17) Where standards fall under EU Directives, it is the view of the Commission of the European Communities (OJ No C 59, 1982-03-09) that the effect of the decision of the Court of Justice in case 815/79 Cremonini/Vrankovich (European Court Reports 1980, p. 3583) is that compliance with A-deviations is no longer mandatory and that the free movement of products complying with such a standard should not be restricted except under the safeguard procedure provided for in the relevant Directive.

A-deviations in an EFTA-country are valid instead of the relevant provisions of the European Standard in that country until they have been removed.

Clause Deviation

Q.31.9.1.3 **United Kingdom** (Statutory Instrument 1768:1994)

Add to the requirement:

These regulations apply to all plugs for domestic use at a voltage of not less than 200 V and in general allow only plugs to BS 1363 to be fitted.

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Annex R
(informative)

National differences relevant in the United States of America

NOTE This annex is informative in this document, but in UL 60730-1, this annex is normative. Refer to UL 60730-1, National differences for US specific requirements.

R.2 Normative references

Refer to UL 60730-1 for specific requirements in the United States.

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Annex S
(informative)

National differences relevant in Japan

NOTE This annex is informative in this document, but in JIS C 9730-1, this annex is normative. Refer to JIS C 9730-1, Annex JA for Japanese specific requirements.

S.2 Normative references

Refer to JIS C 9730-1, Annex JA for Japanese specific requirements.

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Annex T
(informative)

National differences relevant in Canada

NOTE This annex is informative in this document, but in CAN/CSA-E60730-1, this annex is normative. Refer to CAN/CSA-E60730-1, National differences for Canada specific requirements.

T.2 Normative references

Refer to CAN/CSA-E60730-1 for specific requirements in the Canada.

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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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DISPOSITIFS DE COMMANDE ÉLECTRIQUE AUTOMATIQUES –

Partie 1: Exigences générales

AVANT-PROPOS

1) La Commission Electrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. A cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
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L'IEC 60730-1 a été établie par le comité d'études 72 de l'IEC: Commandes électriques automatiques. Il s'agit d'une Norme internationale.

Cette sixième édition annule et remplace la cinquième édition parue en 2013, Amendement 1:2015 et Amendement 2:2020. Cette édition constitue une révision technique.

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Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a)	Structure des articles principaux	Les articles de la norme sont regroupés en deux sections d'exigences, dans lesquelles • la première section comprend les Articles 5 à 13 qui, en général, traitent de la construction du produit. Il est à noter que certaines exigences de construction peuvent avoir des exigences de vérification intégrées dans la clause pour faciliter l'utilisation de la norme; et • la seconde section se compose des Articles 14 à 26 qui traitent des exigences de vérification.
b)	Domaine d'application	Des articles sont déplacés et supprimés pour mieux refléter les produits couverts par la Partie 1 et pour faciliter la lecture.
c)	Références normatives	Les références sont mises à jour.
d)	Termes et définitions	Le texte est révisé dans certains articles et les paragraphes pertinents de l'Article H.3 sont réintégrés à l'Article 3.
e)	Exigences générales	La structure générale de la norme est expliquée à l'aide d'une figure pour en représenter l'objectif.
f)	Généralités sur les essais	La taille de l'échantillon est réduite de 3 à 1, exigeant toutefois une analyse; l'ordre des essais est plus flexible; les exigences relatives aux batteries de l'Annexe V sont déplacées.
g)	Caractéristiques assignées	Cet article est supprimé, car couvert par le domaine d'application.
h)	Classification	Cet article est supprimé, car couvert dans l'article Information.
i)	Information	Le Tableau 1 est mis à jour pour refléter les entrées de l'article Classification et toutes les références croisées.
j)	Protection contre les chocs électriques	L'Article 8 est révisé pour inclure les paragraphes de l'Article H.8 et de l'Article V.8, révisés suivant le cas pour faire la distinction entre une partie active et une partie active dangereuse.
k)	Dispositions en vue de la mise à la terre de protection	
l)	Exigences de construction	Un seul condensateur Y1 est autorisé; les exigences pertinentes de H.11 et V.11 sont respectivement déplacées au paragraphe 9.2.5 et au paragraphe 9.13.4.4.
m)	Résistance à l'humidité et à la poussière	Le tableau de classification IP est déplacé de l'article Classification vers l'Article 14; les références sont mises à jour.
n)	Tolérances de fabrication et dérive	Tous les articles ont été déplacés vers l'Annexe H puisque les exigences concernent la sécurité fonctionnelle des dispositifs de commande.
o)	CEM – Emission	L'Article H.23 est déplacé dans l'Article 23.

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p)	CEM – Immunité	De nouvelles exigences CEM (performances) sont incluses pour tous les dispositifs de commande, à l'exception des dispositifs de commande incorporés/intégrés présentant des fonctions de commande de classe A. Les produits destinés aux HBES/SGTB sont également soumis à ces exigences.
q)	Évaluation des pannes sur les circuits électroniques	L'évaluation des pannes est passée de l'Annexe H à l'Article 13; l'essai de tension anormale pour coupure électronique est supprimé.
r)	Annexe H	Toutes les exigences pertinentes pour l'électronique sont déplacées dans les articles correspondants du corps de la norme. Seules les exigences relatives à la sécurité fonctionnelle sont conservées dans la présente annexe.
s)	Annexe T	Les articles sont révisés pour plus de clarté en Annexe P.
t)	Annexe U	Cette annexe n'étant plus jugée utile, elle est supprimée.
u)	Annexe V	Cette annexe est incluse dans la partie principale de la norme.

Le texte de cette Norme internationale est issu des documents suivants:

Projet	Rapport de vote
72/1307/FDIS	72/1320/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.

Le présent 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 https://www.iec.ch/publications.

Une liste de toutes les parties de la série IEC 60730, publiées sous le titre général: *Dispositifs de commande électrique automatiques*, peut être consultée sur le site web de l'IEC.

Afin de constituer une norme vraiment internationale pour couvrir les dispositifs de commande électrique automatiques, il a été nécessaire de prendre en compte des exigences différentes résultant de l'expérience pratique acquise dans plusieurs parties du monde et de reconnaître les différences des systèmes électriques et des règles d'installation nationales.

Les articles "dans certains pays" ont respectivement été déplacés dans les différences régionales et nationales de l'Annexe Q à l'Annexe T.

Il est envisagé que dans la prochaine édition du présent document, il soit possible de supprimer les différences qui sont couvertes par de nouvelles normes de l'IEC en cours d'élaboration dans d'autres comités d'études.

La présente Partie 1 doit être utilisée conjointement avec la Partie 2 appropriée au type de dispositif de commande concerné ou aux dispositifs de commande pour applications particulières. La présente Partie 1 peut aussi être utilisée, autant que de raison, aux dispositifs de commande non mentionnés dans une Partie 2 et aux dispositifs de commande conçus selon de nouveaux principes, pour lesquels de nouvelles exigences peuvent être nécessaires.

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Si, pour un article ou un paragraphe particulier, le texte de la Partie 2 indique:

Addition: le texte de la Partie 1 est applicable avec l'exigence complémentaire indiquée dans une Partie 2;

Modification: le texte de la Partie 1 est applicable avec la modification mineure indiquée dans une Partie 2;

Remplacement: le texte de la Partie 2 remplace entièrement le texte de la Partie 1.

Lorsqu'aucune modification n'est nécessaire, la Partie 2 indique que l'article ou le paragraphe approprié est applicable.

NOTE Dans le présent document, les caractères d'imprimerie suivants sont employés:

– exigences proprement dites: caractères romains;
– *modalités d'essais: caractères italiques;*
– commentaires: petits caractères romains;
– termes définis: **en gras**.

Le comité a décidé que le contenu de la publication de base et de son amendement ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
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DISPOSITIFS DE COMMANDE ÉLECTRIQUE AUTOMATIQUES –

Partie 1: Exigences générales

1 Domaine d'application

Le présent document s'applique aux dispositifs de commande électrique automatiques

- destinés à être utilisés dans, sur, ou avec du matériel pour appareil domestique et à usage analogue;

NOTE 1 Partout où il est utilisé dans le présent document, le terme "matériel" signifie "appareil, équipement et matériel".

- pour l'automatisation du bâtiment relevant du domaine d'application des séries ISO 16484 et IEC 63044 (HBES/SGTB);

EXEMPLE 1 Les vannes montées indépendamment, les dispositifs de commande des systèmes de réseau électrique intelligent et les dispositifs de commande des systèmes d'automatisation des bâtiments relevant du domaine d'application de l'ISO 16484-2.

- de matériel qui est utilisé par le public (le matériel destiné à être utilisé dans des magasins, des bureaux, des hôpitaux, des fermes et des applications commerciales et industrielles, par exemple);

EXEMPLE 2 Dispositifs de commande pour les installations de restauration, de chauffage et d'air conditionné.

- qui sont des **dispositifs de commande activés intelligents**;

EXEMPLE 3 Dispositif de commande de réseau électrique intelligent, interfaces à distance/dispositif de commande de matériel consommant de l'énergie, y compris les ordinateurs ou smartphones.

- à courant alternatif (AC) ou continu (DC) dont la tension assignée ne dépasse pas 690 V AC ou 600 V DC lorsque la source de courant continu est fournie par des batteries primaires ou secondaires;
- utilisés dans, sur ou en association avec des matériels qui utilisent l'électricité, le gaz, le pétrole, des combustibles solides, l'énergie thermique solaire, etc., ou une combinaison de ces sources d'énergie;
- utilisés comme partie d'un système de commande ou de dispositifs de commande solidaires mécaniquement de dispositifs de commande multifonctions ayant des sorties non électriques;
- utilisant des **thermistances CTP** ou CTN et aux **thermistances** discrètes, dont les exigences sont contenues à l'Annexe J;
- actionnés mécaniquement ou électriquement qui commandent ou sont sensibles à des caractéristiques telles que température, pression, temps, humidité, lumière, effets électrostatiques, débit ou niveau d'un liquide, courant, tension ou accélération, ou leurs combinaisons;
- et manuels dans la mesure où ils font partie intégrale, électriquement et/ou mécaniquement, des dispositifs de commande automatiques.

NOTE 2 Les exigences pour les interrupteurs mécaniques à action manuelle ne faisant pas partie d'un dispositif de commande automatique sont contenues dans l'IEC 61058-1-1.

Le présent document s'applique

– à la sécurité intrinsèque des dispositifs de commande électrique automatiques;

– à la sécurité fonctionnelle des dispositifs de commande électrique automatiques et des systèmes de sécurité;

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– aux dispositifs de commande dans lesquels les performances (par exemple, l'effet des phénomènes de CEM) du produit peuvent nuire à la sécurité et aux performances globales du système commandé;

– aux valeurs de fonctionnement, aux temps de fonctionnement et aux séquences de fonctionnement dans la mesure où ils interviennent dans la sécurité du matériel.

Le présent document spécifie les exigences de construction, de fonctionnement et d'essai des dispositifs de commande électrique automatiques utilisés dans, sur ou en association avec un matériel.

Le présent document

- ne s'applique pas aux **dispositifs de commande électronique** automatiques prévus exclusivement pour des applications industrielles, sauf mention particulière dans la Partie 2 ou la norme du matériel. Cependant, le présent document peut être appliqué pour évaluer les dispositifs de commande électrique automatiques destinés spécifiquement aux applications industrielles dans les cas où aucune norme de sécurité pertinente n'existe;
- ne prend pas en considération la valeur de réponse d'une action automatique d'un dispositif de commande lorsqu'elle est influencée par la méthode de montage du dispositif de commande dans le matériel. Dans les cas où une telle valeur de réponse est importante du point de vue de la protection de l'utilisateur ou de l'environnement, la valeur spécifiée dans la norme particulière du matériel ou déterminée par le fabricant s'applique;
- ne traite pas de l'intégrité du signal de sortie transmis aux dispositifs de réseau, comme l'interopérabilité avec d'autres dispositifs, à moins qu'elle n'ait été évaluée comme partie intégrante du système de commande.

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 60038, *Tensions normales de l'IEC*

IEC 60065:2014, *Appareils audio, vidéo et appareils électroniques analogues – Exigences de sécurité*

IEC 60068-2-75, *Essais d'environnement – Partie 2-75: Essais – Essai Eh: Essais au marteau*

IEC 60085, *Isolation électrique – Evaluation et désignation thermiques*

IEC 60099-1:1991, *Parafoudres – Partie 1: Parafoudres à résistance variable avec éclateurs pour réseaux à courant alternatif*[1]

IEC 60112:2020, *Méthode de détermination des indices de résistance et de tenue au cheminement des matériaux isolants solides*

IEC 60127 (toutes les parties), *Coupe-circuits miniatures*

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*

[1] Retirée.

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IEC 60245-1, *Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V – Partie 1: Exigences générales*

IEC 60269 (toutes les parties), *Fusibles basse tension*

IEC 60335-1:2020, *Appareils électrodomestiques et analogues – Sécurité – Partie 1: Exigences générales*

IEC 60364 (toutes les parties), *Installations électriques à basse tension*

IEC 60384-14, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 14: Spécification intermédiaire – Condensateurs fixes d'antiparasitage et raccordement à l'alimentation*

IEC 60384-16, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 16: Spécification intermédiaire – Condensateurs fixes pour courant continu à diélectrique en film de polypropylène métallisé*

IEC 60384-17, *Condensateurs fixes utilisés dans les équipements électroniques – Partie 17: Spécification intermédiaire – Condensateurs fixes pour tension alternative et pour impulsions à diélectrique en film de polypropylène métallisé*

IEC 60417, *Symboles graphiques utilisables sur le matériel*

IEC 60423, *Systèmes de conduits pour la gestion du câblage – Diamètres extérieurs des conduits pour installations électriques et filetages pour conduits et accessoires*

IEC 60529:1989, *Degrés de protection procurés par les enveloppes (Code IP)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC 60539 (toutes les parties), *Thermistances à coefficient de température négatif à chauffage direct*

IEC 60664-1:2007[2], *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 1: Principes, exigences et essais*

IEC TR 60664-2 (toutes les parties), *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension*

IEC 60664-3:2016, *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 60664-4, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 4: Considérations sur les contraintes de tension à haute fréquence*

IEC 60695-2-10, *Essais relatifs aux risques du feu – Partie 2-10: Essais au fil incandescent/chauffant – Appareillage et méthode commune d'essai*

IEC 60695-2-11:2021, *Essais relatifs aux risques du feu – Partie 2-11: Essais au fil incandescent/chauffant – Méthode d'essai d'inflammabilité pour produits finis (GWEPT)*

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2 Retirée.

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IEC 60695-10-2, *Essais relatifs aux risques du feu – Partie 10-2: Chaleurs anormales – Essai à la bille*

IEC 60738 (toutes les parties), *Thermistances – Coefficient de température positif à chauffage direct*

IEC 60747-5-5, *Dispositifs à semiconducteurs – Partie 5-5: Dispositifs optoélectroniques – Photocoupleurs*

IEC 60884-1, *Prises de courant pour usages domestiques et analogues – Partie 1: Règles générales*

IEC 60884-2-5:2017, *Prises de courant pour usages domestiques et analogues – Partie 2-5: Exigences particulières pour les adaptateurs*

IEC 60998-2-2, *Dispositifs de connexion pour circuits basse tension pour usage domestique et analogue – Partie 2-2: Règles particulières pour dispositifs de connexion en tant que parties séparées avec organes de serrage sans vis*

IEC 60998-2-3, *Dispositifs de connexion pour circuits basse tension pour usage domestique et analogue – Partie 2-3: Règles particulières pour dispositifs de connexion en tant que parties séparées avec organes de serrage à perçage d'isolant*

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 61000-3-2, *Compatibilité électromagnétique (CEM) – Partie 3-2: Limites – Limites pour les émissions de courant harmonique (courant appelé par les appareils ≤ 16 A par phase)*

IEC 61000-3-3, *Compatibilité électromagnétique (CEM) – Partie 3-3: Limites – Limitation des variations de tension, des fluctuations de tension et du papillotement dans les réseaux publics d'alimentation basse tension, pour les matériels ayant un courant assigné ≤ 16 A par phase non soumis à un raccordement conditionnel*

IEC 61000-3-11, *Compatibilité électromagnétique (CEM) – Partie 3-11: Limites – Limitation des variations de tension, des fluctuations de tension et du papillotement dans les réseaux publics d'alimentation basse tension – Equipements ayant un courant assigné ≤75 A et soumis à un raccordement conditionnel*

IEC 61000-3-12, *Compatibilité électromagnétique (CEM) – Partie 3-12: Limites – Limites pour les courants harmoniques produits par les appareils connectés aux réseaux publics basse tension ayant un courant appelé >16 A et ≤75 A par phase*

IEC 61000-4-2:2008, *Compatibilité électromagnétique (CEM) – Partie 4-2: Techniques d'essai et de mesure – Essai d'immunité aux décharges électrostatiques*

IEC 61000-4-3, *Compatibilité électromagnétique (CEM) – Partie 4-3: Techniques d'essai et de mesure – Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques*

IEC 61000-4-4, *Compatibilité électromagnétique (CEM) – Partie 4-4: Techniques d'essai et de mesure – Essai d'immunité aux transitoires électriques rapides en salves*

IEC 61000-4-5:2014, *Compatibilité électromagnétique (CEM) – Partie 4-5: Techniques d'essai et de mesure – Essai d'immunité aux ondes de choc*
IEC 61000-4-5:2014/AMD1:2017

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IEC 61000-4-6, *Compatibilité électromagnétique (CEM) – Partie 4-6: Techniques d'essai et de mesure – Immunité aux perturbations conduites, induites par les champs radioélectriques*

IEC 61000-4-8, *Compatibilité électromagnétique (CEM) – Partie 4-8: Techniques d'essai et de mesure – Essai d'immunité au champ magnétique à la fréquence du réseau*

IEC 61000-4-11, *Compatibilité électromagnétique (CEM) – Partie 4-11: Techniques d'essai et de mesure – Essais d'immunité aux creux de tension, coupures brèves et variations de tension pour les appareils à courant d'entrée inférieur ou égal à 16 A par phase*

IEC 61000-4-13:2002, *Compatibilité électromagnétique (CEM) – Partie 4-13: Techniques d'essai et de mesure – Essais d'immunité basse fréquence aux harmoniques et inter-harmoniques incluant les signaux transmis sur le réseau électrique alternatif*
IEC 61000-4-13:2002 /AMD1:2009
IEC 61000-4-13:2002 /AMD2:2015

IEC 61000-4-20, *Compatibilité électromagnétique (CEM) – Partie 4-20: Techniques d'essai et de mesure – Essais d'émission et d'immunité dans les guides d'onde TEM*

IEC 61000-4-21, *Compatibilité électromagnétique (CEM) – Partie 4-21: Techniques d'essai et de mesure – Méthodes d'essai en chambre réverbérante*

IEC 61000-4-22, *Compatibilité électromagnétique (CEM) – Partie 4-22: Techniques d'essai et de mesure – Mesures de l'immunité et des émissions rayonnées dans des enceintes complètement anéchoïques (FAR)*

IEC 61000-4-28, *Compatibilité électromagnétique (CEM) – Partie 4-28: Techniques d'essai et de mesure – Essai d'immunité pour les équipements dont le courant d'entrée ne dépasse pas 16 A par phase*

IEC 61000-6-1:2016, *Compatibilité électromagnétique (CEM) – Partie 6-1: Normes génériques – Norme d'immunité pour les environnements résidentiels, commerciaux et de l'industrie légère*

IEC 61000-6-2:2016, *Compatibilité électromagnétique (CEM) – Partie 6-2: Normes génériques – Norme d'immunité pour les environnements industriels*

IEC 61000-6-3:2020, *Compatibilité électromagnétique (CEM) – Partie 6-3: Normes génériques – Norme sur l'émission relative aux appareils utilisés dans les environnements résidentiels*

IEC 61000-6-4:2018, *Compatibilité électromagnétique (CEM) – Partie 6-4: Normes génériques – Norme sur l'émission pour les environnements industriels*

IEC 61051-1, *Varistances utilisées dans les équipements électroniques –Partie 1: Spécification générique*

IEC 61051-2, *Varistances utilisées dans les équipements électroniques – Partie 2: Spécification intermédiaire pour varistances pour limitations de surtensions transitoires*

IEC 61051-2-2, *Varistances utilisées dans les équipements électroniques. Deuxième partie: Spécification particulière-cadre pour varistances à l'oxyde de zinc pour limitations de surtensions transitoires – Niveau d'assurance E*

IEC 61210, *Dispositifs de connexion – Bornes plates à connexion rapide pour conducteurs électriques en cuivre – Exigences de sécurité*

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IEC 61249 (toutes les parties), *Matériaux pour cartes imprimées et autres structures d'interconnexion*

IEC 61558-2-6, *Safety of transformers, reactors, power supply units and combinations thereof − Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers for general applications* (disponible en anglais seulement)

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 61810-3, *Relais électromécaniques élémentaires – Partie 3: Relais à contacts guidés (liés mécaniquement)*

IEC 62151, *Sécurité des matériels reliés électriquement à un réseau de télécommunications*

IEC 62319 (toutes les parties), *Thermistances polymères – Coefficient de température positif de fonction échelon à chauffage direct*

IEC 62326 (toutes les parties), *Cartes imprimées*

IEC 62368-1, *Equipements des technologies de l'audio/vidéo, de l'information et de la communication – Partie 1: Exigences de sécurité*

IEC 63044 (toutes les parties), *Systèmes Electroniques pour les Foyers Domestiques et les Bâtiments (HBES) et Systèmes de Gestion Technique du Bâtiment (SGTB)*

CISPR 11, *Appareils industriels, scientifiques et médicaux – Caractéristiques de perturbations radioélectriques – Limites et méthodes de mesure*

CISPR 14-1:2020, *Compatibilité électromagnétique – Exigences relatives aux appareils électrodomestiques, aux outils électriques et aux appareils analogues – Partie 1: Émission*

CISPR 32:2015, *Compatibilité électromagnétique des équipements multimédia – Exigences d'émission*
CISPR 32:2015/AMD1:2019

ISO 4046-4:2016, *Papier, carton, pâtes et termes connexes – Vocabulaire – Partie 4: Catégories et produits transformés de papier et de carton*

ISO 7637-2:2011, *Véhicules routiers – Perturbations électriques par conduction et par couplage – Partie 2: Perturbations électriques transitoires par conduction uniquement le long des lignes d'alimentation*

ISO 7637-3:2016, *Véhicules routiers – Perturbations électriques par conduction et par couplage – Partie 3: Transmission des perturbations électriques par couplage capacitif ou inductif le long des lignes autres que les lignes d'alimentation*

ISO 16484 (toutes les parties), *Systèmes d'automatisation et de gestion technique du bâtiment (SGTB)*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

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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

NOTE Lorsque les termes "tension" et "courant" sont employés, ils impliquent les valeurs efficaces, sauf spécification contraire.

3.1 Définitions concernant les caractéristiques assignées de tension, courant, fréquence et puissance

3.1.1
tension, courant, fréquence ou puissance assignée
tension, courant, fréquence ou puissance assignée au **dispositif de commande** par son fabricant

Note 1 à l'article: Pour une alimentation triphasée, la **tension assignée** est la tension entre phases.

3.1.2
plages de tension, de courant, de fréquence ou de puissance assignées
plages de tension, de courant, de fréquence ou de puissance nominales assignées au **dispositif de commande** par son fabricant et exprimées par leurs limites inférieure et supérieure

3.1.3
tension de service
plus grande valeur efficace de la valeur de la tension alternative ou continue appliquée à toute isolation particulière pouvant se produire quand le matériel est alimenté à la **tension assignée**

Note 1 à l'article: Les **surtensions transitoires** sont ignorées.

Note 2 à l'article: Les conditions en circuit ouvert et les conditions de fonctionnement normal sont prises en compte.

3.1.4
très basse tension
TBT
tension ne dépassant pas les valeurs maximales de 50 V en courant alternatif (valeur efficace), 70,7 V en courant alternatif (valeur de crête) ou 120 V en courant continu (lissé) entre conducteurs et entre un conducteur quelconque et la terre, qu'il est admis de maintenir indéfiniment en conditions de fonctionnement normal et en conditions de première **panne**

Note 1 à l'article: Le terme "lissé" définit par convention une valeur efficace de tension d'ondulation ne dépassant pas 10 % de la composante continue.

Note 2 à l'article: Conformément à l'IEC 61140:2016, l'utilisation de la **TBT** hors d'un **schéma TBTS** ou d'un **schéma TBTP** ne constitue pas une mesure de protection contre les chocs électriques.

3.1.5
très basse tension de sécurité
très basse tension de protection
TBTS/TBTP
tension destinée à être utilisée dans un **schéma TBTS** ou dans un **schéma TBTP** entre des **parties simultanément accessibles** et toute **partie accessible** et la terre, ne dépassant pas les limites de 30 V en courant alternatif (valeur efficace), 42,4 V en courant alternatif (valeur de crête) ou 60 V en courant continu (lissé) en conditions de fonctionnement normal et en conditions de première **panne**, qui est fournie par une source indépendante (groupes convertisseurs et batteries par exemple) ou lorsqu'elle est obtenue à partir d'une tension plus élevée fournie par un **transformateur de sécurité** ou un convertisseur équipé d'enroulements séparés fournissant une isolation équivalente

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Note 1 à l'article: Les limites de tension se fondent sur l'hypothèse que le **transformateur de sécurité** est alimenté à sa tension assignée.Pour les besoins de l'essai de sortie de 12.2.1, la limite de la tension de sortie secondaire doit être augmentée comme cela est spécifié en 19.2.2.

Note 2 à l'article: Les transformateurs utilisés dans des convertisseurs qui possèdent des enroulements séparés et qui fournissent une isolation équivalente sont couverts par l'IEC 61558-2-6 et l'IEC 61558-2-16.

Note 3 à l'article: Les limites **TBTS/TBTP** sont définies indépendamment de toute condition particulière qui peut se produire dans l'installation. Des exigences différentes peuvent être spécifiées dans les normes qui couvrent les installations électriques (par exemple la série IEC 60364) ou dans les règlements locaux applicables.

Note 4 à l'article: Le terme "lissé" définit par convention une valeur efficace de tension d'ondulation ne dépassant pas 10 % de la composante continue.

Note 5 à l'article: Les limites **TBTS/TBTP** peuvent être différentes dans d'autres normes de produit ou de système. Dans le cas d'un dispositif de commande déclaré pour une utilisation exclusive dans des applications relevant d'une norme différente, les limites fixées par la norme d'application s'appliquent (par exemple, les dispositifs de commande destinés à une utilisation exclusive dans des appareils électrodomestiques conformes à la série de normes IEC 60335 ou ceux connectés à des systèmes HBES/SGTB conformes à l'IEC 63044-3 acceptent des limites de tension **TBTS** différentes).

3.1.6
transformateur de sécurité
transformateur dont l'enroulement primaire est séparé électriquement de l'enroulement secondaire par une isolation au moins équivalente à une **double isolation** ou à une **isolation renforcée**, et qui est prévu pour alimenter des circuits en **très basse tension de sécurité**

3.1.7
circuit secondaire limité isolé
circuit établi par un enroulement secondaire isolé d'un transformateur ayant une capacité maximale de 100 VA et une tension secondaire à circuit ouvert dont la valeur assignée ne dépasse pas 1 000 V

3.1.8
mode pilote
classe de **fonctionnement** dans laquelle la charge électrique finale est commandée par un moyen auxiliaire tel qu'un relais ou un contacteur

3.1.9
surtension transitoire
surtension d'une durée ne dépassant pas quelques millisecondes, oscillatoire ou non, généralement fortement amortie

Note 1 à l'article: Les **surtensions transitoires** peuvent être immédiatement suivies par des surtensions temporaires. Dans un tel cas, les deux surtensions sont considérées comme des événements distincts.

Note 2 à l'article: L'IEC 60071-1 définit trois types de **surtensions transitoires**, appelées surtensions à front lent, surtensions à front rapide et surtensions à front très rapide en fonction de leur durée jusqu'à la valeur de crête, durée de queue ou durée totale, et de la possibilité d'oscillations superposées.

[SOURCE: IEC 60050-614:2016, 614-03-14]

3.1.10
tension assignée de choc
tension de tenue aux chocs électriques assignée par le fabricant au matériel ou à une de ses parties, caractérisant la capacité de tenue spécifiée de son isolation aux surtensions

Note 1 à l'article: L'expression "tension assignée de choc" est identique à la "tension de tenue aux chocs" donnée dans la catégorie de surtension de l'IEC 60664-1.

3.1.11
catégorie de surtension
chiffre définissant une condition de **surtension transitoire**

Note 1 à l'article: Les catégories de surtension I, II, III et IV sont utilisées. Voir Annexe D.

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[SOURCE: IEC 60050-581:2008, 581-21-02, modifié – La Note 1 à l'article a été ajoutée.]

3.1.12
schéma TBTS
schéma électrique dont la tension ne peut pas dépasser les valeurs en 3.1.5:

– dans des conditions normales, et

– dans des conditions de **défaut** simple, y compris les **défauts** à la terre de protection dans les autres circuits électriques

[SOURCE: IEC 60050-826:2004, 826-12-31, modifié − L'expression "la valeur de la très basse tension" a été modifiée en "les valeurs en 3.1.5" et la Note 1 à l'article a été supprimée.]

3.1.13
schéma TBTP
schéma électrique dont la tension ne peut pas dépasser les valeurs en 3.1.5:

– dans des conditions normales, et

– dans des conditions de première **panne**, à l'exception des **défauts** à la terre de protection dans les autres circuits électriques

[SOURCE: IEC 60050-826:2004, 826-12-32, modifié − "la valeur de la très basse tension" a été modifiée en "les valeurs en 3.1.5" et la Note 1 à l'article a été supprimée.]

3.2 Définitions des différents types de dispositifs de commande en fonction de l'application

3.2.1
dispositif de commande électrique
dispositif utilisé dans, sur ou avec un matériel dans le but de faire varier ou de modifier l'effet produit à la sortie du matériel par un processus comprenant les phases de **mise en marche**, de **transmission** et de **fonctionnement**

Note 1 à l'article: Un dispositif de commande électrique est appelé ci-après "**dispositif de commande**".

Note 2 à l'article: Au moins l'un de ces aspects doit être de nature électrique ou électronique.

3.2.2
dispositif de commande manuelle
dispositif de commande dont la **mise en marche** résulte d'une **manœuvre** et dont les phases de **transmission** et **fonctionnement** sont réalisées directement et sans retard intentionnel

3.2.3
dispositif de commande automatique
dispositif de commande dont au moins l'une des phases opératoires n'est pas manuelle

3.2.4
dispositif de commande sensible
dispositif de commande automatique dont la **mise en marche** est commandée par un élément sensible à une **grandeur de manœuvre** particulière, telle que température, courant, humidité, lumière, niveau d'un liquide, position, pression ou vitesse

3.2.5
thermostat
dispositif de commande thermosensible, à action cyclique, destiné à maintenir la température entre deux valeurs particulières dans les conditions de fonctionnement normal et pour lequel un **réglage par l'utilisateur** peut être prévu

Note 1 à l'article: Un **thermostat** provoque une **action de type 1** ou de **type 2** telle que déclarée**.**

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3.2.6
limiteur de température
dispositif de commande thermosensible destiné à maintenir une température en dessous ou au-dessus d'une valeur particulière dans les conditions de fonctionnement normal et pour lequel un **réglage par l'utilisateur** peut être prévu

Note 1 à l'article: Un **limiteur de température** peut être du type à réarmement automatique ou manuel. Il n'effectue pas le **fonctionnement** inverse pendant le **cycle de fonctionnement** normal de l'appareil.

Note 2 à l'article: Un **limiteur de température** provoque une **action de type 1** ou **de type 2** telle que déclarée.

3.2.7
coupe-circuit thermique
dispositif de commande thermosensible destiné à maintenir une température en dessous ou au-dessus d'une valeur particulière dans les conditions de fonctionnement anormal et pour lequel un **réglage par l'utilisateur** n'est pas prévu

Note 1 à l'article: Un **coupe-circuit thermique** peut être du type à réarmement automatique ou manuel.

Note 2 à l'article: Un **coupe-circuit thermique** produit une **action de type 2**.

3.2.8
régulateur d'énergie
dispositif de commande à fonctionnement cyclique qui transforme l'énergie en une charge et qui peut incorporer des moyens de **réglage par l'utilisateur** pour modifier l'énergie moyenne délivrée

Note 1 à l'article: Le rapport entre la durée des périodes de fermeture du circuit et le temps écoulé détermine l'énergie moyenne.

3.2.9
dispositif de commande à base de temps
dispositif de commande automatique dans lequel la phase de **transmission** s'effectue au moyen d'un **moteur primaire** synchrone ou d'un circuit électrique à base de temps

3.2.10
dispositif de commande à fonctionnement électrique
dispositif de commande automatique dans lequel la **transmission** s'effectue au moyen d'un **moteur primaire** électrique et dont le **fonctionnement** commande un circuit électrique, sans retard intentionnel significatif

Note 1 à l'article: Un exemple de ce type de dispositif est un relais.

Note 2 à l'article: Un relais à action retardée peut être un **dispositif de commande à fonctionnement électrique** ou **à base de temps**, selon accord entre le laboratoire et le fabricant.

3.2.11
minuterie
dispositif de commande à base de temps qui doit être **manœuvré** pour que le cycle suivant puisse avoir lieu

Note 1 à l'article: Pendant un cycle le dispositif de commande peut exiger un signal externe électrique ou mécanique avant de quitter une position de repos pour permettre la continuation du cycle. Un exemple de ce type de dispositif est un programmateur.

3.2.12
minuterie cyclique
dispositif de commande à base de temps qui enchaîne automatiquement un nouveau cycle à la fin du cycle précédent

Note 1 à l'article: Un exemple de ce type de **dispositif de commande** est l'horloge de commande horaire d'un appareil de chauffage à accumulation.

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3.2.13
électrovanne
dispositif de commande automatique dans lequel la **transmission** est effectuée par un **moteur primaire** électrique et dont le **fonctionnement** agit sur le débit d'un liquide ou d'un gaz

3.2.14
mécanisme à fonctionnement électrique
dispositif de commande automatique dans lequel la **transmission** est effectuée par un **moteur primaire** électrique et dont le **fonctionnement** agit sur un dispositif mécanique

Note 1 à l'article: Un exemple de ce type de dispositif est le verrouillage à fonctionnement électrique du couvercle d'une essoreuse.

Note 2 à l'article: Un moteur électrique n'est pas compris dans cette définition.

3.2.15
dispositif de commande de fonctionnement
dispositif de commande qui démarre ou régule le matériel en fonctionnement normal

Note 1 à l'article: Ce dispositif de commande de fonctionnement peut fournir des **fonctions de commande de classe A**, **B** ou **C**.

3.2.16
dispositif de commande de protection
dispositif de commande dont le **fonctionnement** est prévu pour éviter les situations dangereuses pendant un fonctionnement anormal du matériel

3.2.17
dispositif de commande multi-usage
dispositif de commande électrique qui peut être classé et utilisé dans diverses utilisations

Note 1 à l'article: Un exemple de **dispositif de commande multi-usage** est le **thermostat** qui peut être aussi utilisé comme **limiteur de température**.

3.2.18
dispositif de commande multifonction
dispositif de commande électrique qui intègre plusieurs fonctions

Note 1 à l'article: Un exemple de **dispositif de commande multifonction** est la combinaison d'un **thermostat** et d'un capteur d'humidité.

3.2.19
système
dispositif de commande, capteurs de commande et actionneurs tels qu'appliqués à une application ou à des processus

3.3 Définitions concernant les fonctions des dispositifs de commande

3.3.1
mise en marche
cause initiale modifiant un aspect du **dispositif de commande** de telle manière que s'accomplissent la **transmission** et le **fonctionnement**

3.3.2
transmission
phase intermédiaire essentielle entre la **mise en marche** et le **fonctionnement** pour que le **dispositif de commande** puisse accomplir la fonction à laquelle il est destiné

Note 1 à l'article: Cela comprend, sans toutefois s'y limiter, l'utilisation de:

a) lignes/protocoles de communication;

b) matériel et/ou logiciel supplémentaires;

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c) IR/RF; ou

toutes les combinaisons de a) à c) par l'intermédiaire d'Internet en utilisant, par exemple, des modems, des téléphones portables, etc.

3.3.3
fonctionnement
modification de l'aspect du **dispositif de commande** qui fait varier la puissance d'entrée d'une partie ou de la totalité du matériel

3.3.4
action automatique
action d'un **dispositif de commande automatique** dans lequel la **transmission** et le **fonctionnement** résultent d'une **mise en marche** d'origine non **manœuvrée**

3.3.5
action automatique à ouverture et fermeture lentes
mode de **fonctionnement** dans lequel la vitesse d'ouverture et/ou de fermeture d'un contact est directement proportionnelle au taux de variation de la **grandeur de manœuvre** ou à la vitesse du mouvement d'un **moteur primaire**

Note 1 à l'article: Cette action peut être applicable à la fermeture, à l'ouverture ou aux deux.

3.3.6
action manuelle
action d'un **dispositif de commande automatique** ou **manuel** dans lequel la **transmission** et le **fonctionnement** résultent d'une **mise en marche** effectuée par **manœuvre**

3.3.7
manœuvre
déplacement de l'**organe de manœuvre** du **dispositif de commande** effectué à la main, au pied ou de toute autre manière par l'**utilisateur**

3.3.8
position repérée
position à laquelle l'**organe de manœuvre** revient de lui-même s'il est relâché après avoir été légèrement écarté

3.3.9
position intermédiaire
position stable d'un **organe de manœuvre** à proximité d'une **position repérée** correspondant à un **fonctionnement** intermédiaire du **dispositif de commande**

3.3.10
grandeur de manœuvre
caractéristique physique d'un milieu dont les variations ou la stabilité sont détectées

3.3.11
valeur de fonctionnement
valeur de la grandeur de manœuvre (température, pression, courant, etc.) à laquelle fonctionne le **dispositif de commande sensible** lors d'une élévation ou d'une baisse de la **grandeur de manœuvre**

3.3.12
temps de fonctionnement
durée ou différence de temps entre deux fonctions quelconques, électriques ou mécaniques, faisant partie d'une **action automatique** d'un **dispositif de commande à base de temps**

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3.3.13
séquence de fonctionnement
séquence ou programme ordonné de déroulement du **fonctionnement** des fonctions électriques ou mécaniques d'un **dispositif de commande** à la suite d'une **action automatique** ou **manuelle** d'un **dispositif de commande**

Note 1 à l'article: Elle comprend une combinaison de contacts ouverts ou fermés pour toute **position repérée**, **intermédiaire** ou **de réglage par le fabricant du matériel** ou de **réglage par l'utilisateur**.

3.3.14
valeur de réponse
valeur, **temps** ou **séquence de fonctionnement** qui lie un **dispositif de commande** à un matériel particulier

3.3.15
déclenchement libre
action automatique, avec un **organe de manœuvre** de réarmement, dans laquelle l'**action automatique** est indépendante de la manipulation ou de la position du mécanisme de réarmement

3.3.16
réglage
réglage mécanique d'une partie d'un **dispositif de commande** destiné à choisir une **valeur de fonctionnement**

3.3.17
réglage par le fabricant du dispositif de commande
tout **réglage** effectué par le **fabricant du dispositif de commande** non destiné à être modifié par le **fabricant du matériel**, l'**installateur** ou l'**utilisateur**

3.3.18
réglage par le fabricant du matériel
tout **réglage** effectué par le **fabricant du matériel** non destiné à être modifié par l'**installateur** ou l'**utilisateur**

3.3.19
réglage par l'installateur
tout **réglage** effectué par l'**installateur**, selon les instructions du **fabricant du matériel** ou du **fabricant du dispositif de commande**, non destiné à être modifié par l'**utilisateur**

3.3.20
réglage par l'utilisateur
toute sélection d'une **valeur de fonctionnement** par une **manœuvre** effectuée par l'**utilisateur**

3.3.21
point de consigne
valeur sélectionnée par **réglage**

3.3.22
point de consigne ajustable
valeurs multiples, situées à l'intérieur d'une plage déclarée de valeurs, pouvant être sélectionnées par **réglage**

3.3.23
cycle de fonctionnement
toutes actions automatiques ou **manuelles** impliquées dans un **fonctionnement** du début à la fin d'un matériel commandé

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3.3.24
cycle de fonctionnement par contact
toute action de mise en contact suivie d'une mise hors contact, ou d'une mise hors contact suivie d'une mise en contact

3.3.25
différentielle de fonctionnement
différence entre les valeurs supérieure et inférieure de la **valeur de fonctionnement**

3.3.26
différentielle ajustable
capacité de changer ou de modifier la **différentielle de fonctionnement** à l'intérieur des limites assignées par **fonctionnement** d'un mécanisme à action manuelle

3.3.27
différentielle fixe
différentielle de fonctionnement dont le **réglage** du fabricant ne peut être modifié

3.3.28
pression de travail maximale
trait maximal indiqué ou pression de travail maximale du **système** auquel le dispositif de commande ou certaines de ses parties peuvent être assujettis

3.3.29
température maximale
T_{max}
température maximale ambiante continue à laquelle la **tête de commande** est prévue d'être exposée en fonctionnement normal

3.3.30
fonction de commande à distance ou fonction de télécommande
fonction assurant tout **fonctionnement** des **dispositifs de commande** par des moyens externes

Note 1 à l'article: Cela comprend, sans toutefois s'y limiter, l'utilisation de:

a) lignes/protocoles de communication;

b) matériel et/ou logiciel supplémentaires;

c) **transmission** IR/RF; ou

toutes les combinaisons de a) à c) par l'intermédiaire d'Internet en utilisant, par exemple, des modems, des téléphones portables, etc.

3.3.31
arrêt de sécurité
changement d'état de toutes les sorties électriques de sécurité critiques du **dispositif de commande**, lesquelles basculent à un état sécurisé, y compris l'arrêt

3.3.32
température de la surface de montage
$T_{s\ max}$
température maximale déclarée à laquelle la surface de montage du dispositif de commande est destinée à être exposée, y compris tout dépassement probable lors de la mise en fonctionnement d'un dispositif de commande

3.3.33
courant de contact
courant électrique passant dans le corps humain ou dans le corps d'un animal lorsque ce corps est en contact avec une ou plusieurs parties accessibles d'une installation ou de matériels

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Note 1 à l'article: Le courant de contact est souvent appelé "courant de fuite" dans de nombreuses normes de sécurité telles que la série de normes IEC 60335.

[SOURCE: IEC 60050-195:2021, 195-05-21, modifié – La Note 1 à l'article a été ajoutée.]

3.4 Définitions relatives aux coupures et interruptions de circuit

Certains **dispositifs de commande** peuvent incorporer plusieurs types de coupure ou d'interruption de circuit.

3.4.1
coupure sur tous les pôles
déconnexion de tous les conducteurs d'alimentation excepté le conducteur de protection de mise à la terre, par une seule manœuvre

Note 1 à l'article: Le conducteur de mise à la terre de protection n'est pas considéré comme un conducteur d'alimentation.

3.4.2
coupure totale de circuit
séparation des contacts de tous les pôles d'alimentation autres que celui de terre de protection pour fournir l'équivalence de l'**isolation principale** entre le réseau d'alimentation et les parties destinées à être déconnectées

Note 1 à l'article: Il existe des exigences dimensionnelles et de rigidité diélectrique.

Note 2 à l'article: Lorsque le nombre de pôles sur le **dispositif de commande** est égal au nombre de pôles d'alimentation de l'appareil auquel il est raccordé, une **coupure totale de circuit** fournit une **coupure sur tous les pôles**.

Note 3 à l'article: Un **dispositif électronique** n'assure pas cette coupure.

3.4.3
microcoupure
séparation adéquate des contacts d'au moins l'un des pôles d'alimentation pour assurer une coupure fonctionnelle

Note 1 à l'article: Il existe une exigence de rigidité diélectrique de l'écartement des contacts mais pas d'exigence dimensionnelle.

Note 2 à l'article: Une **microcoupure** signifie que, pour les **dispositifs de commande non sensibles**, la fonction commandée par la coupure est franche et que, pour les **dispositifs de commande sensibles**, elle est sûre à l'intérieur des limites de la **grandeur de manœuvre** déclarée dans le Tableau 1, exigence 30.

Note 3 à l'article: Un **dispositif électronique** n'assure pas cette coupure.

3.4.4
micro-interruption
ouverture d'un circuit par une séparation des contacts, par une action cyclique ou par une action non cyclique qui ne fournit pas une **coupure totale** ou une **microcoupure** de circuit

Note 1 à l'article: Il n'existe pas d'exigences dimensionnelles ou de rigidité diélectrique pour l'écartement des contacts.

Note 2 à l'article: Un **dispositif électronique** n'assure pas cette coupure.

3.4.5
position ARRÊT
position qui indique d'une manière visible ou implicite une **coupure totale** ou une **microcoupure** de circuit

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3.4.6
coupure électronique
interruption d'action non cyclique par un **dispositif électronique** d'un circuit assurant une coupure fonctionnelle, c'est-à-dire une coupure autre que par des moyens d'ouverture, en satisfaisant à certaines exigences électriques sur au moins un pôle

Note 1 à l'article: Une **coupure électronique** garantit que, pour tous les **dispositifs de commande non sensibles**, la fonction contrôlée par la coupure est assurée et que, pour tous les **dispositifs de commande sensibles**, la fonction contrôlée est assurée entre les limites de la **grandeur de manœuvre** fixées dans l'exigence 30 du Tableau 1.

La coupure peut être obtenue par une **action automatique** ou par une **action manuelle**.

Quelques **dispositifs de commande** peuvent comporter des circuits de coupure ayant plus d'une configuration.

3.5 Définitions des différents types de dispositifs de commande en fonction de la construction

3.5.1
dispositif de commande intégré
dispositif de commande dont le bon fonctionnement dépend de son montage et de sa fixation corrects dans un matériel et qui ne peut être soumis à essai qu'en association avec les parties concernées du matériel

Note 1 à l'article: Un **dispositif de commande intégré** est également un **dispositif de commande** qui fait partie d'un **dispositif de commande** plus complexe (électrique ou non électrique).

3.5.2
dispositif de commande incorporé
dispositif de commande destiné à être monté dans ou sur un matériel, mais qui peut être soumis à essai séparément

Note 1 à l'article: Le fait qu'un **dispositif de commande incorporé** puisse être soumis à essai séparément n'implique pas qu'il ne peut être soumis à essai dans un matériel comme spécifié en 4.3.4.1.1.

Note 2 à l'article: Un **dispositif de commande incorporé** est également un **dispositif de commande** destiné à être incorporé dans ou sur un **dispositif de commande** plus complexe (électrique ou non électrique).

3.5.3
dispositif de commande intercalé dans un câble souple
dispositif de commande à boîtier séparé prévu pour être relié au matériel et à son alimentation au moyen de câbles souples, de socles ou de prises, et qui est prévu pour être manœuvré manuellement

Note 1 à l'article: Un fusible dans une prise n'est pas considéré comme faisant partie du **dispositif de commande**.

3.5.4
dispositif de commande séparé
dispositif de commande intercalé dans un câble souple qui est prévu pour être posé sur une table ou sur le sol

Note 1 à l'article: Il peut être actionné à la main, au pied ou de toute autre manière similaire par l'utilisateur.

3.5.5
dispositif de commande à montage indépendant
dispositif de commande prévu pour être relié en permanence à un **câblage fixe**, indépendamment du matériel commandé

Note 1 à l'article: Ce dispositif peut être:

– soit pour montage sur une surface, telle qu'une paroi;

– soit pour montage encastré, par exemple dans un évidement pratiqué dans une paroi, lorsque l'installation doit pouvoir se faire par l'avant;

– soit pour montage sur un panneau, par exemple sur un panneau de **commande** ou à l'intérieur de celui-ci, lorsque l'installation peut se faire par l'arrière.

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3.5.6
dispositif de commande à traction
dispositif de commande destiné à être monté sur ou dans un matériel et actionné par un **cordon de traction**

3.5.7
dispositif de commande électronique
dispositif de commande qui comporte au moins un **dispositif électronique**

3.5.8
dispositif électronique
dispositif dans lequel le passage d'un courant est dû principalement à un déplacement d'électrons dans le vide, dans un gaz, ou dans un semiconducteur

[SOURCE: IEC 60050-531:1974, 531-11-01]

3.5.9
ensemble électronique
groupe de composants, dont l'un au moins est un **dispositif électronique**, mais dans lequel des parties individuelles peuvent être remplacées sans endommager l'ensemble

Note 1 à l'article: Un exemple est constitué par un groupe de composants montés sur une carte de circuit imprimé.

3.5.10
circuit intégré
microstructure dans laquelle tous les éléments de circuit ou certains d'entre eux sont associés de façon inséparable et interconnectés électriquement de façon qu'elle soit considérée comme indivisible pour la construction et le commerce

[SOURCE: IEC 60050-521:2002, 521-10-03]

3.5.11
circuit hybride
circuit produit en substrat de céramique au moyen d'un film épais, film mince ou dispositif de montage en surface (SMD), sans connexion électrique accessible, excepté les points d'entrée/sortie, et avec toutes les connexions internes réalisées comme faisant partie de la structure directrice ou autre construction intégrée

3.5.12
manœuvre à deux positions
caractéristique séquentielle de deux mouvements distincts d'un **organe de manœuvre**

3.6 Définitions des types d'actions automatiques de dispositifs de commande

3.6.1
action de type 1
action automatique pour laquelle la **tolérance de fabrication** et la **dérive** de sa **valeur**, de son **temps** ou de sa **séquence de fonctionnement** n'ont pas été déclarées et soumises à essai suivant le présent document

3.6.2
action de type 2
action automatique pour laquelle la **tolérance de fabrication** et la **dérive** de sa **valeur**, de son **temps** ou de sa **séquence de fonctionnement** ont été déclarées et soumises à essai suivant le présent document

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3.7 Définitions concernant la protection contre les chocs électriques et le type d'isolation

3.7.1
partie active
conducteur ou partie conductrice prévue pour être mise sous tension en **usage normal**, comprenant le conducteur neutre mais, par convention, pas de conducteur PEN, PEM ou PEL

Note 1 à l'article: Les parties accessibles conformes à 6.1.1 ne sont pas considérées comme des **parties actives**.

Note 2 à l'article: Les définitions de conducteurs PEN, PEM et PEL se trouvent dans l'IEC 61140:2016.

3.7.2
partie active dangereuse
partie active qui peut provoquer, dans certaines conditions, un choc électrique nuisible

[SOURCE: IEC 60050-195:2021, 195-06-05, modifié – La Note 1 à l'article a été supprimée.]

3.7.3
dispositif de commande de la classe 0
dispositif de commande dans lequel la protection contre les chocs électriques repose sur l'**isolation principale**

Note 1 à l'article: Cela implique qu'aucune disposition n'est prévue pour le raccordement des parties conductrices accessibles, s'il y en a, à un **conducteur de protection** faisant partie du **câblage fixe** de l'installation, la protection en cas de **défaillance** de l'**isolation principale** reposant sur l'environnement.

Note 2 à l'article: Une borne de mise à la terre est admise uniquement pour assurer la continuité ou le fonctionnement électrique (en tant que fonctions distinctes de la protection).

3.7.4
dispositif de commande de la classe 0l
dispositif de commande intercalé dans un câble souple ayant au moins une **isolation principale** en toutes ses parties et comportant une borne de mise à la terre de protection, mais équipé d'un **câble souple fixé à demeure** sans conducteur de mise à la terre de protection et d'une fiche de prise de courant sans contact de mise à la terre de protection qui ne peut être introduite dans un socle ou une prise mobile avec contact de mise à la terre de protection

Note 1 à l'article: Une borne de mise à la terre est admise uniquement pour assurer la continuité (en tant que fonctions distinctes de la protection).

3.7.5
dispositif de commande de la classe I
dispositif de commande dans lequel la protection contre les chocs électriques ne repose pas uniquement sur l'**isolation principale**, mais dans lequel une mesure de sécurité supplémentaire a été prise sous forme de moyens de raccordement des parties conductrices accessibles à un conducteur de mise à la terre de protection faisant partie du **câblage fixe** de l'installation de manière telle que des parties conductrices accessibles ne puissent devenir dangereuses en cas de **défaillance** de l'**isolation principale**

Note 1 à l'article: Cette disposition comprend un **conducteur de protection** faisant partie du câble souple. Lorsque les **dispositifs de commande de la classe I** sont équipés d'un câble souple à deux conducteurs, à condition que ce câble soit équipé d'une fiche qui ne peut être introduite dans un socle avec contact de mise à la terre, la protection est équivalente à celle de la classe 0. Néanmoins, il convient que les dispositions en vue de la mise à la terre du matériel soient entièrement conformes, à tous autres égards, aux exigences de la classe I.

Note 2 à l'article: Les **dispositifs de commande** de la **classe I** peuvent avoir des parties à **double isolation**, ou des parties fournissant une protection contre les chocs électriques par l'utilisation de la **TBTS** ou de la **TBTP**.

3.7.6
dispositif de commande de la classe II
dispositif de commande dans lequel la protection contre les chocs électriques ne repose pas uniquement sur l'**isolation principale**, mais dans lequel ont été prises des mesures supplémentaires de sécurité, telles que la **double isolation** ou l'**isolation renforcée**, ces

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mesures ne comportant pas de moyen de mise à la terre de protection et ne dépendant pas des conditions d'installation

Note 1 à l'article: Ce **dispositif de commande** peut être de l'un des types définis de 3.7.6.1 à 3.7.6.3.

Note 2 à l'article: Les **dispositifs de commande de la classe II** peuvent avoir des parties fournissant une protection contre les chocs électriques par l'utilisation de la **TBTS**.

Note 3 à l'article: Les **dispositifs de commande de la classe II** ne peuvent pas avoir des parties fournissant une protection contre les chocs électriques par l'utilisation de la **TBTP**, de tels circuits exigeant un raccordement à une borne de mise à la terre.

3.7.6.1
dispositif de commande de la classe II à enveloppe isolante
dispositif de commande ayant une enveloppe durable et pratiquement continue en matériau isolant enfermant toutes les parties métalliques, à l'exception des petites parties, telles que plaques signalétiques, vis et rivets, qui sont séparées des **parties actives** par une isolation au moins équivalente à l'**isolation renforcée**

3.7.6.2
dispositif de commande de la classe II à enveloppe métallique
dispositif de commande ayant une enveloppe métallique pratiquement continue, dans lequel la **double isolation** est partout utilisée, à l'exception des parties utilisant une **isolation renforcée**, parce qu'une **double isolation** est manifestement irréalisable

3.7.6.3
dispositif de commande de la classe II à enveloppe isolante/enveloppe métallique
dispositif de commande qui est une combinaison des types décrits en 3.7.6.1 et 3.7.6.2

Note 1 à l'article: L'enveloppe d'un **dispositif de commande de la classe II** à enveloppe isolante peut faire partie ou constituer l'**isolation supplémentaire** ou **renforcée**. Un **dispositif de commande** à **double isolation** complète et/ou **isolation renforcée** complète qui comporte une borne ou un contact de mise à la terre est considéré comme étant de la classe 0I ou I.

3.7.7
dispositif de commande de la classe III
dispositif de commande reposant sur la limitation de la tension aux valeurs en 3.1.5 comme disposition contre les chocs électriques pour la protection principale et

- sans mesure pour la protection en cas de **panne**;
- qui, pour l'alimentation, est seulement raccordé à un **schéma TBTS** ou à un **schéma TBTP**, pour constituer une partie de ce **système**;
- dans lequel les circuits internes ne fonctionnent pas à un niveau supérieur à la **TBT**;
- dans lequel, en cas de première **panne** dans le **dispositif de commande**, aucune tension de contact permanente ne peut apparaître ou être générée à un niveau supérieur à la **TBT**; et
- sans moyen de raccordement pour un **conducteur de protection**

3.7.8
partie amovible
partie qui

- peut être ôtée ou ouverte sans l'aide d'un outil; ou
- peut être ôtée ou ouverte à l'aide d'un outil conformément à **l'usage normal** et aux consignes d'entretien par l'utilisateur telles que déclarées par le fabricant de dispositifs de commande; ou
- qui ne satisfait pas à l'essai de 9.11.1.3

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3.7.9
partie accessible ou surface accessible
toute partie ou surface qui peut être touchée avec le doigt d'épreuve de la Figure 5, lorsque le **dispositif de commande**, monté comme en **usage normal**, est débarrassé de toutes les **parties amovibles**

3.7.10 Définitions relatives au type d'isolation

NOTE Les abréviations utilisées de 3.7.10.1 à 3.7.10.5 ont les significations suivantes:

L **partie active**;
A **partie accessible** (surface conductrice ou isolante);
I partie intermédiaire.

3.7.10.1
isolation fonctionnelle
isolation entre des **parties actives** dont les potentiels sont différents et qui est nécessaire au bon **fonctionnement** du **dispositif de commande** ou du matériel commandé (L-L)

3.7.10.2
isolation principale
isolation des **parties actives**, destinée à assurer la protection principale contre les chocs électriques (L-A ou L-I)

Note 1 à l'article: L'**isolation principale** comprend l'isolation entre des **parties actives** et

– des parties conductrices intermédiaires ou une feuille métallique appliquée sur des surfaces isolantes intermédiaires (situation de la classe II);
– des parties conductrices accessibles (situations des classes 0, 0I, I);
– des parties conductrices raccordées à des parties conductrices accessibles (situations des classes 0, 0I ou I);
– une feuille métallique appliquée sur des surfaces isolantes accessibles (situation de la classe 0).

3.7.10.3
isolation supplémentaire
isolation indépendante prévue en plus de l'**isolation principale**, en vue d'assurer la protection contre les chocs électriques en cas de **défaillance** survenant dans l'**isolation principale** (I-A)

Note 1 à l'article: Cette isolation comprend l'isolation entre des parties conductrices intermédiaires ou une feuille métallique appliquée sur des surfaces isolantes intermédiaires et

– des parties conductrices accessibles (situation de la classe II);
– des parties conductrices raccordées à des parties conductrices accessibles (situation de la classe II);
– une feuille métallique appliquée sur des surfaces isolantes accessibles (situation de la classe II).

3.7.10.4
isolation renforcée
système d'isolation unique des **parties actives** assurant, dans les conditions spécifiées par le présent document, un degré de protection contre les chocs électriques équivalent à une **double isolation** (L-A)

Note 1 à l'article: Cette isolation comprend une isolation entre des **parties actives** et

– des parties conductrices accessibles;
– des parties conductrices raccordées à des parties conductrices accessibles;
– une feuille métallique appliquée sur des surfaces isolantes accessibles.

Note 2 à l'article: L'expression "système d'isolation" n'implique pas que l'isolation doit être homogène. Elle peut comprendre plusieurs couches qui ne peuvent pas être soumises à essai séparément comme une **isolation supplémentaire** ou une **isolation principale**.

3.7.10.5
double isolation
isolation comprenant à la fois une **isolation principale** et une **isolation supplémentaire** (L-I-A)

[SOURCE: IEC 60050-195:2021, 195-06-08]

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3.7.11
impédance de protection
impédance connectée entre les parties actives et les parties conductrices accessibles d'une valeur telle que le courant, en usage normal et dans les conditions probables de **panne** dans le matériel, est limité à une valeur de sécurité

3.7.12
liaison équipotentielle
ensemble de liaisons électriques pour réaliser l'équipotentialité entre parties conductrices

[SOURCE: IEC 60050-195:2021, 195-01-10]

3.7.12.1
liaison équipotentielle de protection
liaison équipotentielle réalisée à des fins de sécurité électrique

Note 1 à l'article: La **liaison équipotentielle** fonctionnelle est définie dans l'IEC 60050-195:2021, 195-01-16].

[SOURCE: IEC 60050-195:2021, 195-01-15, modifié – La Note 1 à l'article a été ajoutée.]

3.7.13
partie conductrice accessible
masse <dans une installation>
partie conductrice d'un matériel, susceptible d'être touchée, et qui n'est pas sous tension dans des conditions normales, mais peut le devenir lorsque l'**isolation principale** est défaillante

Note 1 à l'article: Une partie conductrice d'un **dispositif de commande** pouvant devenir sous tension uniquement en cas de contact avec une **partie conductrice accessible** n'est pas considérée elle-même comme étant une **masse**.

[SOURCE: IEC 60050-195:2021, 195-06-10, modifié – La Note 1 à l'article a été ajoutée.]

3.7.14
écran conducteur
écran en matériau conducteur destiné à réduire la pénétration d'un champ électrique

[SOURCE: IEC 60050-195:2021, 195-02-38]

3.7.15
écran de protection, <électrique>
écran conducteur utilisé pour séparer un circuit électrique et/ou des conducteurs des parties actives dangereuses

[SOURCE: IEC 60050-195:2021, 195-06-17]

3.7.16
protection par écran, <électrique>
séparation de circuits électriques et/ou de conducteurs par rapport aux **parties actives dangereuses** par un **écran de protection électrique** relié au **réseau équipotentiel de protection** et destiné à fournir une protection contre les chocs électriques

[SOURCE: IEC 60050-195:2021, 195-06-18]

3.7.17
séparation simple
séparation entre circuits électriques ou entre un circuit électrique et la terre de protection par une **isolation principale**

[SOURCE: IEC 60050-826:2004, 826-12-28, modifié en remplaçant "locale" par "de protection".]

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3.7.18
séparation de protection, <électrique>
séparation entre deux circuits électriques au moyen d'une protection principale et d'une protection en cas de défaut

[SOURCE: IEC 60050-195:2021, 195-06-19]

3.7.19
mise à la terre de protection
action de mettre à la terre à des fins de sécurité électrique

[SOURCE: IEC 60050-195:2021, 195-01-11]

3.7.20
mise à la terre fonctionnelle
action de mettre à la terre pour des raisons autres que la sécurité électrique

[SOURCE: IEC 60050-195:2021, 195-01-13]

3.8 Définitions concernant les éléments constituants des dispositifs de commande

3.8.1
élément sensible
partie d'un **dispositif de commande** qui est destinée à être exposée à l'influence de la **grandeur de manœuvre** à laquelle répond l'**action automatique** d'un **dispositif de commande sensible**

3.8.2
tête de commande
ensemble du **dispositif de commande**, à l'exception de tout **élément sensible**

Note 1 à l'article: Si la construction du dispositif ne permet pas de faire une telle distinction entre **élément sensible** et **tête de commande**, c'est l'ensemble du **dispositif** qui est appelé **élément sensible**.

3.8.3
organe de manœuvre
partie qui est déplacée manuellement, en la tirant, en la poussant ou en la retournant, pour provoquer la **mise en marche** du **dispositif de commande** ou pour le **réglage par l'utilisateur**

Note 1 à l'article: Est exclu de cette définition, tout moyen, tel qu'une vis pointeau, permettant le **réglage par le fabricant du dispositif de commande** si ce moyen est convenablement immobilisé dans sa position initiale ou s'il exige un **outil** pour le **réglage par le fabricant de dispositifs**.

3.8.4
liaison de manœuvre
tout élément qui relie l'**organe de manœuvre** au mécanisme du **dispositif de commande**

3.8.5
cordon de traction
organe de manœuvre souple sur lequel une traction est exercée pour faire une **manœuvre**

3.8.6
moteur primaire
tout dispositif fournissant l'énergie mécanique exigée pour la **transmission** pour un **dispositif de commande automatique**, tel qu'un **dispositif de commande à fonctionnement électrique**, une **électrovanne**, un **mécanisme à fonctionnement électrique** ou un **dispositif de commande à base de temps**

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Note 1 à l'article: Ce peut être un mécanisme à accumulation d'énergie (tel qu'un moteur à ressort), un dispositif électromagnétique (tel qu'un moteur électrique, un électro-aimant pas à pas), un dispositif électrothermique (tel que l'élément chauffant d'un **régulateur d'énergie**), ou toute autre source d'énergie mécanique.

3.8.7
liaison sélective
dispositif mécanique grâce auquel l'**organe de manœuvre** peut avoir une action prioritaire par rapport à celle du **moteur primaire** ou de la **grandeur de manœuvre**, pour provoquer ou autoriser la **mise en marche** ou l'annulation d'une action

3.8.8
couvercle
capot
partie accessible lorsque le **dispositif de commande** est monté comme en **usage normal** et qui ne peut être enlevée qu'à l'aide d'un **outil**

Note 1 à l'article: L'enlèvement de cette partie ne doit cependant pas exiger d'**outil spécial**.

3.8.9
partie (ou élément) à fixation sans vis
partie (ou élément) accessible qui, après fixation, installation, montage ou assemblage dans ou sur un matériel ou autre élément, ou encore sur un support spécialement préparé, est maintenu en place par des moyens directs qui ne dépendent pas de vis

Note 1 à l'article: Le démontage ou enlèvement peut exiger un **outil**, utilisé directement sur la partie (ou élément), ou encore utilisé pour accéder au moyen de retenue.

Note 2 à l'article: Ne sont pas considérés comme **parties (ou éléments) à fixation sans vis**:

– des parties d'éléments fixées en permanence par rivets, collage ou moyens analogues;
– les connecteurs à languette;
– les **bornes sans vis**;
– les fiches et prises de courant normales;
– les socles de connecteur normaux, même si ces socles comportent des dispositifs à loquet supplémentaires destinés à empêcher un débranchement à action unique;
– le remplacement d'une lampe à douille à baïonnette;
– la construction à cosse tournante;
– la construction à fixation par frottement.

3.9 Définitions concernant les différents types de bornes et connexions utilisées dans les dispositifs de commande

3.9.1
borne à trou
borne comportant un trou ou une cavité destinés à recevoir un conducteur qui est ensuite bloqué sous la pointe d'une ou plusieurs vis

Note 1 à l'article: La pression de serrage peut être appliquée soit directement par la vis, soit par l'intermédiaire d'une pièce de serrage qui transmet la pression de la vis (voir Figure 12).

3.9.2
borne à serrage sous tête de vis
borne dans laquelle l'âme d'un conducteur est serrée sous la tête de la vis

Note 1 à l'article: La pression de serrage peut être appliquée soit directement par la tête de la vis, soit par l'intermédiaire d'une pièce telle qu'une rondelle, une plaquette ou un dispositif évitant l'effilochage du conducteur (voir Figure 11).

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3.9.3
borne à goujon fileté
borne dans laquelle le conducteur est serré sous un écrou

Note 1 à l'article: La pression de serrage peut être appliquée soit directement par un écrou de forme appropriée, soit par l'intermédiaire d'une pièce telle qu'une rondelle, une plaquette ou un dispositif évitant l'effilochage du conducteur (voir Figure 11).

3.9.4
borne sans vis
borne dans laquelle le conducteur est bloqué directement ou indirectement par des éléments de serrage tels que des ressorts, des coins, des excentriques, des cônes ou équivalent

Note 1 à l'article: Ne sont pas considérées comme des **bornes sans vis**:

– les bornes nécessitant la pose préalable de dispositifs spéciaux sur les conducteurs, par exemple les **connecteurs à languette**;
– les bornes exigeant l'enroulement du conducteur (wrapping), par exemple celles avec des joints enroulés;
– les bornes assurant un contact direct avec les conducteurs au moyen d'arêtes ou de pointes destinées à percer l'isolation.

3.9.5
connecteur à languette
assemblage d'une **languette** et d'un **réceptacle** permettant de relier à volonté une âme conductrice ou un conducteur à un **dispositif de commande**, à une autre âme ou à un autre conducteur

3.9.6
réceptacle
partie femelle d'un **connecteur à languette** destinée à être fixée en permanence sur une âme conductrice ou un conducteur (voir Figure 17)

3.9.7
languette
partie mâle d'un **connecteur à languette** (voir Figure 15 et Figure 16)

3.9.8
languette inamovible
languette fixée de manière permanente sur une âme conductrice ou sur un conducteur

3.9.9
languette fixe
languette fixée de manière permanente sur un **dispositif de commande** ou en faisant partie intégrante

3.9.10
connexion
pièce permettant la connexion d'un conducteur à un **dispositif de commande** de telle manière que son remplacement exige un **outil spécial**, un procédé spécial ou une préparation spéciale de l'extrémité d'un conducteur

Note 1 à l'article: Le soudage à l'étain exige un **outil spécial**. Le soudage électrique exige un procédé spécial. La pose d'une cosse sur l'extrémité d'un conducteur est considérée comme une préparation spéciale.

3.9.11
connexion soudée
connexion dans laquelle le conducteur est fixé mécaniquement et la continuité électrique est assurée par une soudure

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3.9.12
borne à plaquette
borne dans laquelle l'âme d'un conducteur est serrée sous une plaquette au moyen de deux ou plusieurs vis ou écrous (voir Figure 14a)

3.9.13
borne pour cosses et barrettes
borne à serrage sous tête de vis ou **borne à goujon fileté**, prévue pour le serrage d'une cosse ou d'une barrette au moyen d'une vis ou d'un écrou (voir Figure 14b)

3.9.14
borne à capot taraudé
borne dans laquelle l'âme d'un conducteur est serrée au moyen d'un écrou contre le fond d'une fente pratiquée dans un goujon fileté

Note 1 à l'article: L'âme est serrée contre le fond de la fente par une rondelle de forme appropriée placée sous l'écrou, par un téton central si l'écrou est un capot taraudé, ou par d'autres moyens aussi efficaces pour transmettre la pression de l'écrou à l'âme à l'intérieur de la fente (voir Figure 13).

3.9.15
borne d'équipotentialité de protection
borne destinée à des fins de **liaison équipotentielle de protection**

Note 1 à l'article: Par exemple un **écran de protection** ou une borne **PE** d'un **dispositif de commande** ou d'un matériel.

3.9.16
conducteur de protection
PE
conducteur prévu à des fins de sécurité électrique

[SOURCE: IEC 60050-195:2021, 195-02-09]

3.10 Définitions concernant les modes de connexion aux dispositifs de commande

3.10.1
conducteur externe
câble, cordon souple, âme conductrice ou conducteur dont une partie sort d'un **dispositif de commande intercalé dans un câble souple**, d'un **dispositif de commande à montage indépendant** ou d'un matériel dans ou sur lequel un **dispositif de commande** est monté

Note 1 à l'article: Un tel conducteur peut soit être un câble d'alimentation, un câble fonctionnel ou un cordon de raccordement entre différentes parties d'un appareil, soit constituer une partie du **câblage fixe** d'un matériel.

3.10.2
câblage fixe
tout **conducteur externe** qui est fixé de manière permanente à la structure d'un bâtiment de manière telle qu'en **usage normal** il y ait peu de chances qu'un effort quelconque soit appliqué au conducteur à son point de fixation au matériel ou au **dispositif de commande**

Note 1 à l'article: Une telle fixation à la structure du bâtiment peut se faire, par exemple, soit en enfermant les conducteurs dans un conduit, soit en enterrant des câbles dans les murs, soit en fixant de façon appropriée les câbles aux murs ou autres surfaces, etc.

3.10.3
conducteur interne
câble souple, âme conductrice ou conducteur qui n'est ni **conducteur externe** ni **conducteur intégré**

Note 1 à l'article: Un exemple est un conducteur à l'intérieur du matériel pour interconnecter le **dispositif de commande** et le matériel.

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3.10.4
conducteur intégré
conducteur qui se trouve à l'intérieur d'un **dispositif de commande**, ou qui est utilisé pour le raccordement permanent des bornes ou des **connexions** d'un **dispositif de commande**

3.10.5
câble souple non fixé à demeure
conducteur externe souple qui est relié à un **dispositif de commande** ou à un matériel par l'intermédiaire d'un connecteur, un socle ou une prise mobile

3.10.6
câble souple fixé à demeure
conducteur externe souple relié à ou monté sur un **dispositif de commande** par l'une des méthodes de 3.10.6.1 à 3.10.6.4

3.10.6.1
fixation de type X
moyen de fixation tel que le câble souple puisse être facilement remplacé sans l'aide d'**outils spéciaux** par des câbles normaux sans préparation spéciale

3.10.6.2
fixation de type M
moyen de fixation tel que le câble puisse être facilement remplacé sans l'aide d'**outils spéciaux**, mais destiné à être utilisé uniquement avec un câble spécial, tel qu'un câble qui comporte une protection surmoulée ou des extrémités spécialement préparées

Note 1 à l'article: Ce moyen de fixation ne s'applique pas si le câble peut être remplacé par un câble normal au cours des opérations d'**entretien**, à moins que la norme particulière du matériel ne le permette.

3.10.6.3
fixation de type Y
moyen de fixation du câble souple d'alimentation tel que tout remplacement soit prévu pour être réalisé par le fabricant, ses représentants pour l'entretien ou une personne qualifiée similaire

3.10.6.4
fixation de type Z
moyen de fixation tel que le câble souple ne puisse être remplacé sans bris ou destruction d'une partie du **dispositif de commande**

3.10.7
pile primaire
cellule
tout type de **cellule** électrochimique dans lequel la réaction électrochimique étudiée n'est pas réversible

Note 1 à l'article: Un exemple est une pile alcaline.

3.10.8
pile secondaire
cellule rechargeable
tout type de **cellule** électrochimique dans lequel la réaction électrochimique étudiée est réversible

Note 1 à l'article: Une pile rechargeable est un groupe de deux **cellules secondaires** ou plus.

Note 2 à l'article: Des exemples de piles rechargeables sont les piles à hydrure métallique de nickel (NiMH), au ion-lithium (Li-ion), etc.

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3.11 Définitions concernant le fonctionnement des dispositifs à action de type 2

3.11.1
tolérance de fabrication
différence maximale entre les mesures de la **valeur**, du **temps** ou de la **séquence de fonctionnement** indiquée pour deux **dispositifs de commande** quelconques fournis par le fabricant sous la même **référence unique de type** et soumis aux mêmes essais

Note 1 à l'article: La différence peut être rapportée à une valeur absolue si le paragraphe approprié de l'Article 17 l'autorise.

3.11.2
dérive
variation maximale de la **valeur**, du **temps** ou de la **séquence de fonctionnement** d'un échantillon quelconque, susceptible de se produire au cours des essais conformes aux conditions décrites dans le présent document

Note 1 à l'article: Cette variation peut être rapportée à une valeur absolue ou combinée à la **tolérance de fabrication** si le paragraphe approprié de l'Article 17 l'autorise.

3.12 Définitions concernant les exigences des lignes de fuite et distances dans l'air

3.12.1
distance dans l'air
plus courte distance dans l'air entre deux parties conductrices ou entre une partie conductrice et une feuille métallique appliquée contre une surface en matériau isolant

Note 1 à l'article: La méthode de mesure est détaillée à l'Annexe B et à la Figure 18.

3.12.2
ligne de fuite
plus court chemin le long d'une surface de matériau isolant entre deux parties conductrices, ou entre une partie conductrice et une feuille métallique appliquée sur toute **surface accessible** en matériau isolant

Note 1 à l'article: La méthode de mesure est détaillée à l'Annexe B et à la Figure 18.

3.12.3
pollution
toute addition de matière étrangère, solide, liquide ou gazeuse pouvant entraîner la réduction de la rigidité diélectrique ou de la résistivité surfacique de l'isolation

3.12.4 Définitions relatives à l'environnement

3.12.4.1
macroenvironnement
environnement de la pièce ou de tout autre lieu dans lequel le matériel est installé ou utilisé

3.12.4.2
microenvironnement
environnement immédiat de l'isolation qui influence en particulier le dimensionnement des distances dans l'air et des **lignes de fuite**

3.12.4.3
degré de pollution
chiffre caractérisant la **pollution** attendue du **microenvironnement**

Note 1 à l'article: Les **degrés de pollution** 1, 2, 3 et 4 sont utilisés. Voir Annexe F.

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3.13 Définitions diverses

3.13.1
référence unique de type
code marqué sur le **dispositif de commande** qu'il identifie de manière non équivoque et qui permet de commander au fabricant un dispositif de rechange parfaitement interchangeable avec le premier du point de vue électrique, mécanique, des dimensions et des fonctions

3.13.2
outil
tournevis, pièce de monnaie ou tout autre objet permettant de tourner un écrou, une vis ou un élément analogue

3.13.3
outil spécial
outil qui ne se trouve pas normalement dans une maison, tel qu'une clé six pans

Note 1 à l'article: Les **outils** tels que les pièces de monnaie, les tournevis et les clés plates prévus pour tourner des écrous carrés, six pans, etc., ne sont pas considérés comme des **outils spéciaux**.

3.13.4
usage normal
emploi du **dispositif de commande** ou du matériel auquel il est associé aux fins prévues et conformément aux instructions de son fabricant

Note 1 à l'article: L'**usage normal** englobe des conditions de surcharge ou de fonctionnement anormal prévues dans la norme particulière du matériel.

Note 2 à l'article: En revanche, l'**usage normal** exclut des opérations éventuellement nécessaires pour maintenir le **dispositif de commande** ou le matériel en ordre de marche, même si ces opérations d'entretien sont exécutées par l'**utilisateur** conformément aux instructions du fabricant.

Note 3 à l'article: L'**usage normal** peut inclure le mode de veille et un ou plusieurs modes de fonctionnement.

3.13.5
entretien par l'utilisateur ou maintenance par l'utilisateur
opérations périodiques nécessaires pour maintenir le **dispositif de commande**, ou le matériel, en ordre de marche, lesquelles sont détaillées dans les instructions du fabricant à l'**utilisateur**

3.13.6
entretien
opérations nécessaires pour maintenir le **dispositif de commande**, ou le matériel, en ordre de marche, qui seraient confiées à une personne compétente, dans un atelier, par un électricien ou par un organisme de service

Note 1 à l'article: Cela comprend le remplacement d'un câble souple, d'un coupe-circuit thermique, etc.

3.13.7
entretien ou réparation par le fabricant
opérations d'**entretien** qui ne peuvent être exécutées que par le fabricant ou par ses représentants agréés

Note 1 à l'article: Ces opérations peuvent nécessiter des **outils spéciaux** et couvrent le **réglage par le fabricant du dispositif de commande**.

3.13.8
défaillance
cessation de l'aptitude d'un dispositif à accomplir une fonction requise

[SOURCE: IEC 60050-603:1986, 603-05-06]

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3.13.9
panne
défaut
dérangement (en télécommunication)
état d'une entité inapte à accomplir une fonction exigée, non comprise l'inaptitude due à la maintenance préventive ou à d'autres actions programmées ou due à un manque de moyens extérieurs

Note 1 à l'article: Une "**défaillance**" est un passage d'un état à un autre, par opposition à une "**panne**", qui est un état.

Note 2 à l'article: Après **défaillance** d'une entité, cette entité est en état de **panne**.

Note 3 à l'article: Cette notion, telle qu'elle est définie, ne s'applique pas à une entité constituée seulement de logiciels.

Note 4 à l'article: Une **panne** est souvent la conséquence d'une **défaillance** de l'entité elle-même, mais elle peut exister sans **défaillance** préalable.

3.13.10
réseau intelligent
réseau d'énergie électrique qui utilise les technologies d'échange d'information et de **commande**, l'informatique distribuée et les capteurs et actionneurs associés, pour des objectifs tels que:

– intégrer le comportement et les actions des **utilisateurs** du réseau et des autres parties prenantes,
– fournir efficacement une alimentation en électricité durable, économique et sûre

[SOURCE: IEC 60050-617:2009+AMD1:2011, 617-04-13]

3.13.11
dispositif de commande activé intelligent
dispositif de commande qui intègre ou utilise une ou plusieurs des fonctionnalités suivantes:

– réponse à la puissance appelée par le réseau intelligent,
– signaux de demande provenant de matériel consommant de l'énergie,
– technologies de communication IdO,
– analyse de données,
– fonctions de commande pour optimiser l'efficacité énergétique et satisfaire aux exigences opérationnelles

Note 1 à l'article: Par exemple, dispositif de commande de réseau électrique intelligent, interfaces à distance/dispositif de commande de matériel consommant de l'énergie, y compris les ordinateurs ou smartphones.

3.13.12
tracé intentionnellement fragile
tracé d'une carte de circuit imprimé destiné à se rompre dans des conditions de fonctionnement anormal afin d'empêcher l'apparition d'une condition qui pourrait compromettre la conformité au présent document

Note 1 à l'article: Voir 9.1.4.

3.14 Définitions concernant le fabricant et l'utilisateur

3.14.1
fabricant de dispositifs de commande
fabricant du **dispositif de commande**

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3.14.2
fabricant de matériel
fabricant de matériel dans lequel, sur lequel ou avec lequel le **dispositif de commande** est utilisé

3.14.3
installateur
personne qualifiée pour installer le **dispositif de commande** et peut-être le matériel associé

3.14.4
utilisateur
personne qui utilise le **dispositif de commande** à l'aide de la documentation (**entretien par l'utilisateur**) pendant sa durée normale

Note 1 à l'article: L'**utilisateur** est considéré comme une personne inexpérimentée.

3.15 Définitions en rapport avec les thermistances

Voir J.3.15.

3.16 Définitions relatives à la structure des dispositifs de commande utilisant des logiciels

Voir H.3.16.

3.17 Définitions relatives à l'absence d'erreur pour les dispositifs de commande utilisant des logiciels

Voir H.3.17.

3.18 Définitions relatives aux techniques de commande de panne/erreur des dispositifs de commande utilisant des logiciels

Voir H.3.18.

3.19 Définitions relatives aux essais de mémoire des dispositifs de commande utilisant des logiciels

Voir H.3.19.

3.20 Définitions de la terminologie des logiciels – Généralités

Voir H.3.20.

3.21 Définitions relatives aux classes de fonctions de commande

Voir H.3.21.

3.22 Définitions relatives à la sécurité fonctionnelle

Voir H.3.22.

3.23 Définitions relatives à l'accès à l'échange de données

Voir H.3.23.

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3.24 Définitions relatives aux performances CEM

3.24.1
accès
interface particulière du matériel qui couple ce matériel avec ou est influencée par l'environnement électromagnétique extérieur

Note 1 à l'article: Voir Figure 1.

Note 2 à l'article: Les accès E/S sont des accès d'entrée, de sortie ou bidirectionnels, de mesure, de contrôle ou de données.

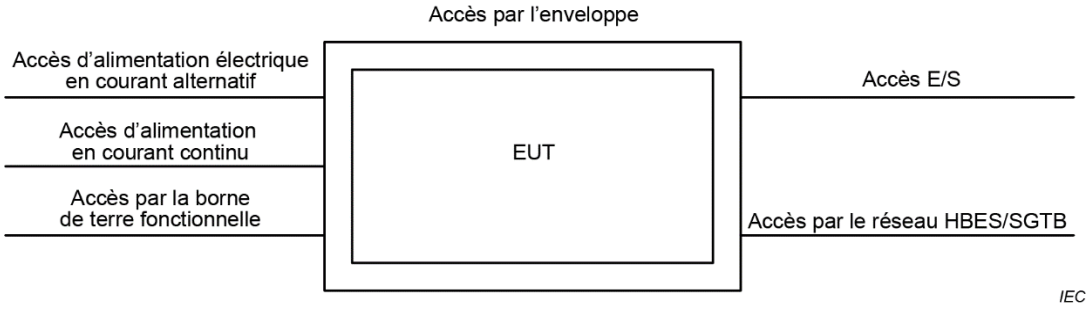


Figure 1 – Exemple d'accès

[SOURCE: IEC 61000-6-1:2016, 3.1, modifié − La Note 1 à l'article et sa Figure 1 ont été modifiées.]

3.24.2
accès par l'enveloppe
frontière physique du matériel à travers laquelle des champs électromagnétiques peuvent rayonner ou à laquelle ils peuvent se heurter

[SOURCE: IEC 61000-6-1:2016, 3.2, modifié − Cette modification ne concerne que la version anglaise.]

3.24.3
accès E/S
accès auquel un conducteur ou un câble destiné à transporter des signaux est connecté à l'équipement

EXEMPLE Entrées, sorties et lignes de commande analogiques/numériques, bus de données, réseaux de communication autres que les réseaux HBES/SGTB (3.24.10), etc.

[SOURCE: IEC 61000-6-1:2016, 3.3, modifié – Le terme "accès signal/commande" a été modifié en "accès E/S" et un exemple a été ajouté avec des entrées/sorties numériques et l'exclusion des réseaux HBES/SGTB.]

3.24.4
accès d'alimentation en courant continu
accès utilisé pour le raccordement à un **système** de production d'énergie en courant continu basse tension, à un système de stockage d'énergie ou à un réseau de distribution en courant continu pour alimenter l'appareil

[SOURCE: IEC 61000-6-3:2020, 3.1.13, modifié – La Note 1 à l'article a été supprimée.]

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3.24.5
réseau de distribution en courant continu
réseau d'alimentation électrique local en courant continu dans l'infrastructure d'un site ou d'un bâtiment donné destiné à une utilisation flexible par un ou plusieurs types d'équipements et assurant une alimentation continue indépendamment des conditions du réseau public d'alimentation

Note 1 à l'article: La connexion à une batterie locale distante n'est pas considérée comme un réseau de distribution en courant continu, si une telle liaison ne comprend que l'alimentation pour un seul équipement.

[SOURCE: IEC 61000-6-1:2016, 3.10]

3.24.6
EUT
matériel soumis à essai

Note à l'article: L'abréviation "EUT" est dérivée du terme anglais développé correspondant "Equipment Under Test".

3.24.7
environnement électromagnétique résidentiel
environnement électromagnétique d'un site, y compris des sites commerciaux, publics et de l'industrie légère, où il existe un niveau d'interférence électromagnétique normalement attendu dans les maisons, les boutiques et les locaux professionnels, les cinémas, les centres sportifs, les ateliers et les laboratoires, par exemple

EXEMPLE 1 Les emplacements résidentiels sont notamment: les maisons, appartements, bâtiments agricoles utilisés à des fins d'hébergement.

EXEMPLE 2 Les emplacements commerciaux, publics ou d'industrie légère sont notamment:

- les points de vente au détail, par exemple les boutiques, supermarchés;
- les locaux commerciaux, par exemple les bureaux, banques, centres de données;
- les zones de divertissement public, par exemple les cinémas, bars publics, salles de danse;
- les lieux de culte;
- les lieux publics, par exemple les parcs, installations de loisir, bureaux publics;
- les hôpitaux, les établissements d'enseignement, par exemple les écoles, universités, facultés;
- les voies publiques, les stations ferroviaires et les zones publiques d'un aéroport;
- les emplacements d'industrie légère, par exemple les ateliers, laboratoires, centres de services.

3.24.8
environnement électromagnétique industriel
site où l'ensemble des phénomènes électromagnétiques est caractérisé par un réseau d'alimentation séparé, alimenté par un transformateur haute ou moyenne tension et dédié à l'alimentation de l'installation

EXEMPLE Installations sidérurgiques, de transformation des pâtes et papiers, chimiques, de construction automobile, agricoles et les zones haute tension des aéroports.

Note 1 à l'article: Les sites industriels peuvent généralement être décrits par l'existence d'une installation avec une ou plusieurs des caractéristiques suivantes:

– éléments d'équipements installés et connectés ensemble et fonctionnant en même temps;
– quantité significative de puissance électrique générée, transmise et/ou consommée;
– commutations fréquentes de fortes charges inductives ou capacitives;
– courants élevés et champs magnétiques associés;
– présence d'équipements industriels, scientifiques ou médicaux (ISM) (par exemple, machines de soudage).

L'environnement électromagnétique d'un site industriel est principalement produit par les équipements et les installations qui se trouvent sur le site. Il existe certains types d'installations industrielles, dans lesquels une partie des phénomènes électromagnétiques peut avoir un niveau plus élevé que dans d'autres installations.

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Note 2 à l'article: L'environnement électromagnétique dépend en général du temps et sa description peut exiger une approche statistique.

Note 3 à l'article: Il est très important de ne pas confondre l'environnement électromagnétique avec le site lui-même.

[SOURCE: IEC 61000-6-2:2016, 3.7 et 3.8 combinés et modifiés en une seule définition]

3.24.9
ligne de grande longueur
ligne qui à l'intérieur d'un bâtiment est d'une longueur supérieure à 30 m, ou qui sort du bâtiment (y compris une ligne installée à l'extérieur)

[SOURCE: IEC 61000-6-1:2016, 3.6, modifié – Définition étendue à toutes les lignes et pas uniquement aux lignes raccordées à un accès signal/commande]

3.24.10
accès par le réseau HBES/SGTB
accès auquel un conducteur ou câble destiné à transporter des signaux de communication entre les différents dispositifs du réseau HBES/SGTB est connecté à l'appareil

Note 1 à l'article: Pour les besoins de l'essai, l'accès par le réseau HBES/SGTB est équivalent à l'accès de télécommunication/réseau conformément à l'IEC 61000-6-3.

Note 2 à l'article: HBES signifie Home and Building Electronic Systems (Systèmes Electroniques pour les Foyers Domestiques et les Bâtiments), et SGTB signifie Systèmes de Gestion Technique du Bâtiment.

[SOURCE: IEC 63044-5-1:2017, 3.1.5, modifié – La Note 2 à l'article a été ajoutée.]

4 Généralités

4.1 Structure générale du document

Les articles du présent document sont regroupés en deux sections d'exigences, dans lesquelles

- la première section comprend les Articles 5 à 13 qui, en général, traitent de la construction du produit. Il est à noter que certaines exigences de construction ont des exigences de vérification intégrées dans l'article pour faciliter l'utilisation du document;
- la deuxième section se compose des Articles 14 à 26 qui traitent des exigences de vérification.

NOTE Pour une explication du mot "vérification", voir IEC 60050-192:2015,192-01-17.

La structure ci-dessus s'applique également à l'Annexe I et à l'Annexe J.

Les exigences du présent document ont été structurées sur la base de deux principes de sécurité de base: la sécurité intrinsèque et la sécurité fonctionnelle.

La sécurité intrinsèque est liée au risque potentiel de choc électrique, d'incendie et de blessures corporelles qui existe dans la conception du dispositif de commande, en fonctionnement normal et anormal du dispositif de commande et indépendamment de toute déclaration concernant les fonctions de sortie. Tous les dispositifs de commande, indépendamment de leur classification, doivent être conformes aux exigences de sécurité intrinsèque.

Les exigences relatives à la sécurité intrinsèque de tous les produits couverts par le domaine d'application du présent document se trouvent dans le corps principal du document.

La sécurité fonctionnelle est liée au bon fonctionnement de la ou des fonctions de sécurité déclarées, dont la défaillance ou le dysfonctionnement peut entraîner un danger. Le danger peut résulter d'une perte de la fonction de protection (fonction de sortie) entraînant un risque

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d'explosion, de température excessive, de choc électrique, d'incendie et/ou de blessures corporelles, etc. Les exigences de sécurité fonctionnelle, qui sont pertinentes pour un dispositif de commande, dépendent de la classification de la fonction de sortie.

Les exigences relatives à la sécurité fonctionnelle sont spécifiées dans l'Annexe H du présent document et doivent être utilisées conjointement avec les exigences de la partie principale, le cas échéant. Certaines exigences étant applicables à la fois pour la sécurité intrinsèque et la sécurité fonctionnelle, l'emplacement de ces exigences a été choisi suivant le cas. Par exemple, le Tableau 14 représente les modes de **panne** des composants électroniques utilisés pour l'évaluation des **pannes**.

Une représentation graphique de la structure du document et des exigences applicables est fournie à la Figure 2:

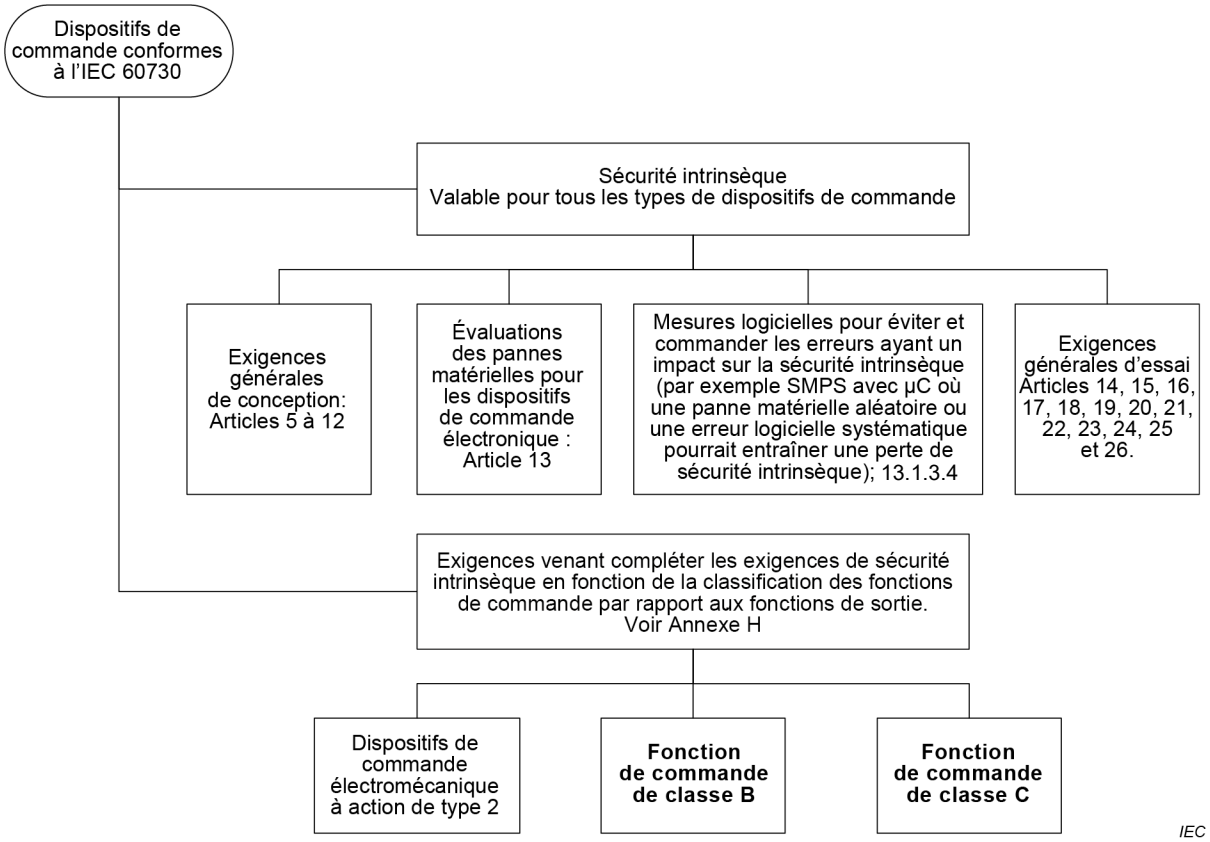


Figure 2 – Structure du document concernant la sécurité intrinsèque et la sécurité fonctionnelle

4.2 Exigences générales

Les **dispositifs de commande** doivent être conçus et construits de façon telle qu'en **usage normal** ils fonctionnent sans provoquer de blessure aux personnes ou de dommage au matériel environnant, même en cas d'utilisation sans précaution pouvant se produire en **usage normal**.

La conformité est vérifiée, en général, en effectuant les essais spécifiés applicables du présent document et de la Partie 2 appropriée, le cas échéant.

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4.3 Généralités sur les essais

4.3.1 Généralités

Les essais mentionnés dans le présent document sont des essais de type.

NOTE Si les résultats de l'un des essais spécifiés peuvent être déterminés sans aucun doute par évaluation, alors le ou les essais peuvent ne pas être réalisés.

4.3.2 Conditions d'essai

4.3.2.1 Sauf spécification contraire dans le présent document, les essais sont effectués sur des échantillons en état de livraison et montés dans la position spécifiée par le fabricant mais, s'il y a lieu, dans la position de montage la plus défavorable.

4.3.2.2 Si la température ambiante est susceptible d'influencer les résultats des essais, elle doit être maintenue à (20 ± 5) °C, sauf en cas de doute, où elle doit être maintenue à (23 ± 2) °C, sauf spécification contraire dans un article particulier.

4.3.2.3 Les **organes de manœuvre** sont placés dans leur position la plus défavorable, qu'elle soit **repérée**, **intermédiaire** ou **de réglage par l'utilisateur**, à moins que d'autres instructions ne figurent dans un article particulier.

4.3.2.4 Sauf spécification contraire dans le présent document ou si cela ressort clairement de la construction du dispositif de commande (pour les **dispositifs de commande électronique** généralement), les essais sont effectués dans l'ordre des articles du présent document.

*Pour les **dispositifs de commande électronique**, les essais des Articles 24.1, 25 et 13.1 sont effectués avant les essais de l'Article 21.*

4.3.2.5 Pendant les essais du présent document, la manœuvre est effectuée, si besoin est, par le matériel d'essai, à l'exception des essais à grande vitesse de 19.12.

4.3.2.6 Pendant et pour les besoins des essais du présent document, autres que les essais de 19.12, la liaison de manœuvre peut être utilisée pour actionner le dispositif de commande si l'organe de manœuvre n'est pas livré par le fabricant.

4.3.2.7 Les taux de variation de la température déclarés en 5.2 et utilisés dans l'Article 19 (soit α_1, β_1, α_2 et β_2) doivent avoir des tolérances d'essai de ±12 K/h.

Pour d'autres grandeurs de manœuvre, les taux minimaux et maximaux de variation déclarés dans le Tableau 1, exigence 31 et utilisés à l'Article 19 (soit α_1, β_1, α_2 et β_2) doivent avoir des tolérances d'essai telles que spécifiées dans la Partie 2 appropriée.

4.3.2.8 Pour tous les essais, les instruments de mesure ou les moyens de mesure utilisés doivent être choisis de manière à ne pas affecter de façon sensible les valeurs mesurées.

NOTE Les principes d'incertitude des mesures peuvent être consultés dans diverses sources (par exemple, dans l'IECEE OD-5014).

4.3.3 Échantillons exigés

4.3.3.1 Sauf indication contraire, un seul échantillon est soumis aux essais des Articles 6 à 26, incluant les annexes relatives. Pour les dispositifs de commande électronique, un échantillon doit être utilisé pour la vérification des Articles 5 à 13 et un autre échantillon pour les Articles 14 à 26, tandis que pour les **dispositifs de commande électronique**, des échantillons différents peuvent être utilisés, sauf si des essais sont exigés sur le même échantillon.

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Si l'échantillon ne satisfait pas à un ou plusieurs des essais, la cause de la non-conformité doit être identifiée et des mesures correctives doivent être prises. L'essai qui a causé la non-conformité et tous ceux qui l'ont précédé qui pourraient avoir eu une influence sur le résultat de l'essai sont répétés sur deux autres jeux d'échantillons identiques qui doivent alors tous satisfaire à ces essais. De même, tous les essais pour lesquels l'action corrective a une influence sur le résultat initial de l'essai doivent être réitérés.

4.3.3.2 Pour certains essais destructifs du présent document, des échantillons supplémentaires peuvent être exigés.

4.3.3.3 Les dispositifs de commande qui sont prévus pour satisfaire aux exigences de plusieurs Parties 2 doivent, en général, subir les essais de chaque Partie 2 séparément.

NOTE Par un accord entre le fabricant et le laboratoire, les exigences et essais communs à plusieurs Parties 2 ne sont vérifiés qu'une seule fois, à moins que les essais communs puissent influencer les résultats de l'un quelconque des essais particuliers.

4.3.4 Instructions pour les essais

4.3.4.1 Selon les échantillons soumis

4.3.4.1.1 Les dispositifs de commande à utiliser dans ou avec un matériel peuvent être soumis à essai avec le matériel ou séparément. Lorsqu'ils sont soumis à essai dans ou avec un matériel, le type de charge contrôlé est classé d'après la charge spécifique déclarée. Lorsqu'ils sont soumis à essai séparément en tant que dispositif de commande individuel, le type de charge contrôlé est classé d'après, soit la charge spécifique déclarée, soit une charge résistive pure, ou encore d'après une charge résistive et inductive. Dans tous les cas, le courant qui circule dans le circuit approprié lorsque le matériel fonctionne sous charge normale, est considéré comme le courant assigné de ce circuit.

4.3.4.1.2 Pour tous les dispositifs de commande soumis à l'essai, que ce soit dans, sur ou avec un matériel, toutes autres informations correspondantes exigées en 5.2 peuvent être obtenues par examen et en effectuant des mesures sur le matériel soumis.

4.3.4.1.3 Les dispositifs de commande intégrés sont classés d'après la charge spécifique déclarée et sont soumis à essai dans le matériel, ou une partie de celui-ci, pour lequel ils sont prévus.

4.3.4.1.4 Les dispositifs de commande qui ne sont pas présentés à l'essai dans ou avec un matériel sont soumis séparément aux essais.

4.3.4.1.5 Les dispositifs de commande destinés à être utilisés avec des câbles souples fixés à demeure sont soumis à essai avec le câble approprié raccordé.

4.3.4.2 Selon les caractéristiques assignées

4.3.4.2.1 Les dispositifs de commande uniquement prévus pour un courant alternatif sont soumis à essai en courant alternatif à la fréquence assignée, si elle est déclarée; les dispositifs uniquement prévus pour un courant continu sont soumis à essai en courant continu. Les dispositifs pouvant fonctionner indifféremment en courant alternatif ou continu sont soumis à essai dans le cas le plus défavorable.

4.3.4.2.2 Les dispositifs de commande prévus uniquement pour un courant alternatif qui ne comportent pas de déclaration de fréquence assignée sont soumis à essai à 50 Hz ou 60 Hz, suivant la valeur la plus défavorable. Les dispositifs de commande ayant une fréquence assignée dans une plage déclarée autre que 50 Hz à 60 Hz sont soumis à essai à la fréquence la plus défavorable dans la plage marquée ou déclarée.

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4.3.4.2.3 Pour l'essai des dispositifs de commande prévus uniquement pour un courant continu, il est tenu compte de l'influence éventuelle de la polarité sur le fonctionnement du dispositif de commande.

4.3.4.2.4 Lorsque les dispositifs de commande ont des valeurs assignées différentes en courant alternatif et continu, pour les essais des Articles 14, 15, 16 et 19, deux jeux d'échantillons sont utilisés, l'un pour les essais aux valeurs assignées alternatives, l'autre pour les essais aux valeurs assignées continues.

NOTE Le laboratoire aura toute latitude pour fixer un nombre restreint d'essais à effectuer pour couvrir les diverses valeurs assignées déclarées.

4.3.4.2.5 Sauf spécification contraire, les dispositifs de commande pour lesquels une ou plusieurs plages de tensions sont déclarées doivent être soumis à essai à la tension la plus défavorable dans la plage déclarée, cette tension étant multipliée par le facteur indiqué à l'article approprié (voir 4.3.4.2.7).

4.3.4.2.6 Pour les dispositifs de commande pour lesquels plusieurs valeurs de tension ou de courant assignés sont déclarées ou marquées, les essais de l'Article 19 sont répétés pour chaque combinaison de **tension et courant assignés**.

NOTE Le laboratoire aura toute latitude pour fixer un nombre restreint d'essais à effectuer pour couvrir les diverses valeurs assignées déclarées.

4.3.4.2.7 Pour les dispositifs de commande pour lesquels une plage de tensions est déclarée, les essais sont effectués sur un jeu d'échantillons à chaque limite de la plage, à moins que la différence entre les limites de la plage ne dépasse pas 10 % de la valeur moyenne de la plage, auquel cas les essais sont effectués sur un seul jeu d'échantillons à la limite supérieure de la plage.

4.3.4.2.8 Les dispositifs de commande destinés à fonctionner avec une alimentation particulière sont soumis à essai avec cette alimentation.

4.3.4.2.9 Un circuit de raccordement au réseau d'alimentation en courant continu est classé comme circuit **TBTS/TBTP**, circuit TBT ou circuit de tension réseau en fonction de la tension maximale de fonctionnement de l'alimentation. Cette tension maximale de fonctionnement doit tenir compte de la "tension flottante" de charge de pile secondaire associée au **système** d'alimentation prévu, indépendamment des caractéristiques assignées de tension indiquées pour le matériel.

NOTE La tension flottante est la tension constante appliquée en permanence à une **cellule** voltaïque pour la maintenir complètement chargée. La tension flottante varie de manière significative selon la composition chimique et la construction de la pile secondaire et en fonction de la température ambiante.

4.3.4.2.10 Le fonctionnement du dispositif de commande alimenté par des piles secondaires (rechargeables) se fait dans les conditions suivantes:

– le **dispositif de commande**, alimenté par sa pile complètement chargée, fonctionne comme spécifié dans le présent document;
– si possible, le **dispositif de commande** est alimenté à partir du réseau par son chargeur de pile, la pile étant initialement déchargée de sorte que le **dispositif de commande** ne peut pas fonctionner;
– si le **dispositif de commande** incorpore un couplage inductif entre deux parties qui sont débrochables, le **dispositif de commande** est alimenté par le réseau en retirant la **partie amovible**.

4.3.4.2.11 Voir J.4.3.4.2.11.

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4.3.4.3 Selon la protection contre les chocs électriques

4.3.4.3.1 Si, dans les dispositifs de commande des classes 0, 0I ou I, ou dans les dispositifs de commande destinés à des matériels des classes 0, 0I ou I, certaines parties sont tenues d'avoir une double isolation ou une **isolation renforcée**, ces parties sont contrôlées selon les exigences appropriées spécifiées pour les dispositifs de commande de la classe II.

4.3.4.3.2 Dans tout dispositif de commande de la classe I ainsi que dans tout dispositif de commande utilisé dans un matériel de la classe I, des surfaces accessibles métalliques non mises à la terre et des surfaces accessibles isolantes doivent être dotées d'une isolation conforme aux exigences pour un dispositif de commande de la classe II (voir 7.1.1).

4.3.4.3.3 Si, dans les dispositifs de commande des classes 0, 0I, I ou II, ainsi que les dispositifs de commande destinés à des matériels des classes 0, 0I, I ou II, certaines parties sont tenues d'être alimentées à l'aide de circuits **TBTS**, ces parties sont également contrôlées selon les exigences appropriées pour la protection par l'utilisation de **TBTS** de 9.2.6.

*Si, dans les **dispositifs de commande de la classe I** ou des **dispositifs de commande** destinés à des matériels de classe I, certaines parties sont tenues d'être alimentées à l'aide de circuits **TBTP**, ces parties sont également contrôlées selon les exigences appropriées pour la protection par l'utilisation de **TBTP** de 9.2.6.*

NOTE Par définition (3.7.6), les **dispositifs de commande de la classe II** ne peuvent pas utiliser des circuits **TBTP**.

4.3.4.4 Selon les variantes du fabricant

4.3.4.4.1 Les dispositifs de commande identiques, mais qui peuvent produire des valeurs de fonctionnement, des durées de fonctionnement ou des séquences de fonctionnement variables en raison du réglage par le fabricant ou de l'ajout d'autres composants ou d'autres parties pendant la phase de fabrication, sont traités comme un lot homogène. Normalement, les dispositifs de commande qui sont ajustés pour les conditions de service les plus sévères sont considérés comme suffisants. Cependant, le laboratoire peut exiger des échantillons supplémentaires, ajustés à d'autres valeurs, s'il peut être démontré clairement que ces valeurs sont nécessaires à l'approbation de la totalité de la plage.

4.3.4.4.2 Dans ces cas, une attention particulière doit être portée aux variations éventuelles des tolérances de fabrication et de la dérive des valeurs, temps et séquences de fonctionnement et, pour les dispositifs de commande sensibles, aux valeurs minimales et maximales des pentes de variation de la grandeur de manœuvre appropriée qui pourraient être applicables aux différentes parties de la plage.

4.3.4.5 Selon la fonction

4.3.4.5.1 Les dispositifs de commande à plusieurs fonctions doivent être généralement soumis à essai séparément pour chacune de ces fonctions. Pendant les essais de contrôle d'une fonction particulière, les grandeurs de manœuvre et les moteurs primaires associés aux autres fonctions doivent être maintenus à la valeur et la position les plus sévères de la ou des plages déclarées.

4.3.4.5.2 De tels dispositifs de commande ne disposant pas d'une section appropriée de l'Article 19 doivent être soumis à essai suivant un processus décidé par accord entre le fabricant et le laboratoire de sorte que les valeurs, le temps et les séquences de fonctionnement essentiels prévus soient soumis à essai.

4.3.4.5.3 Tout dispositif de commande ayant une fonction qui n'est pas définie en 3.2, ou dans la Partie 2 appropriée, peut être soumis à essai et approuvé suivant le présent document, sauf pour l'Article 19. Un programme d'essai pour l'Article 19 doit être basé, dans la mesure du possible, sur l'objectif de cet article et doit être décidé par accord entre le fabricant et le laboratoire.

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4.3.4.5.4 Voir J.4.3.4.5.

5 Informations techniques exigées

5.1 Exigences générales

Le **fabricant de dispositifs de commande** doit fournir toutes les informations utiles afin que:

– un **dispositif de commande** approprié puisse être sélectionné;

– le **dispositif de commande** puisse être monté et utilisé d'une manière telle qu'il satisfasse aux exigences du présent document;

– les essais correspondants puissent être effectués pour déterminer la conformité aux exigences du présent document.

5.2 Méthodes pour fournir les informations techniques

5.2.1 Les informations doivent être présentées en utilisant une ou plusieurs des méthodes suivantes. Les informations exigées pour les **dispositifs de commande** et la méthode appropriée pour fournir ces informations doivent suivre les déclarations du Tableau 1.

NOTE La présentation du Tableau 1 n'est pas nécessairement la forme pratique utilisée pour l'échange d'informations entre le fabricant et le laboratoire.

– Marquage (C) – ces informations doivent se trouver sur le **dispositif de commande** à proprement parler, sauf dans le cas d'un **dispositif de commande intégré**, où ce marquage peut se trouver sur une partie adjacente du matériel à condition qu'il soit évident qu'il s'agit du marquage destiné au **dispositif de commande**.

– Documentation sur copie papier (D) – ces informations doivent être fournies à l'**utilisateur** ou à l'**installateur** du **dispositif de commande** et doivent être composées d'instructions lisibles. Chaque **dispositif de commande** doit être accompagné par ce genre d'informations. Les notices d'instructions ainsi que les autres documents exigés dans le présent document doivent être rédigés dans la ou les langues officielles du pays dans lequel le **dispositif de commande** est destiné à être vendu.

– Pour les **dispositifs de commande** destinés à être exclusivement livrés au **fabricant du matériel**, les notices d'instruction sont remplacées par un dépliant, de la correspondance technique ou un schéma, etc. Il n'est pas nécessaire que chaque **dispositif de commande** soit accompagné d'un document de ce genre.

– Documentation sur supports électroniques, sur mémoire interne ou externe, ou sur des pages web (par exemple un QR code) (E) – ces informations sont données comme variantes aux informations fournies en (D).

– Déclaration (X) – ces informations doivent être fournies au laboratoire en fonction d'accords passés entre celui-ci et le fabricant. Elles peuvent être présentées, par exemple, sous forme de marquage apposé sur le **dispositif de commande**, de dépliant, de correspondance technique ou de schémas, ou encore, dans le cas d'un **dispositif de commande** soumis sur, dans ou avec un matériel, sous forme de mesures et d'examens du matériel soumis. Il convient de fournir également ces informations au **fabricant du matériel**, selon le cas.

5.2.2 Les informations présentées comme exigées au titre du marquage (C) ou de la documentation (D,E) doivent également être fournies au laboratoire sous une forme convenue si celui-ci l'exige.

5.2.3 Pour les **dispositifs de commande** soumis dans, sur ou avec un matériel, l'exigence de documentation (D,E) est remplacée par une exigence de déclaration (X).

5.2.4 Pour un **dispositif de commande intégré** qui fait partie d'un **dispositif de commande** plus complexe, le marquage relatif au **dispositif de commande intégré** peut être compris dans le marquage du **dispositif de commande** plus complexe.

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5.2.5 L'exigence de documentation (D,E) est considérée comme satisfaite si l'information nécessaire a été fournie par marquage (C).

5.2.6 L'exigence de déclaration (X) est considérée comme satisfaite si l'information nécessaire a été fournie soit par la documentation (D,E) soit par marquage (C).

5.2.7 A l'exception des cas prévus en 5.4, toutes les informations sur les **dispositifs de commande intégrés** sont fournies par déclaration (X). Sauf spécification contraire indiquée dans une Partie 2 pour les **dispositifs de commande incorporés**, les seuls marquages exigés sont le nom du fabricant ou sa marque de fabrique et la **référence unique de type**, si les autres marquages exigés sont fournis dans la documentation (D,E). Pour les **dispositifs de commande incorporés** déclarés dans le Tableau 1, exigence 45, se reporter aux explications contenues dans la documentation (D,E) selon 5.2.1.

5.2.8 Pour les **dispositifs de commande** qui ne sont pas intégrés ou incorporés, quand le manque de place empêche la lisibilité du marquage spécifié, le **dispositif de commande** doit être marqué uniquement de la **référence unique de type** et du nom du fabricant (ou de sa marque de fabrique). Les autres marquages exigés doivent figurer dans la documentation (D,E).

5.2.9 Il est permis d'apposer des marquages supplémentaires, à condition qu'ils ne risquent pas d'engendrer des malentendus.

5.2.10 Lorsqu'il est fait usage de symboles, ils doivent être les suivants:

Ampères		A
Volts		V
Watts		W
Volts-ampères		VA
Courant alternatif (monophasé)		~ IEC 60417-5032 (2002-10)
Courant alternatif (triphasé)		3~ IEC 60417-5032-1 (2002-10)
Courant alternatif (triphasé avec neutre)		3N~ IEC 60417-5032-2 (2002-10)
Courant continu		⎓ IEC 60417-5031 (2002-10)
Dispositif de commande de la classe II		⧈ IEC 60417-5172 (2003-02)
Dispositif de commande de la classe III		Ⅲ IEC 60417-5180 (2003-02)
Limites de température ambiante de la **tête de commande**	T	(La lettre T est précédée du signe moins et de la valeur numérique de la température la plus basse si T_{min} est plus basse que 0 °C; elle est suivie de la valeur numérique de la température la plus élevée si T_{max} diffère de 55 °C.)
Courant assigné du fusible correspondant en ampères		▭ IEC 60417-5016 (2002-10)

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Fréquence..... Hz

Terre de protection.....  IEC 60417-5019 (2006-08)

Mise à la terre fonctionnelle .....  IEC 60417-5018 (2011-07)

Attention .....  ISO 7000-0434B (2004-01)

Lire le manuel de l'utilisateur .....  ISO 7000-0790 (2004-01)

Pour l'identification du degré de protection procuré par l'enveloppe, les symboles représentés dans le Tableau 1, exigence 9, doivent être utilisés.

NOTE 1 Les informations sur la tension et le courant assignés peuvent se faire en chiffres seulement, la valeur du courant assigné étant placée devant ou au-dessus de celle de la tension assignée dont elle est séparée par un trait. Pour les circuits à charge résistive ou inductive, le courant assigné pour la charge inductive figure entre parenthèses à la suite du courant assigné pour la charge résistive. Le symbole désignant la nature de l'alimentation suit les indications de courant et de tension.

La tension, le courant et le type d'alimentation peuvent être indiqués comme suit:

$$16\ (3)\ \text{A}\ 240\ \text{V}\sim \quad \text{ou} \quad 16\ (3)\ /\ 240\sim \quad \text{ou} \quad \frac{16\,(3)}{240}\sim$$

NOTE 2 Exemples de la façon de fournir des informations concernant les limites de température d'un **dispositif de commande**:

- 20T 30 (soit moins 20 °C jusqu'à plus 30 °C);
- T85 (soit 0 °C jusqu'à plus 85 °C).

NOTE 3 Pour des charges spécifiques déclarées, il est possible de se référer à un schéma ou à des types, par exemple:

"moteur électrique, n° de schéma..., n° de nomenclature..., fabriqué par..." ou "5 × 80 W, fluorescent".

Tableau 1 – Informations techniques exigées et méthodes pour fournir ces informations

	Information	Article ou paragraphe	Méthode
1	Nom du fabricant ou marque de fabrique	5.2.7	C
2	**Référence unique de type** [a]	3.13.1, 5.2.7	C
3	Tension assignée ou plage de tensions assignées, en volts (V)	3.1.2, 4.3.4.2 16.4,	C
4	Type d'alimentation AC, DC, AC et DC, alimentation par batterie, alimentations spécifiques ou alimentations multiples	4.3.4.2	C
5	Fréquence si elle n'est pas comprise dans la plage de 50 Hz à 60 Hz inclus	4.3.4.2	C
6	Fonction du **dispositif de commande**	3.2, 4.3.4.2, 4.3.4.5, 19.15	D ou E
7	Type de **dispositif de commande** en fonction de la construction et si celui-ci est électronique	3.5, 3.5.7	X
8	Le type de charge contrôlé par chaque circuit[b] tel qu'une charge pratiquement résistive, une charge résistive ou inductive, une charge spécifique déclarée, une charge de 20 mA, une charge par moteur déclarée et une charge par **mode pilote**	16, 19, Tableau 18, Tableau 19, Tableau 20, 23.2.2 26.2.3	C

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	Information	Article ou paragraphe	Méthode
9	Degré de protection procuré par l'enveloppe[c] (classification IP selon l'IEC 60529)	9.5, 14.1	C
10	Marquage des bornes pour connexions externes	5.4.2	C
11	Bornes de **conducteurs externes** prévues pour une gamme de sections de conducteurs plus étendue que celles qui figurent dans le Tableau 2.	8.1	D ou E
12	Pour les **bornes sans vis**, moyen de connexion et de déconnexion des conducteurs [d], si non immédiatement identifiables	8	D
13	Détail des conducteurs spéciaux destinés à être reliés aux bornes prévues pour les **conducteurs internes**	8.2.1	D ou E
14	Température maximale des bornes pour **conducteurs internes** et bornes pour **conducteurs externes** de **dispositifs de commande intégrés** et **incorporés**, si supérieure à 85 °C	16	X
15	Limites de température applicables à la **tête de commande** si la valeur minimale (T_{min}) est inférieure à 0 °C ou la valeur maximale ($\boldsymbol{T_{max}}$) est différente de 55 °C Les valeurs préférentielles pour $\boldsymbol{T_{max}}$ sont 30 °C, 55 °C, 70 °C, 85 °C, 105 °C, 125 °C, 150 °C. Les valeurs préférentielles pour T_{min} sont 0 °C, −10 °C, −20 °C, −30 °C, et −40 °C	16.5 16.7, 19.3	C
16	Limites de température des surfaces de montage ($\boldsymbol{T_s}$) Température maximale de la surface de montage ($\boldsymbol{T_{s\ max}}$) si elle est supérieure à 20 K au-dessus de $\boldsymbol{T_{max}}$	16.5 a), 19.3	C
17	Type de **dispositif de commande** selon la protection contre les chocs électriques	3.7.3, 3.7.4, 3.7.5, 3.7.6, 3.7.7, 6, 7	X
18	Pour les **dispositifs de commande de la classe II**, symbole de la construction de classe II	5.3	C
19	Nombre de cycles de **manœuvre** (M) pour chaque **action manuelle** Les valeurs préférentielles sont: 100 000 cycles; 30 000 cycles; 10 000 cycles; 6 000 cycles; 3 000 cycles[j]; 300 cycles[j]; 30 cycles[j] NOTE Pour les dispositifs de commande à plusieurs actions manuelles, une valeur différente peut être déclarée pour chacune. Pour les dispositifs de commande à plusieurs positions ARRÊT, chaque déplacement d'une position ARRÊT à la suivante est considéré comme un cycle de manœuvre.	19.10, 19.11	X
20	Nombre de cycles automatiques (A) pour chaque action automatique. Les valeurs préférentielles sont: 300 000 cycles; 200 000 cycles; 100 000 cycles; 30 000 cycles; 20 000 cycles; 10 000 cycles; 6 000 cycles; 3 000 cycles[1)]; 1 000 cycles[1)]; 300 cycles[2)]; 30 cycles[2)4)]; 1 cycle[3)]. [1)] Non applicable aux thermostats et autres dispositifs à action cyclique rapide. [2)] N'est applicable qu'à un réarmement manuel. [3)] Uniquement pour les dispositifs à action unique exigeant le remplacement d'un élément après chaque fonctionnement. [4)] Ne peut être réarmé qu'au cours de l'entretien ou de la réparation par le fabricant. NOTE Pour les dispositifs de commande à plusieurs actions automatiques, une valeur différente peut être déclarée pour chaque action.	13.1.3.3, Tableau 14, 19.7.6, 19.8.4,	X
21	Période de vieillissement (Y) pour **dispositifs de commande** avec action de type 1.M ou 2.M Les valeurs préférentielles sont: 60 000 h; 30 000 h; 10 000 h; 3 000 h; 300 h; 15 h.	19.6	X
22	Pour chaque circuit, type de coupure ou d'interruption	3.4.1, 3.4.2, 3.4.3, 3.4.4	X

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	Information	Article ou paragraphe	Méthode
23	IRC des matériaux isolants utilisés	11.3.1, Tableau 12, Note [c], Tableau 13, Note [d], 21.2.9	X
24	Méthode de montage du **dispositif de contrôle**[d]	9.6, 9.11, 10.1, 16, 19 et 20	D
25	Marquage et méthode de mise à la terre du **dispositif de commande**	5.4.2.3, 7, 7.1.1, 7.1.2	D
26	Type de fixation des **câbles souples fixés à demeure** [e]	8.1, 9.7	D ou E
27	Plage de diamètre extérieur autorisé pour les cordons utilisés dans les dispositifs de commande avec le type de fixation X lorsque cela est pertinent pour le respect de l'Article 14	14.1.4	D ou E
28	Condition de transport prévue du **dispositif de commande** [f]	18.1	X
29	Détail de toute limitation du **temps de fonctionnement** [g]	16, 19	D ou E
30	Limites de variation de la **grandeur de manœuvre** pour tout **élément sensible** assurant une **microcoupure** ou une **coupure électronique**	9.3.2, 9.4.16, 19.14, 20.1.5, 13.1.1	X
31	Taux minimal et/ou maximal de variation de la grandeur de manœuvre, ou fréquence cyclique minimale et/ou maximale dans le cas d'un **dispositif de commande sensible** à une grandeur [h]	4.3.2.7, H.17, 19	X
32	Valeurs de dépassement de la **grandeur de manœuvre** nécessaires au bon fonctionnement ou utilisables pour les essais, pour les **dispositifs de commande sensibles**	19	X
33	**Action de type 1** ou **de type 2**	3.6	D ou E
34	Caractéristiques complémentaires pour **action de type 1** ou **de type 2**	9.4	D ou E
35	**Tolérance de fabrication** et condition d'essai (électrique, mécanique et thermique) correspondante	3.11.1, 9.4.3, H.17, 19.14	X
36	**Dérive**	3.11.2, 9.4.3, H.17, 18.2.4	X
37	Caractéristiques de réarmement pour action de court-circuit [i]	9.4.11, 9.4.12,	D ou E
38	Si le **dispositif de commande** est destiné à être tenu à la main ou à être incorporé à un matériel tenu à la main	21, 9.12.4.4.1	X
39	Limitation éventuelle du nombre et de la répartition des **réceptacles** de connecteurs à languette pouvant être montés	8.2.4.4	D ou E
40	Pour toute **action de type 2,** la **tolérance de fabrication** et la **dérive** de sa **valeur de fonctionnement**, de sa **durée de fonctionnement** ou de sa **séquence de fonctionnement** (déclarées dans le Tableau 1, exigence 35 et exigence 36)	9.4.3	D ou E
41	Extension de tout **élément sensible**	3.8.1	X
42	**Valeur de fonctionnement** (ou valeurs) ou **temps de fonctionnement**	3.3.11, 3.3.12, 9, 16, H.17.6,19	D
43	Classe d'intégration (immunité au choc électrique) et modes de fonctionnement	12.2 H.25.8.1 H.25.8.3 Annexe N	X
44	**Degré de pollution** prévu du **dispositif de commande**	Annexe F	D ou E
45	**Dispositif de commande** prévu pour livraison exclusive au **fabricant de matériel**	5.2.1, 5.2.7	X
46	Températures de l'essai au fil incandescent	21.2.5, 21.2.6, 21.2.7, et 21.2.8	X

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	Information	Article ou paragraphe	Méthode
47	Les paramètres minimaux des dispositifs de refroidissement éventuels (par exemple radiateur) non fournis avec le **dispositif de commande** électronique mais essentiels à son **fonctionnement** correct	16	D
48	Type de la forme d'onde de sortie, si elle n'est pas sinusoïdale	24.1	X
49	Détails relatifs à la forme d'onde du **courant de contact** produit après une **défaillance** de l'**isolation principale**	13.1	X
50	Les paramètres caractéristiques des **dispositifs électroniques** ou autres composants de circuit considérés comme ne présentant pas de risque de défaut (voir alinéa 1 de 13.1.3.1)	13.1	X
51	Type de la ou des formes d'onde de sortie produites après la **défaillance** d'un **dispositif électronique** ou d'un autre composant de circuit (voir point g) de 13.1.3.8)	13.1	X
52	L'effet sur la ou les sorties commandées après la **défaillance** d'un composant de circuit électronique, si cela s'applique (point c) de 13.1.3.8)	13.1	X
53	Tout composant sur lequel est basée la fiabilité de la **coupure électronique** qui est déconnecté comme exigé par la note n du Tableau 16	15.2 13.1	X
54	Charge externe et mesures de l'émission du dispositif de commande à utiliser pour les essais	23.3	X
55	**Tension assignée de choc**	3.1.10, 11.2	D ou E
56	Type de revêtement de protection de la carte de circuit imprimé	Annexe L ou Annexe M	X
57	Température pour l'essai à la bille	21.2.5, 21.2.6 et 21.2.7	X
58	Couple maximal déclaré sur manchon simple utilisant des matériaux thermoplastiques	Tableau 9, Note [a]	D ou E
59	**Degré de pollution** dans le **microenvironnement** de la **ligne de fuite** ou **distance dans l'air**, si plus propre que celui du **dispositif de commande**, et comment il est conçu	Tableau 14	X
60	**Tension assignée de choc** pour la **ligne de fuite** ou **distance dans l'air**, si différente de celle du **dispositif de commande**, et comment elle est réalisée	Tableau 14	D ou E
61	Les valeurs prévues pour les tolérances des distances pour lesquelles l'exclusion du mode de **panne** "court" est revendiquée	13.1.3.3, Tableau 14, 13.1.3.5	X
62	Pour les **dispositifs de commande de la classe III**, symbole de la construction de classe III	5.4.2.5	C
63	Pour les circuits **TBTS** ou **TBTP**, les limites **TBT** réalisées	3.1.5, 6.1.1, P.3.2	X
64	Valeur de la tension accessible du circuit **TBTS**/**TBTP**, si elle diffère de 6.1.1, et de la ou des normes de produit auxquelles il est fait référence pour l'application du **dispositif de commande** et dans lesquelles le ou les niveaux **TBTS**/**TBTP** sont donnés.	3.1.4, 6.1.1	X
65	Essais et groupes d'émission tels que déclarés selon la CISPR 11	23.2	X
66	Les essais d'immunité pour les **dispositifs de commande de protection** destinés à être utilisés avec les appareils relevant de l'IEC 60335	Tableau H.12	X
67	Courant de court-circuit maximal comme déclaré	9.3.5.2.1 b)	X
68	Dispositif de protection contre les surintensités, externe au **dispositif de commande**	9.2.8, 26.2	D ou E
69	Marquage pour le type de pile remplaçable	5.4.3.3	C
70	Pour les **dispositifs de commande incorporés** ou les **dispositifs de commande intégrés**, déterminer si l'essai de surcharge doit être réalisé au niveau de commande	26.2.2	X
71	Altitude maximale à laquelle le **dispositif de commande** peut être utilisé si l'altitude est supérieure à 2 000 m	11.2	X
72	Nombre maximal d'actions de **réarmement** au cours d'une période donnée	9.12.4.4.5	D
73	Nombre d'actions de **réarmement** distant	19.1.6.5	X

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	Information	Article ou paragraphe	Méthode
74	Résistance à la chaleur et au feu pour les dispositifs de commande destinés à être utilisés dans des appareils relevant de l'IEC 60335	21.2.4	X
75	Type d'environnement électromagnétique de l'une des deux limites d'émission CEM pour l'**environnement électromagnétique résidentiel** ou l'**environnement électromagnétique industriel**	23, Tableau 23 ou Tableau 24	D ou E
76	Type d'environnement électromagnétique de l'un des deux niveaux d'immunité CEM	25.3.2	D ou E
77	**Environnement électromagnétique résidentiel**	Tableau 26 ou	
78	**Environnement électromagnétique industriel**	Tableau 27	
79	Longueur de câble inférieure ou égale à 30 m (si cela ne concerne pas des **lignes de grande longueur**)	25.3.2, Tableau 26 ou Tableau 27	D ou E
80	Longueur de câble inférieure ou égale à 3 m (si cela ne concerne pas des **lignes de grande longueur**)	25.3.2, Tableau 26 ou Tableau 27	D ou E
81	Applicable aux essais et à la fréquence	25.3.2, Tableau 26 ou Tableau 27	D ou E
82	Exigences supplémentaires pour les dispositifs de commande HBES/SGTB[k] en **environnement électromagnétique résidentiel** conformément à l'IEC 63044-5-2 ou en **environnement électromagnétique industriel** conformément à l'IEC 63044-5-3	25.3.2, Tableau 26 ou Tableau 27	D ou E
83	Dispositif de commande sensible aux champs magnétiques (voir Note e des deux tableaux)	25.3.2, Tableau 26 ou Tableau 27	D ou E
84	Dispositifs de commande déclarés pour les performances CEM	25.1, Tableau 25	D
85	Tension minimale et maximale de la pile	24.2	X
86	**Dispositifs de commande électronique** de fonction de commande de classe A, conformes avec 25.7 à 25.10	25.1, Tableau 25	D
87	Type d'alimentation en courant continu pour applications non fixes	Annexe I, I.1	D

[a] La **référence unique de type** doit être telle que le fait de la citer en entier permette de commander au fabricant un **dispositif de commande** de remplacement parfaitement interchangeable avec l'original du point de vue de ses caractéristiques électriques, mécaniques, dimensionnelles et fonctionnelles.

Cette référence peut comprendre une référence de série avec d'autres marquages et indications, comme une tension assignée ou une température ambiante, l'ensemble de ces données constituant la référence unique de type.

[b] Pour les **dispositifs de commande** qui comportent plus d'un circuit, l'intensité applicable à chaque circuit et à chaque borne. En cas de différences d'un circuit à l'autre, il doit être précisé à quel circuit ou à quelle borne l'information s'applique. Pour les circuits à charge résistive et inductive, le courant assigné ou la charge assignée exprimée en VA, avec les facteurs de puissance indiqués dans le tableau approprié de 19.2.

[c] L'exigence de marquage (C) ne s'applique pas aux **dispositifs de commande** ou à leurs parties classées IP00, IP10, IP20, IP30 et IP40.

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d	Si, pour les **dispositifs de commande à montage indépendant**, il est nécessaire de prendre des précautions particulières lors de l'installation ou de l'utilisation du **dispositif**, des précisions doivent être données à cet effet dans la notice d'instructions qui accompagne le **dispositif**. Des précautions particulières peuvent être nécessaires, par exemple dans le cas de **dispositifs de commande à montage indépendant** encastré. Afin de s'assurer qu'après encastrement les conditions spécifiées dans le présent document sont respectées, la notice d'instructions du **dispositif de commande** doit comprendre les précisions appropriées concernant: – les dimensions de l'emplacement destiné au **dispositif de commande**; – les dimensions et la position des moyens de support et de fixation du **dispositif de commande** à l'intérieur de cet emplacement; – un espace minimal entre les différentes parties du **dispositif de commande** et les parties de l'emplacement qui l'entourent; – les dimensions minimales des ouvertures de ventilation et la disposition correcte de celles-ci; – le raccordement du **dispositif de commande** à l'alimentation et l'interconnexion des éléments constituants séparés éventuels. Si les conducteurs d'alimentation d'un **dispositif de commande** peuvent entrer en contact avec des parties du bloc ou du compartiment à bornes pour le **câblage fixe**, et si ces parties ont une température qui, en **usage normal**, dépasse la température spécifiée dans le Tableau 17, la notice d'instructions doit également indiquer que le **dispositif de commande** doit être raccordé au moyen de conducteurs ayant une caractéristique T appropriée (voir Note h du Tableau 17). Pour les **dispositifs de commande** avec câblage entre un capteur, un élément sensible ou élément de manœuvre et le reste du **dispositif de commande** où une partie de ce câblage fait, ou est destinée à faire, partie d'une installation fixe, le fabricant doit donner dans la documentation les informations pertinentes pour l'installation correcte et le type approprié de câble ou de cordon exigé pour cette partie de l'installation fixe.
e	Les **dispositifs de commande intercalés dans un câble souple**, **séparés** et **à montage indépendant**, équipés de **câbles souples fixés à demeure** ayant des **fixations du type Y** ou du **type Z**, doivent être accompagnés de la documentation (D) comprenant en substance les informations suivantes, selon le cas: – "Le câble d'alimentation de ce dispositif de commande ne peut pas être remplacé; si le câble est endommagé, il convient de jeter le dispositif" (Z) ou – "Le câble d'alimentation de ce dispositif de commande ne peut être remplacé que par le fabricant ou son agent agréé" (Y).
f	La méthode d'emballage n'a pas à être déclarée.
g	Pour les **dispositifs de commande intercalés dans un câble souple**, les **dispositifs de commande séparés** et les **dispositifs de commande à montage indépendant**, cette information doit être fournie par la méthode C.

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[h] α_1 = pente ascendante minimale

β_1 = pente descendante minimale

Les taux (α_1 et β_1) de variation de la **grandeur de manœuvre** sont ceux qui correspondent à un **usage normal**.

α_2 = pente ascendante maximale (applicable uniquement aux **actions de type 2**)

β_2 = pente descendante maximale (applicable uniquement aux **actions de type 2**)

Aux fins d'essais, les valeurs de α_1 et de β_1 doivent être conformes aux valeurs déclarées sans pouvoir être inférieures aux limites données pour les **actions de type 1** ou **de type 2** dans les Parties 2 appropriées. Les valeurs de α_2 et β_2 ne sont données que pour les essais et peuvent être remplacées par la déclaration d'une valeur cyclique maximale. Dans le cadre du présent document, les taux de variations doivent être exprimés dans les unités du tableau ci-après*:

Grandeur de manœuvre	Unité de taux de variation
Pression	Pa/s
Température	K/h
Position	mm/s
Eclairement	lux/s
Vitesse	mm/s^2
Niveau liquide	mm/s
Courant	A/s
Humidité	%/s
Débit d'air	m^3/s^2

[*] Lors de l'utilisation d'autres grandeurs de manœuvre, ces grandeurs doivent être exprimées en unités SI.

[i] Le fabricant peut déclarer que le réarmement manuel ne doit pas être effectué avant le terme d'une durée spécifiée, ou au-delà d'une valeur spécifique de la **grandeur de manœuvre**.

[j] Ces valeurs ne sont applicables qu'à des actions de **dispositifs de commande** réservées à certains types de matériels et à des applications telles que les **dispositifs de commande** à prises de tension multiples, les **dispositifs de commande** à position été/hiver pour chauffe-eau et lorsque la norme particulière le permet explicitement.

[k] Produits HBES/SGTB.

5.3 Symbole de classe II

5.3.1 Le symbole de construction de la classe II ne doit être utilisé que pour les **dispositifs de commande** de la classe II. Le symbole de construction de la classe II n'est exigé ni pour les **dispositifs de commande incorporés** ni pour les **dispositifs de commande intégrés**.

5.3.2 Les dimensions des symboles de la classe II doivent être telles que la longueur des côtés du carré extérieur soit égale à environ deux fois la longueur des côtés du carré intérieur.

5.3.2.1 La longueur des côtés du carré extérieur du symbole ne doit pas être inférieure à 5 mm, à moins que la dimension la plus grande du **dispositif de commande** ne dépasse pas 15 mm, auquel cas les dimensions du symbole peuvent être réduites, mais la longueur des côtés du carré extérieur ne doit pas être inférieure à 3 mm.

5.3.2.2 Les **dispositifs de commande** fournissant une protection contre les chocs électriques telle qu'exigée pour la classe II mais qui comportent des bornes pour la continuité de la mise à la terre à des fins fonctionnelles ne doivent pas être marqués du symbole pour la construction de classe II, IEC 60417-5172 (2003-02), mais doivent être considérés comme des **dispositifs de commande de la classe I**.

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5.4 Exigences supplémentaires de marquage

5.4.1 Généralités

Le marquage exigé sur le **dispositif de commande** ne doit pas être apposé sur des **parties amovibles**.

Le marquage exigé doit être lisible et durable.

La conformité est vérifiée par examen et par les essais décrits à l'Annexe A.

5.4.2 Marquage des bornes pour connexions externes

5.4.2.1 Les bornes des **dispositifs de commande** qui sont prévues pour le raccordement des conducteurs d'alimentation doivent être indiquées par une flèche pointée vers la borne, sauf si le mode de branchement est sans importance ou évident.

La conformité est vérifiée par examen.

5.4.2.2 Les bornes à relier exclusivement à un **conducteur externe** de neutre doivent être signalées par la lettre "N".

5.4.2.3 Les bornes de mise à la terre destinées aux conducteurs externes de mise à la terre de protection ou à la continuité de la mise à la terre et les bornes servant à la mise à la terre à des fins fonctionnelles (par opposition à des fonctions de protection contre les chocs électriques) doivent être indiquées

– pour la terre de protection, par le symbole de terre pour la terre de protection, IEC 60417-5019 (2006-08);
– pour la terre fonctionnelle, par le symbole de terre pour la mise à la terre fonctionnelle, IEC 60417-5018 (2011-07).

5.4.2.4 Toutes les autres bornes doivent être identifiées de façon appropriée, ou leurs fonctions doivent être évidentes ou encore le circuit du **dispositif de commande** doit être visible. Les symboles flèche, "N" ou de terre ne doivent pas être utilisés, sauf comme indiqué ci-dessus.

La conformité est vérifiée par examen.

5.4.2.5 Les dispositifs de commande séparés, à montage indépendant et intercalés dans un câble souple destinés à être reliés uniquement à des **schémas TBTS** ou des **schémas TBTP** doivent être marqués du symbole graphique IEC 60417-5180 (2003-02). Cette exigence ne s'applique pas si les moyens de connexion à l'alimentation sont prévus pour la seule alimentation en **TBTS** ou en **TBTP**.

Les **dispositifs de commande** fournissant une protection contre les chocs électriques telle qu'exigée pour les **dispositifs de commande de la classe III** mais qui comportent des bornes à des fins de mise à la terre fonctionnelle ou pour la continuité de la mise à la terre externe doivent être marqués du symbole pour la construction de classe III.

NOTE Le symbole de la terre fonctionnelle est l'IEC 60417-5018 (2011-07).

5.4.3 Marquages pour l'installation et l'entretien

5.4.3.1 Les **dispositifs de commande** destinés à être réglés par l'**utilisateur** ou par le **fabricant de matériel** pendant l'installation doivent porter l'indication du sens de l'augmentation ou de la diminution de la **valeur de réponse**.

NOTE Une indication "t" ou "–" est suffisante.

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Les **dispositifs de commande** destinés à être réglés par le **fabricant de matériel** ou son **installateur** doivent être accompagnés d'une documentation (D) indiquant la méthode appropriée pour bloquer en position de **réglage**.

5.4.3.2 Les parties détruites pendant le **fonctionnement** normal du **dispositif de commande**, et devant être remplacées, doivent porter une indication pour faciliter leur identification dans un catalogue ou analogue, même après leur fonctionnement, à moins qu'elles ne soient destinées à n'être remplacées que lors des opérations d'**entretien ou réparation par le fabricant**.

5.4.3.3 Si un matériel est fourni avec une pile remplaçable et si elle est remplacée par un type incorrect susceptible d'engendrer un risque d'explosion (par exemple, avec des batteries au lithium), les spécifications suivantes s'appliquent:

– si la pile est destinée à être remplacée par l'**utilisateur**, un marquage doit être apposé à proximité de la pile ou une déclaration doit figurer dans les instructions d'utilisation et les instructions de service;
– si la pile n'est pas destinée à être remplacée par l'**utilisateur**, un marquage doit être apposé à proximité de la pile ou une déclaration doit figurer dans les instructions de service.

Ce marquage ou cette déclaration doit comporter le texte suivant ou une expression analogue:

ATTENTION
RISQUE D'EXPLOSION SI LA PILE EST REMPLACÉE PAR UN TYPE INCORRECT
ÉLIMINER LES PILES USAGEES CONFORMEMENT AUX INSTRUCTIONS

5.4.3.4 Le compartiment de pile des **dispositifs de commande** comportant des piles destinées à être remplacées par l'**utilisateur** doit porter un marquage indiquant la tension de pile et la polarité des bornes.

Si des couleurs sont utilisées, la borne positive est à identifier en rouge et la borne négative en noir.

La couleur ne doit pas être utilisée comme seule indication pour indiquer la polarité.

5.4.3.5 Les instructions relatives aux **dispositifs de commande** comportant des piles destinées à être remplacées par l'**utilisateur** doivent comprendre les informations suivantes:

– la référence du type de pile;
– l'orientation de la pile par rapport à la polarité;
– la méthode de remplacement des piles;
– un avertissement signalant de ne pas utiliser des piles d'un type incorrect;
– le mode de traitement des piles non étanches.

Les instructions relatives aux **dispositifs de commande** comportant une pile contenant des matériaux dangereux pour l'environnement doivent fournir des informations détaillées sur la manière de retirer ou d'éliminer la pile et doivent spécifier que:

– la pile doit être retirée du **dispositif de commande** avant la mise au rebut;
– le **dispositif de commande** doit être déconnecté du réseau d'alimentation avant de retirer la pile;
– la pile doit être éliminée en toute sécurité.

5.4.3.6 Pour les dispositifs de commande alimentés par piles secondaires (rechargeables), les instructions doivent donner des informations concernant les opérations de charge des piles.

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5.5 Marquages d'avertissement ou de mise en garde

Les avertissements ou mises en garde doivent être rédigés dans les instructions du fabricant (D ou E), à condition que le symbole ISO 7000-0434B (2004-01) soit apposé sur le produit.

6 Protection contre les chocs électriques

6.1 Exigences générales

6.1.1 Les **dispositifs de commande** doivent être construits de façon à avoir une protection adéquate contre le contact accidentel avec des **parties actives**, dans n'importe laquelle des positions défavorables pouvant survenir en **usage normal**, et après que toutes les **parties amovibles**, autres que les lampes placées derrière un **couvercle** détachable, ont été démontées. Cependant, pendant la mise en place ou le démontage des lampes, une protection contre un contact accidentel avec des **parties actives** de la lampe doit être assurée.

Sauf spécification contraire, les **parties accessibles** raccordées à des **schémas TBTS** ou à des **schémas TBTP** dont la tension ne dépasse pas les limites **TBTS** de 3.1.5 ne sont pas considérées comme des **parties actives dangereuses**.

Les circuits **TBTS**/**TBTP** ne sont pas considérés comme des **parties actives dangereuses** si:

– le **dispositif de commande** est prévu uniquement pour une utilisation dans une application relevant d'une autre norme de produit dans laquelle la valeur limite de la tension pour des conducteurs nus accessibles en **TBTS**/**TBTP** est différente;

et

– le fabricant déclare l'application, la norme de produit régissant l'application et le niveau de tension pour les circuits **TBTS**/**TBTP** accessibles considérés comme non dangereux par la norme d'application (déclarés dans le Tableau 1, exigence 64).

Pour les parties accessibles raccordées à un **schéma TBTS** ou à un **schéma TBTP** dont la tension dépasse les limites de 3.1.5, ou est supérieure aux valeurs déclarées dans le Tableau 1, exigence 64, le courant mesuré entre les parties simultanément accessibles et entre les **parties accessibles** et la terre ne doivent pas dépasser les limites en 6.1.10 en conditions sans **panne** (normales) et en conditions de première **panne**.

6.1.2 Les propriétés isolantes des vernis, de l'émail, du papier, du coton, d'une pellicule d'oxyde sur des parties métalliques, des perles isolantes et de la matière de remplissage ne doivent pas être considérées comme assurant la protection exigée contre les contacts accidentels avec des **parties actives dangereuses**. Les matériaux de remplissage autodurcissables peuvent être touchés sans danger, à condition qu'ils satisfassent aux exigences des Articles 15 et 11.

6.1.3 Pour les **dispositifs de commande de la classe II** et les **dispositifs de commande** destinés aux matériels de la classe II qui sont raccordés en **usage normal** à un réseau d'alimentation en gaz ou en eau, toute partie métallique raccordée de façon conductrice aux tuyaux de gaz ou en contact électrique avec le **système** d'eau doit être séparée des **parties actives dangereuses** par une **double isolation** ou une **isolation renforcée**.

6.1.4 Les **dispositifs de commande de la classe II** et les **dispositifs de commande** destinés au matériel de la classe II qui sont prévus pour être raccordés en permanence à un **câblage fixe** doivent être conçus de façon que le degré de protection contre les chocs électriques exigé ne soit pas affecté par l'installation du **dispositif de commande**.

NOTE La protection contre les chocs électriques des **dispositifs de commande de la classe II à montage indépendant** peut être affectée, par exemple, par l'installation de conduits métalliques ou de câbles équipés d'une gaine métallique.

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6.1.5 Pour les **dispositifs de commande intégrés** et **incorporés**, les essais de 6.1.8 ne s'appliquent qu'aux parties accessibles lorsque le **dispositif de commande** est monté dans une position conforme aux déclarations du fabricant et lorsque toutes ses **parties amovibles** ont été enlevées.

6.1.6 Pour les **dispositifs de commande intercalés dans un câble souple** et les **dispositifs de commande séparés**, les essais de 6.1.8 sont effectués avec des câbles souples de la section nominale la plus petite ou la plus grande spécifiée en 8.1.5, suivant le cas le plus défavorable. Les **parties amovibles** sont enlevées et les **couvercles** à charnières qui peuvent être ouverts sans l'aide d'un **outil** sont ouverts.

6.1.7 Pour les **dispositifs de commande à montage indépendant**, l'essai est effectué, le **dispositif de commande** étant monté comme en usage normal et équipé d'un câble souple ayant la section nominale la plus faible ou la plus grande spécifiée en 8.1.5, suivant le cas le plus défavorable, ou d'un conduit rigide, pliable ou souple. Les **parties amovibles** sont enlevées et les couvercles à charnières qui peuvent être ouverts sans l'aide d'un **outil** sont ouverts.

6.1.8 *La conformité aux spécifications de 6.1.1 à 6.1.7 inclus est vérifiée par examen et par les essais suivants:*

a) *Le doigt d'épreuve de la Figure* 5 *est appliqué sans forcer dans toutes les positions possibles. Les ouvertures qui ne permettent pas la pénétration de ce doigt sont en outre soumises à essai au moyen d'un doigt d'épreuve rigide et de mêmes dimensions, qui est appliqué avec une force de 20 N; si ce doigt entre, l'essai au moyen du doigt d'épreuve représenté à la Figure* 5 *est répété, le doigt étant introduit dans l'ouverture si cela s'avère nécessaire. Si le doigt d'épreuve rigide n'entre pas, la force appliquée est portée à 30 N. Si alors la protection est à ce point déplacée ou l'ouverture à ce point déformée que le doigt d'épreuve représenté à la Figure* 5 *peut entrer sans forcer, l'essai avec ce dernier doigt est répété. Un indicateur de contact électrique est utilisé pour déceler un éventuel contact.*

NOTE Pour déceler les contacts indésirables, une lampe avec une tension d'au moins 40 V peut être utilisée.

b) *Le doigt d'épreuve représenté à la Figure* 5 *doit être conçu de façon telle que chacune de ses sections puisse être tournée d'un angle de 90° par rapport à l'axe du doigt dans une même direction seulement.*

c) *Les trous des matériaux isolants et des parties métalliques non mises à la terre doivent en outre être contrôlés au moyen de la broche d'épreuve représentée à la Figure 4, appliquée sans forcer dans toutes les positions possibles.*

d) Il ne doit pas être possible de toucher ni avec le doigt d'épreuve normal ni avec la broche d'épreuve des **parties actives dangereuses**.

e) Pour les **dispositifs de commande** comportant des parties à **double isolation**, il ne doit pas être possible de toucher avec le doigt d'épreuve normalisé représenté à la Figure 5 les parties métalliques séparées des **parties actives dangereuses** uniquement par une **isolation principale**.

f) *S'il existe des instructions concernant l'enlèvement d'une partie en* ***usage normal*** *ou pendant les opérations d'****entretien par l'utilisateur****, et s'il n'y a pas d'avertissement sur la partie qui indique "Débrancher avant enlèvement", cette partie est considérée comme* ***amovible*** *conformément aux spécifications de 6.1.5, 6.1.6 et 6.1.7 uniquement, même si l'enlèvement est à effectuer à l'aide d'un* ***outil****. S'il existe un tel avertissement sur la partie, il est permis, après l'enlèvement, de toucher des parties séparées des* ***parties actives dangereuses*** *par une* ***isolation principale****.*

6.1.9 Les parties conductrices accessibles ne doivent pas être considérées comme des parties actives dangereuses lorsqu'elles sont séparées de la source d'alimentation par une impédance de protection.

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6.1.10 Lorsqu'une **impédance de protection** est utilisée, le courant entre la ou les parties et un pôle quelconque de la source d'alimentation ne doit pas dépasser 0,7 mA (valeur de crête) en courant alternatif ou 2 mA en courant continu:

– pour les fréquences supérieures à 1 kHz, la limite 0,7 mA (valeur de crête) est multipliée par la valeur de la fréquence en kHz mais ne doit pas dépasser 70 mA (valeur de crête);
– pour les tensions supérieures à 42,4 V (valeur de crête) et inférieures ou égales à 450 V (valeur de crête), la capacité ne doit pas dépasser 0,1 µF;
– pour les tensions supérieures à 450 V (valeur de crête) et inférieures ou égales à 15 kV (valeur de crête), le produit de la capacité en farads par le potentiel en volts ne doit pas dépasser 45 µC;
– pour les tensions supérieures à 15 kV (valeur de crête), le produit de la capacité en farads par le carré du potentiel en volts ne doit pas dépasser 350 mJ.

La conformité est vérifiée par des mesures.

Les tensions et les courants sont mesurés entre une partie conductrice accessible particulière (ou toute combinaison de ces parties) et le conducteur de terre de protection. Les mesurages doivent être effectués dans une configuration d'alimentation normale, avec des pôles d'alimentation interchangeables.

Les détails du circuit de mesure sont représentés à la Figure K.1 de l'Annexe K.

6.1.11 Entre des circuits de la classe III et des circuits connectés au réseau ou à la terre, l'isolation externe du **transformateur de sécurité** doit être conforme à toutes les exigences qui s'appliquent à l'isolation de la classe II.

NOTE Quand la classe III n'est pas spécifiquement exigée pour un circuit, les exigences de la classe II ne s'appliquent pas entre un circuit de la classe III et la terre.

La conformité est vérifiée par examen et par des mesures.

6.1.12 Les **dispositifs de commande** équipés de compartiments de pile qui peuvent être ouverts sans l'aide d'un **outil**, ou qui selon les instructions d'utilisation peuvent être remplacés par l'**utilisateur** nécessitent uniquement de disposer d'une **isolation principale** entre les **parties actives** et la surface intérieure du compartiment de pile. Si le **dispositif de commande** peut être mis sous tension sans les piles, une **double isolation** ou une **isolation renforcée** est exigée.

NOTE Si une partie est à retirer afin d'éliminer la pile avant mise au rebut du **dispositif de commande**, cette partie n'est pas considérée comme amovible même si les instructions spécifient qu'il est nécessaire de la retirer.

La conformité est vérifiée par examen et par des mesures.

6.2 Organes de manœuvre et liaisons de manœuvre

6.2.1 Un organe de manœuvre ne doit pas être une **partie active**.

6.2.2 Une **liaison de manœuvre** ne doit pas être une **partie active** à moins que l'**organe de manœuvre** associé ne soit isolant et convenablement fixé, ou que la **liaison de manœuvre** ne soit pas accessible lorsque l'**organe de manœuvre** est enlevé.

La conformité aux spécifications de 6.2.1 et 6.2.2 est vérifiée par examen et par les essais en 6.1.

NOTE Un **organe de manœuvre** isolé est considéré comme convenablement fixé lorsqu'il ne peut être enlevé qu'après avoir été cassé, coupé ou sérieusement endommagé.

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6.2.3 Pour les **dispositifs de commande** autres que ceux de la classe III ou destinés à du matériel autre que celui de la classe III, les poignées et autres **organes de manœuvre** destinés à être tenus à la main en **usage normal** doivent être en matériau isolant ou recouverts de façon appropriée de matériau isolant. S'ils sont en métal, leurs **parties accessibles** doivent être séparées des **liaisons de manœuvre** ou de leur moyen de fixation par une **isolation supplémentaire** au cas où de telles parties présenteraient un risque quelconque de devenir actives à la suite d'une **panne** d'isolement.

Pour les **dispositifs de commande** pour raccordement à un **câblage fixe**, ou pour les **dispositifs de commande** pour les matériels fixes, cette exigence ne s'applique pas sous réserve que ces parties soient:

– reliées de façon fiable à une borne de **mise à la terre de protection** ou un contact de mise à la terre de protection; ou

– séparées des parties actives dangereuses par une **protection par écran**.

La conformité est vérifiée par examen.

NOTE Les parties séparées des **parties actives dangereuses** par une **double isolation** ou une **isolation renforcée** ne sont pas considérées comme susceptibles de devenir conductrices en cas de **panne** d'isolement.

6.3 Condensateurs

6.3.1 Pour les **dispositifs de commande intercalés dans un câble souple** et les **dispositifs de commande à montage indépendant** de la classe II, les condensateurs ne doivent pas être reliés à des parties métalliques accessibles, à moins qu'ils ne satisfassent à 6.1.10 et 9.2.5. Pour les **dispositifs de commande incorporés** et les **dispositifs de commande intégrés** utilisés dans les matériels de la classe II, les condensateurs ne doivent pas être reliés à des parties métalliques susceptibles d'être en contact avec des parties métalliques accessibles lorsque le **dispositif de commande** est monté conformément aux déclarations du fabricant.

La conformité est vérifiée par examen.

6.3.2 Les **dispositifs de commande** destinés à être reliés au circuit d'alimentation au moyen d'une fiche de prise de courant doivent être conçus de façon qu'en **usage normal**, il n'y ait pas de **risque** de choc électrique par des condensateurs chargés, en cas de contact avec les broches de la fiche après séparation de la source d'alimentation.

La conformité est vérifiée par les essais suivants, répétés à 10 reprises.

a) Le **dispositif de commande** est alimenté à la tension assignée ou à la limite supérieure de la plage de tensions assignées.

b) L'**organe de manœuvre** éventuel est alors mis dans la position "ARRÊT", si elle existe, et le **dispositif de commande** est séparé de la source d'alimentation en retirant la fiche du socle.

c) Au bout de 1 s, la tension entre les broches de la fiche est mesurée.

d) *Cette tension mesurée ne doit pas dépasser 42,4 V crête. Cet essai n'est effectué que si la capacité du condensateur dépasse 0,1 µF.*

6.4 Couvercles et parties actives ou dangereuses non isolées

Les **dispositifs de commande** qui comportent un **couvercle** ou un **capot** en matériau non métallique doivent être conçus de façon à masquer les vis de fixation de ce **couvercle**, à moins qu'elles ne soient mises à la terre de protection ou séparées des **parties actives dangereuses** par une **double isolation** ou une **isolation renforcée** ou encore qu'elles ne soient pas accessibles après montage dans le matériel.

La conformité est vérifiée par examen.

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6.5 Dispositifs de commande à pile équipés d'un connecteur d'entrée d'alimentation réseau accessible par l'utilisateur

Les **dispositifs de commande** à pile équipés d'un connecteur d'entrée d'alimentation réseau accessible par l'**utilisateur** doivent être conçus de telle sorte que 1 s après la coupure du connecteur d'alimentation réseau la tension entre deux bornes d'entrée d'alimentation réseau accessibles soit inférieure ou égale aux limites données en 6.1.1. L'essai doit être réalisé à l'aide d'une ou plusieurs piles complètement chargées.

7 Dispositions en vue de la mise à la terre de protection

7.1 Dispositifs de commande de la classe 0I et de la classe I

7.1.1 Les parties métalliques accessibles, autres que les **organes de manœuvre**, des

– **dispositifs de commande intercalés dans un câble souple**, **séparés** et **à montage indépendant** de la classe 0I et de la classe I qui peuvent être mis sous tension en cas de **panne** d'isolement, doivent être reliées en permanence et de façon sûre à une borne de mise à la terre ou à une **connexion** de mise à la terre placée à l'intérieur du **dispositif de commande**, ou au contact de mise à la terre d'un socle de connecteur;

– **dispositifs de commande incorporés** et **intégrés** destinés aux appareils de la classe 0I et de la classe I qui peuvent être mis sous tension en cas de **panne** d'isolement, doivent comporter une disposition en vue de mise à la terre.

NOTE 1 Les parties séparées des **parties actives** par une **double isolation** ou une **isolation renforcée**, et les parties qui sont séparées des **parties actives** par des parties métalliques reliées à une borne de mise à la terre, une **connexion** de mise à la terre ou un contact de mise à la terre ne sont pas considérées comme des parties susceptibles d'être mises sous tension en cas de **panne** d'isolement.

NOTE 2 Les exigences des **organes de manœuvre** sont spécifiées en 6.2.3.

Les **dispositifs de commande intégrés** et **incorporés** peuvent être mis à la terre par leurs moyens de fixation, à condition que le contact se fasse par des surfaces métalliques propres. Cette remarque s'applique également, par exemple, à des **dispositifs de commande** comportant des **éléments sensibles** métalliques devant être reliés de façon sûre à des parties métalliques du matériel, si le fabricant a spécifié cette méthode de mise à la terre dans ses déclarations.

7.1.2 Les bornes de mise à la terre, les **connexions** de mise à la terre et les contacts de mise à la terre ne doivent pas être reliés électriquement à une borne de neutre quelconque.

La conformité à 7.1.1 à 7.1.2 inclus est vérifiée par examen.

7.2 Dispositifs de commande de la classe II et de la classe III

Les dispositifs de commande de la classe II et de la classe III ne doivent comporter aucune disposition en vue de la mise à la terre de protection.

La conformité est vérifiée par examen.

7.3 Connexions de terre appropriées

7.3.1 Exigences générales

La connexion entre une borne de mise à la terre, une **connexion** ou un contact de mise à la terre et les parties devant y être reliées, doit être de faible résistance.

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La conformité est vérifiée par l'essai suivant:

– *Un courant à 1,5 fois le courant assigné mais non inférieur à 25 A fourni par une source de courant alternatif dont la tension à vide ne dépasse pas 12 V, est autorisé à passer de la borne de mise à la terre, de la **connexion** de mise à la terre ou du contact de mise à la terre à successivement chacune des parties métalliques accessibles.*

– *La chute de tension est mesurée entre la borne de mise à la terre, la **connexion** de mise à la terre ou le contact de mise à la terre et la partie métallique accessible, et la résistance est calculée à partir du courant et de cette chute de tension. En aucun cas la résistance ne doit dépasser 0,1 Ω. L'essai est poursuivi jusqu'à l'établissement de conditions stables.*

NOTE 1 La résistance de contact entre l'extrémité de la sonde de mesure et la partie métallique en essai est telle qu'elle n'influence pas les résultats de l'essai.

NOTE 2 La mesure de la résistance comprend la résistance de tout **conducteur intégré**, mais la résistance de tout **conducteur externe** ou **interne** est exclue.

7.3.2 Câblage fixe et fixations du type X et du type M

Les bornes de mise à la terre pour le raccordement d'un **câblage fixe** ou des **câbles souples fixés à demeure** doivent utiliser des fixations du type X et du type M.

La conformité aux exigences de 8.1 est vérifiée.

7.3.3 Conducteurs externes

La mise à la terre des **conducteurs externes** ne doit pas se faire par des **bornes sans vis**, cependant, pour les **fixations du type Y** et **fixations du type Z**, il est permis d'utiliser des bornes de mise à la terre sans vis de type organe de serrage conformes à l'IEC 60998-2-2 ou à l'IEC 60998-2-3 ou sans vis de type organe de serrage conformes à l'IEC 60999-1.

7.3.4 Dimensions des bornes de mise à la terre accessibles

Les bornes de mise à la terre accessibles en **usage normal** doivent permettre le raccordement des conducteurs ayant des sections nominales comprises entre 2,5 mm^2 et 6 mm^2 et il ne doit pas être possible de les desserrer sans l'aide d'un **outil**.

7.3.5 Dimensions des bornes de mise à la terre accessibles

Les bornes de mise à la terre non accessibles en **usage normal** pour **conducteurs externes** doivent avoir une section supérieure ou égale à celle qui est exigée pour les bornes actives correspondantes.

7.3.6 Verrouillage des bornes de mise à la terre

Les organes de serrage des bornes de mise à la terre pour **conducteurs externes** doivent être protégés efficacement contre un desserrage accidentel.

La conformité à 7.3.2 à 7.3.6 inclus est vérifiée par examen, par essai manuel et par les essais applicables de 8.1.

NOTE En général, les constructions utilisées habituellement pour les bornes actives assurent une élasticité suffisante pour que les exigences d'une protection efficace contre un desserrage accidentel soient satisfaites, à condition qu'il n'y ait pas de niveaux vibratoires excessifs ni de cycles thermiques rapides. Si la borne est soumise à des vibrations excessives ou à des cycles thermiques rapides, des dispositions spéciales, par exemple l'emploi d'une partie suffisamment élastique telle qu'une plaque de serrage imperdable qui n'est pas susceptible d'être enlevée par inadvertance, peuvent être nécessaires dans le cas des **bornes à trous**.

Les bornes de mise à la terre sans vis de type organe de serrage pour **fixation de type Y** et **fixation de type Z** conformément à 7.3.3 sont considérées comme offrant une élasticité adéquate contre les vibrations et les cycles thermiques.

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7.4 Résistance à la corrosion

7.4.1 Généralités

Toutes les parties de la borne de mise à la terre doivent être résistantes à la corrosion résultant du contact entre ces parties et le cuivre du conducteur de mise à la terre ou de tout autre métal en contact avec ces parties.

7.4.2 Matériaux

Le corps de la borne de mise à la terre doit être en laiton ou en un autre métal résistant aussi bien à la corrosion, à moins qu'il ne fasse partie intégrante de l'armature métallique ou de l'enveloppe métallique, auquel cas toute vis ou tout écrou doit être en laiton, acier nickelé ou autre métal satisfaisant aux exigences de l'Article 22, ou d'un autre métal résistant aussi bien à la corrosion.

7.4.3 Armatures ou enveloppes en aluminium

Si le corps de la borne de mise à la terre fait partie intégrante d'une armature ou d'une enveloppe en aluminium ou en alliage, des dispositions doivent être prises pour éliminer le **risque** de corrosion due à l'action électrochimique résultant du contact entre le cuivre et l'aluminium ou ses alliages.

La conformité à 7.4, 7.4.2 et 7.4.3 est vérifiée par examen et, en cas de doute, par analyse des matériaux en présence et de leurs revêtements.

NOTE La protection contre la corrosion peut être obtenue par placage ou par un procédé analogue.

7.5 Autres exigences

7.5.1 Parties amovibles

Si une **partie amovible** d'un **dispositif de commande** a une connexion de terre, cette connexion doit être établie, lors de la mise en place de la partie, avant que les connexions transportant le courant le soient, et les connexions transportant le courant doivent être interrompues lors de l'enlèvement de la partie amovible, avant la coupure de la connexion de terre.

La conformité est vérifiée par examen.

7.5.2 Dispositif de commande incorporé

Si un **dispositif de commande incorporé** est susceptible, après avoir été monté dans le matériel, d'être séparé de sa mise à la terre normale pour des essais, des **réglages** ou des opérations d'**entretien** effectués alors que le matériel est sous tension, il doit être équipé d'une connexion ou d'un conducteur de mise à la terre tel qu'il ne soit pas exigé de le débrancher du **dispositif de commande** pour effectuer ces essais, **réglages** ou opérations d'**entretien**.

La conformité est vérifiée par examen.

NOTE C'est, par exemple, le cas des **dispositifs de commande** thermosensibles ou de dégivrage des réfrigérateurs.

7.6 Liaison équipotentielle de protection

Les exigences pour la **liaison équipotentielle de protection** sont celles prévues pour la **mise à la terre de protection** de 7.1 à 7.5.

Pour l'installation des dispositifs de commande qui comprennent plusieurs composants (élément thermosensible, transmetteurs, unité de commande centrale, récepteurs, actionneurs, unités d'interfaces) et lorsque de tels composants sont des parties de l'installation électrique

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fixe d'un bâtiment, les exigences pour la liaison de protection dans les normes de l'IEC pour l'installation des bâtiments s'appliquent.

8 Bornes et connexions

8.1 Bornes et connexions pour conducteurs externes en cuivre

8.1.1 Les bornes pour **câblage fixe** et pour **câbles souples fixés à demeure** ayant des **fixations du type X** et **du type M**, à l'exception de celles qui sont spécifiées en 8.1.3 doivent employer des vis, des écrous ou tout autre moyen de serrage aussi efficace ne nécessitant pas d'**outil spécial** pour la connexion et la déconnexion.

8.1.2 Les bornes ou **connexions** pour des **câbles souples fixés à demeure** ayant des **fixations du type Y** et **du type Z** peuvent exiger l'emploi d'**outils spéciaux** pour la connexion ou la déconnexion, mais doivent satisfaire aux exigences applicables aux bornes et **connexions** pour **conducteurs internes**.

La conformité à 8.1.1 et 8.1.2 est vérifiée par examen et par essai.

NOTE 1 Les bornes à serrage sous tête de vis conformes à l'IEC 60998-2-1, les **bornes sans vis** conformes à l'IEC 60998-2-2 ou à l'IEC 60998-2-3 et les bornes de mise à la terre de type organe de serrage conformes à l'IEC 60999-1 sont considérées comme des dispositifs efficaces.

NOTE 2 Les connecteurs à languette sont considérés comme exigeant l'emploi d'un **outil spécial**.

8.1.3 Les vis et les écrous pour le serrage des **conducteurs externes** doivent avoir un filetage métrique ISO ou un filetage aussi efficace. Ils ne doivent pas servir à la fixation d'autres éléments; ils peuvent toutefois serrer des **conducteurs internes** si ceux-ci sont disposés de façon qu'ils ne soient pas susceptibles de se déplacer lors du raccordement des **conducteurs externes**.

La conformité est vérifiée par examen.

NOTE Les filetages SI, BA et unifiés sont considérés comme étant aussi efficaces que le filetage métrique ISO.

8.1.4 Les **connexions** soudées, brasées, serties ou analogues ne doivent pas être utilisées pour la connexion des **câbles souples fixés à demeure** ayant des **fixations du type X** et **du type M**, à moins qu'elles soient autorisées dans la norme du matériel correspondante. Lorsque de telles **connexions** sont utilisées pour des **conducteurs externes**, elles doivent également satisfaire aux exigences de 8.2.2 et 8.2.3.

La conformité est vérifiée par examen.

NOTE Les normes particulières limitent l'utilisation de telles connexions.

8.1.5 Les bornes pour un **câblage fixe** ou pour des **câbles souples fixés à demeure** ayant des **fixations du type X** ou **du type M** doivent permettre au moins le raccordement de conducteurs dont la section nominale est indiquée dans le Tableau 2.

La conformité est vérifiée par examen, par mesure et en raccordant des conducteurs de la plus petite et de la plus grande section spécifiée ou déclarée.

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Tableau 2 – Section des conducteurs

Courant circulant dans la borne [a] A	**Section nominale** mm^2	
	Conducteurs pour câbles souples	**Conducteurs pour câblage fixe**
Jusqu'à 6 inclus [b]	0,5 à 1	1 à 1,5
Au-dessus de 6, jusqu'à 10 inclus	0,75 à 1,5	1 à 2,5
Au-dessus de 10, jusqu'à 16 inclus	1 à 2,5	1,5 à 4
Au-dessus de 16, jusqu'à 25 inclus	1,5 à 4	2,5 à 6
Au-dessus de 25, jusqu'à 32 inclus	2,5 à 6	4 à 10
Au-dessus de 32, jusqu'à 40 inclus	4 à 10	6 à 16
Au-dessus de 40, jusqu'à 63 inclus	6 à 16	10 à 25

[a] Des exigences pour les applications supérieures à 63 A sont à l'étude.

[b] Les sections nominales spécifiées ne s'appliquent pas aux bornes des circuits **TBTS** ou **TBTP** dont le courant ne dépasse pas 3 A.

Si une borne est prévue pour une gamme plus étendue de sections de conducteurs de **câblage fixe** ou de câble souple que celles indiquées aux colonnes 2 et 3 du Tableau 2, cette précision doit figurer dans le Tableau 1, exigence 11.

8.1.6 Les bornes pour un **câblage fixe** ou pour les **câbles souples fixés à demeure** ayant des **fixations du type X** ou **du type M** doivent être fixées de telle manière que le serrage ou le desserrage du moyen de connexion n'entraîne ni desserrage de la borne, ni efforts anormaux sur les **conducteurs internes**, ni réduction des **lignes de fuite** et **distances dans l'air** en dessous des valeurs spécifiées à l'Article 11.

La conformité est vérifiée par examen et par une mesure effectuée après 10 opérations de serrage et de desserrage d'un conducteur de la plus grande section spécifiée en 8.1.5, le conducteur étant déplacé à chaque desserrage. Pour les parties filetées, le couple de serrage maximal appliqué est soit celui indiqué dans le Tableau 9, soit le couple spécifié à la figure applicable (voir Figure 11 à Figure 14 incluse) suivant la valeur la plus grande.

Au cours de l'essai, les bornes ne doivent pas se desserrer et il ne doit pas se produire de dommages tels que rupture de vis, ou endommagements de fente de tête de vis, de filets, de rondelles, d'étrier ou d'autres parties, qui puissent compromettre l'usage ultérieur de la borne.

NOTE 1 Cette exigence n'impose pas que la borne soit conçue de manière à empêcher une rotation ou un déplacement, à condition toutefois que ce mouvement éventuel n'affecte pas la conformité aux autres exigences du présent document.

NOTE 2 Pour éviter le desserrage des bornes, deux vis de fixation, une vis dans un évidement ou tout autre moyen approprié peuvent être utilisés.

NOTE 3 L'enrobage dans une matière de remplissage ou dans une résine durcissante n'est considéré comme un moyen suffisant d'empêcher le desserrage de la borne que si

– l'enrobage n'est pas soumis à des contraintes mécaniques résultant de la connexion ou déconnexion du conducteur ou de l'emploi du matériel; et

– les caractéristiques de la matière de remplissage ne sont pas affectées par la température qui est susceptible d'atteindre la borne dans les conditions les plus défavorables exigées dans le présent document.

8.1.7 Les bornes pour un **câblage fixe** ou pour des **câbles souples fixés à demeure** ayant des **fixations du type X** ou **du type M** doivent être conçues de façon que l'âme du conducteur soit serrée entre des surfaces métalliques avec une pression de contact suffisante et sans dommage excessif pour le conducteur, sauf pour les **bornes sans vis** destinées à des circuits dont le courant ne dépasse pas 2 A, où l'une des surfaces de serrage peut être en matière non métallique.

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La conformité est vérifiée par examen de la borne et des conducteurs après l'essai de 8.1.6.

NOTE Les conducteurs présentant des entailles profondes ou du cisaillement sont considérés comme excessivement endommagés.

8.1.8 Les bornes pour un **câblage fixe** ou pour les **câbles souples fixés à demeure** ayant des **fixations du type X** ne doivent pas exiger une préparation spéciale des conducteurs pour réaliser une connexion correcte.

Les bornes ayant des **fixations du type X** peuvent avoir plusieurs moyens de connexion si au moins l'un de ces moyens est conforme à cette exigence, même si la connexion initiale établie en usine utilise un autre moyen de connexion. Dans ce cas, le moyen initial doit satisfaire aux exigences relatives aux bornes et **connexions** pour **conducteurs internes**.

La conformité est vérifiée par examen.

NOTE L'expression "préparation spéciale d'un conducteur" comprend le soudage de ses brins, l'utilisation des cosses, la confection d'œillets, etc., mais non la remise en forme du conducteur avant son introduction dans la borne ni le retoronnage d'une âme câblée pour consolider l'extrémité.

8.1.9 Les bornes pour un **câblage fixe** ou pour les **câbles souples fixés à demeure** ayant des **fixations du type X** et **du type M** doivent être conçues ou disposées de façon que ni les conducteurs, ni les brins d'une âme câblée ne puissent s'échapper lors du serrage des vis ou des écrous de fixation, ou lors de l'utilisation d'un moyen de fixation aussi efficace.

La conformité est vérifiée par les essais suivants.

a) Les bornes sont équipées des conducteurs prévus selon l'utilisation de la borne, conformément au Tableau 3. Les brins des conducteurs pour câblage fixe sont redressés avant d'être introduits dans les bornes.

b) Les fils des câbles souples sont tordus de façon régulière à raison d'un tour par 20 mm. Le conducteur est introduit dans la borne sur la longueur minimale spécifiée ou, si aucune longueur n'est spécifiée, jusqu'à ce qu'il dépasse juste de l'autre côté de la borne. L'introduction du conducteur se fait dans la position où il risque le plus de s'échapper et la vis est serrée avec un couple égal aux deux tiers de la valeur spécifiée dans le Tableau 9.

c) Pour les câbles souples, l'essai est répété avec un nouveau conducteur tordu comme le premier mais en sens inverse. Après l'essai, aucun brin du conducteur ne doit s'être échappé par l'intervalle qui sépare le moyen de serrage du dispositif de retenue.

Tableau 3 – Conducteurs de borne

Courant circulant dans la borne [a] A		**Conducteur à engager (nombre de brins et diamètre nominal de chaque brin en millimètres)**	
Conducteurs pour câbles souples	**Conducteurs pour câblage fixe**	**Conducteurs pour câbles souples**	**Conducteurs pour câblage fixe**
0 à 6	–	32 × 0,20	–
6 à 10	0 à 6	40 × 0,25	7 × 0,52
10 à 16	6 à 10	50 × 0,25	7 × 0,67
16 à 25	10 à 16	56 × 0,30	7 × 0,85
25 à 32	16 à 25	84 × 0,30	7 × 1,04
–	25 à 32	94 × 0,30	7 × 1,35
32 à 40	32 à 40	80 × 0,40	7 × 1,70
40 à 63	40 à 63	126 × 0,40	7 × 2,14

[a] Des exigences pour les applications supérieures à 63 A sont à l'étude.

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8.1.10 Les bornes doivent être conçues de façon à serrer le conducteur de façon fiable.

La conformité est vérifiée par les essais suivants.

a) Les bornes sont équipées de conducteurs de la plus petite et de la plus grande section nominale spécifiée en 8.1.5, à âmes rigides ou souples selon le cas applicable ou le plus défavorable, puis les vis sont serrées avec un couple égal aux deux tiers de la valeur spécifiée dans le Tableau 9. Chaque conducteur est soumis à une traction dont la valeur est spécifiée dans le Tableau 4. La traction est appliquée sans secousse, pendant 1 min, dans l'axe du logement du conducteur.

b) Normalement, l'essai de traction est appliqué directement au conducteur à proximité de son point d'entrée dans la borne. Toutefois, si la fixation du conducteur comprend un dispositif supplémentaire serti ou serré sur l'âme conductrice ou sur son isolation et s'étendant sur une longueur d'au plus 30 mm mesurée à partir du point d'entrée du conducteur dans la borne, il convient d'appliquer cet essai de traction à ce dispositif, et non à la borne proprement dite.

c) Pendant l'essai, le conducteur ne doit pas se déplacer de plus de 1,6 mm dans la borne.

Tableau 4 – Valeurs d'essai de traction du conducteur

Courant circulant dans la borne A	**Traction** N	
	Bornes pour conducteurs pour câbles souples	**Bornes pour conducteurs pour câblage fixe**
Jusqu'à 3 inclus	20	20
Au-dessus de 3, jusqu'à 6 inclus	30	30
Au-dessus de 6, jusqu'à 10 inclus	30	50
Au-dessus de 10, jusqu'à 16 inclus	50	50
Au-dessus de 16, jusqu'à 25 inclus	50	60
Au-dessus de 25, jusqu'à 32 inclus	60	80
Au-dessus de 32, jusqu'à 40 inclus	90	90
Au-dessus de 40, jusqu'à 63 inclus	100	100

8.1.11 Les bornes doivent être conçues de façon à ne pas atteindre en **usage normal** une température excessive susceptible de détériorer leur support isolant ou l'isolation des conducteurs serrés.

La conformité est vérifiée au cours des essais d'échauffement de l'Article 16.

8.1.12 Les bornes doivent être disposées de façon que chacun des conducteurs d'une gaine de **câblage fixe** ou de câble souple puisse être raccordé raisonnablement près des autres âmes du même câble, sauf si une raison technique valable s'y oppose.

La conformité est vérifiée par examen.

8.1.13 Les bornes pour **câbles souples fixés à demeure** ayant des **fixations du type X** et **du type M** doivent être disposées ou abritées de façon que si un brin vient à se détacher après raccordement des conducteurs, il n'y ait pas de **risque** de contact accidentel entre des **parties actives** et des parties métalliques accessibles, et dans le cas de **dispositifs de commande de la classe II** ou de **dispositifs de commande** destinés au matériel de la classe II, entre les **parties actives** et les parties métalliques séparées des parties métalliques accessibles par une **isolation supplémentaire** seulement. De plus, il ne doit pas y avoir de **risque** de court-circuiter une action déclarée assurant une **coupure totale** ou une **microcoupure** de circuit.

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La conformité est vérifiée par examen et par l'essai suivant:

– *L'extrémité d'une âme câblée ayant une section nominale égale à la section minimale spécifiée pour l'essai de 8.1.5 est dépouillée de son enveloppe isolante sur une longueur de 8 mm. Un brin de l'âme câblée est décâblé et les autres brins sont introduits complètement et serrés dans la borne. Le brin décâblé est plié, sans déchirer l'enveloppe isolante, dans toutes les directions possibles, mais sans angles vifs le long de cloisons.*

– *Le brin décâblé d'un conducteur relié à une borne active ne doit toucher aucune partie métallique accessible ou en liaison avec une partie métallique accessible ou, dans le cas de* ***dispositifs de commande de la classe II*** *ou de* ***dispositifs de commande*** *destinés au matériel de la classe II, aucune partie métallique séparée des parties actives par une* ***isolation supplémentaire*** *seulement.*

– *Le brin décâblé d'un conducteur relié à une borne de mise à la terre ne doit toucher aucune* ***partie active****.*

– *Le brin décâblé d'un conducteur relié à une borne active ne doit pas devenir accessible, ni pouvoir court-circuiter une action déclarée assurant une* ***coupure totale*** *ou une* ***microcoupure*** *de circuit.*

8.1.14 Les bornes doivent être conçues de manière que la continuité du circuit ne soit pas maintenue par une pression de contact transmise par un matériau isolant autre que céramique ou un autre matériau isolant ayant des caractéristiques au moins équivalentes, à moins que l'élasticité des parties métalliques associées soit suffisante pour compenser tout retrait et toute déformation.

La conformité est vérifiée par un examen initial et par d'autres examens des bornes après que les échantillons ont subi les essais de l'Article 19.

NOTE Pour de telles applications, la pertinence des matériaux isolants est jugée en fonction de leur stabilité dimensionnelle dans la plage de températures pour laquelle le **dispositif de commande** est prévu.

8.1.15 Les vis et autres parties filetées des bornes doivent être en métal.

La conformité est vérifiée par examen.

8.1.16 Les **bornes à trou** et les bornes à capot taraudé doivent être conçues de façon à permettre l'engagement d'une longueur suffisante du conducteur pour que son extrémité dépasse nettement l'extrémité de la vis pour assurer un serrage efficace du conducteur dans la borne.

La conformité est vérifiée pour les ***bornes à trou*** *par une mesure de la dimension "g" de la Figure 12 et pour les* ***bornes à capot taraudé*** *par la distance minimale spécifiée à la Figure 13.*

8.2 Bornes et connexions pour conducteurs internes

8.2.1 Raccordement des conducteurs

Les bornes et **connexions** pour conducteurs internes doivent permettre le raccordement de conducteurs ayant des sections nominales indiquées par le Tableau 5.

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Tableau 5 – Sections nominales des conducteurs

Courant circulant dans les bornes ou connexions[a] A	**Section nominale minimale du conducteur** mm^2
Jusqu'à 3 inclus	_ [b]
Au-dessus de 3, jusqu'à 6 inclus	0,75
Au-dessus de 6, jusqu'à 10 inclus	1
Au-dessus de 10, jusqu'à 16 inclus	1,5
Au-dessus de 16, jusqu'à 25 inclus	2,5
Au-dessus de 25, jusqu'à 32 inclus	4
Au-dessus de 32, jusqu'à 40 inclus	6
Au-dessus de 40, jusqu'à 63 inclus	10

[a] Des exigences pour les applications supérieures à 63 A sont à l'étude.

[b] Aucun minimum n'est spécifié, mais le fabricant doit déclarer la section de conducteurs à utiliser pour les essais.

Les exigences de 8.2.1 ne s'appliquent pas aux bornes de dispositifs qui ne sont pas destinées à recevoir des conducteurs normaux sans préparation spéciale, ni aux bornes qui, par leur conception et leur destination, ne peuvent recevoir des conducteurs normaux, ni aux bornes qui sont spécialement conçues pour recevoir des conducteurs de section différente et qui sont destinées exclusivement à certains types de matériels.

NOTE Par exemple, un thermostat destiné à être incorporé dans le tissu d'une couverture chauffante.

8.2.2 Adaptabilité à la fonction

Les bornes et **connexions** doivent être adaptées à leur fonction. Les raccordements pour des **connexions** soudées, serties ou brasées doivent être suffisamment robustes pour résister aux contraintes rencontrées en service normal.

La conformité est vérifiée par examen.

8.2.3 Bornes soudées

Lorsqu'il est fait usage de bornes soudées, le conducteur doit être disposé ou fixé de façon que le maintien en position ne dépende pas seulement de la soudure, à moins que des séparations ne soient prévues de sorte que les **lignes de fuite** et **distances dans l'air** entre les **parties actives** et les autres parties métalliques ne puissent être réduites à moins de 50 % des valeurs spécifiées dans l'Article 11, au cas où le conducteur s'échapperait de la connexion soudée.

La conformité est vérifiée par examen.

NOTE En général, l'accrochage avant soudage est considéré comme un moyen approprié pour maintenir en place le conducteur, à condition que le trou par lequel le conducteur est introduit ne soit pas excessivement grand, et que le conducteur ne fasse pas partie d'un fil rosette méplat à deux conducteurs.

D'autres méthodes de maintien en position du conducteur, telles que le resserrement des bords d'une languette de soudure, sont considérées comme convenables.

8.2.4 Connecteurs à languette

8.2.4.1 Les **languettes** faisant partie intégrante d'un **dispositif de commande** doivent satisfaire aux exigences dimensionnelles de la Figure 15 ou la Figure 16.

La conformité est vérifiée par des mesures.

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Des **languettes** de dimensions autres que celles indiquées à la Figure 15 ou la Figure 16 peuvent être utilisées à condition que les différences de dimensions et de formes soient assez importantes pour rendre impossible un engagement erroné dans un **réceptacle** normal (voir Figure 17).

Pour les dimensions de la Figure 15, de la Figure 16 et de la Figure 17, les dimensions physiques de l'IEC 61210 peuvent être utilisées comme alternative. Les exigences de performances de l'IEC 61210 ne sont pas applicables.

Des **languettes** assurant un détrompage des **réceptacles** selon leur polarité peuvent être utilisées (voir Figure 17).

8.2.4.2 Les **languettes** faisant partie d'un dispositif de commande doivent être constituées d'un matériau et d'un placage ayant des caractéristiques électriques, thermiques et mécaniques adaptées à l'application, notamment en ce qui concerne la résistance à la corrosion et la résistance mécanique. La température maximale des **languettes** doit être conforme aux spécifications du fabricant.

La conformité est vérifiée par les essais du présent document.

8.2.4.3 Les **languettes** faisant partie intégrante d'un **dispositif de commande** doivent avoir une robustesse suffisante pour permettre l'insertion et l'enlèvement des **réceptacles** sans causer de dommages au **dispositif de commande** susceptible d'affecter la conformité au présent document.

La conformité est vérifiée par l'application, sans secousses, de forces de traction axiales égales à celles indiquées dans le Tableau 6. Ces forces ne doivent causer ni déplacement ni dommages notables.

Tableau 6 – Valeurs des forces de traction axiales pour l'insertion et l'enlèvement de languette

Taille de la languette (voir Figure 17)	**Poussée**[a] N	**Traction**[a] N
2,8	50	40
4,8	60	50
6,3	80	70
9,5	100	100

[a] Les valeurs données dans le tableau sont des valeurs maximales admissibles pour l'insertion et l'enlèvement d'un **réceptacle** d'une **languette**.

8.2.4.4 Les **languettes** faisant partie intégrante d'un **dispositif de commande** doivent être suffisamment espacées pour permettre l'engagement des **réceptacles** appropriés.

Pour les dimensions de la Figure 15, de la Figure 16 et de la Figure 17, les dimensions physiques de l'IEC 61210 peuvent être utilisées comme alternative. Les exigences de performances de l'IEC 61210 ne sont pas applicables.

*La conformité est vérifiée par l'engagement du réceptacle approprié sur chaque **languette**, sauf spécification contraire en 7.2. Cet engagement ne doit entraîner aucune déformation de la languette ou des parties adjacentes. De plus, les lignes de fuite et les distances dans l'air ne doivent pas être réduites en dessous des valeurs spécifiées à l'Article 11.*

NOTE Aux **languettes** conformes à la Figure 15 ou la Figure 16 correspondent les **réceptacles** de la Figure 17.

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8.3 Bornes et connexions pour conducteurs intégrés

Il n'existe pas d'exigences ou d'essais spécifiques pour les bornes ou connexions pour **conducteurs intégrés** selon l'Article 8, mais les exigences appropriées des autres articles peuvent s'appliquer.

9 Exigences de construction

9.1 Matériaux

9.1.1 Matériaux isolants – Imprégnés

Le bois, le coton, la soie, le papier ordinaire et les matériaux fibreux ou hygroscopiques analogues ne doivent pas être utilisés comme isolants, sauf s'ils sont imprégnés.

La conformité est vérifiée par examen.

NOTE Un matériau isolant est considéré comme imprégné si un isolant approprié remplit pratiquement les interstices entre les fibres du matériau.

9.1.2 Pièces transportant le courant

Pour les parties en laiton venues de fonderies ou de décolletage, transportant le courant, autres que les parties filetées des bornes, l'alliage utilisé doit contenir au moins 50 % de cuivre, et pour les pièces venues de découpage dans des feuilles laminées, l'alliage utilisé doit contenir au moins 58 % de cuivre.

La conformité est vérifiée par examen, en comparant les exigences aux spécifications du fabricant, ou par analyse du matériau.

9.1.3 Câbles souples fixés à demeure

9.1.3.1 Les **câbles souples fixés à demeure** des **dispositifs de commande de la classe I** doivent comporter une isolation du conducteur à gaine vert/jaune qui est reliée à la borne ou à la **connexion** de mise à la terre du **dispositif de commande**, ou au contact de mise à la terre du socle de connecteur ou de la prise, s'il en existe.

9.1.3.2 L'isolation du conducteur dont la gaine est repérée par la combinaison des couleurs vert/jaune ne doit pas être reliée à des bornes ou des **connexions** autres que les bornes ou les **connexions** de mise à la terre.

La conformité à 9.1.3.1 et 9.1.3.2 est vérifiée par examen.

9.1.4 Tracés intentionnellement fragiles

Les **tracés intentionnellement fragiles** doivent être utilisés dans le seul but de protéger contre les dangers causés par la défaillance des composants indiqués dans le Tableau 14.

9.2 Protection contre les chocs électriques

9.2.1 Double isolation

Pour les dispositifs de commande à **double isolation**, la conception doit être telle que l'**isolation principale** et l'**isolation supplémentaire** puissent être soumises à essai séparément, à moins qu'il ne soit possible de vérifier d'une autre manière leurs propriétés respectives.

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S'il n'est pas possible de soumettre à essai séparément l'**isolation principale** et l'**isolation supplémentaire**, et s'il n'est pas possible de vérifier leurs propriétés par un autre moyen, l'isolation est considérée comme une **isolation renforcée**.

La conformité est vérifiée par examen et par essai.

NOTE Des échantillons ayant subi une préparation spéciale, ou des échantillons des parties isolantes, sont considérés comme des moyens de vérification.

9.2.2 Dérogation à la double isolation ou isolation renforcée

Les **dispositifs de commande de la classe II** et les **dispositifs de commande** destinés au matériel de la classe II doivent être conçus de façon que les **lignes de fuite** et les **distances dans l'air** sur une **isolation supplémentaire** ou une **isolation renforcée** ne puissent être réduites, par suite des effets de l'usure, en dessous des valeurs spécifiées à l'Article 11. Ils doivent être construits de façon que si des fils, des vis, des écrous, des rondelles, des ressorts, des **réceptacles** plats pour connecteur à languette ou des pièces analogues se desserrent ou se détachent, ils ne puissent en **usage normal** se placer dans une position telle que les **lignes de fuite** et les **distances dans l'air** sur une **isolation supplémentaire** ou une **isolation renforcée** soient réduites à moins de 50 % de la valeur spécifiée à l'Article 11.

Dans le cadre de cette exigence:

– *deux fixations indépendantes ne devraient pas se desserrer en même temps;*
– *les parties fixées au moyen de vis ou écrous et rondelles de blocage sont considérées comme non susceptibles de se desserrer, sous réserve qu'il ne soit pas exigé que ces vis ou écrous soient démontés en **entretien** ou en **maintenance par l'utilisateur**;*
– *les ressorts ou les pièces élastiques qui ne se desserrent pas ou ne se détachent pas au cours des essais des Articles 19 et 20 sont considérés comme satisfaisant aux exigences;*
– *les fils à connexions soudées sont considérés comme n'étant pas fixés de façon appropriée à moins d'être fixés mécaniquement en position près de leur **connexion**, indépendamment de la soudure;*
– *les fils connectés aux bornes sont considérés comme n'étant pas fixés de façon appropriée sauf en cas de fixation supplémentaire près de la borne. Dans le cas des âmes câblées, cette fixation supplémentaire doit serrer l'enveloppe isolante et non l'âme conductrice;*
– *les conducteurs rigides courts sont considérés comme non susceptibles de se séparer des bornes s'ils restent en place quand une vis ou un écrou est desserré.*

La conformité est vérifiée par examen, par mesure et/ou par essai manuel.

9.2.3 Conducteurs intégrés

9.2.3.1 Les **conducteurs intégrés** doivent être suffisamment rigides, suffisamment bien fixés et suffisamment bien isolés pour qu'en **usage normal** les **lignes de fuite** et les **distances dans l'air** ne puissent être réduites en dessous des valeurs spécifiées à l'Article 11.

9.2.3.2 L'isolation, si elle existe, doit être étudiée de manière à éviter toute détérioration au cours du montage ou en **usage normal**.

La conformité à 9.2.3.1 et 9.2.3.2 est vérifiée par examen, par des mesures et par un essai manuel.

NOTE Un conducteur est considéré comme étant nu si son isolation n'est pas au moins équivalente du point de vue électrique à celles qui sont spécifiées pour des câbles souples dans les normes applicables de l'IEC, ou si elle ne satisfait pas à l'essai de rigidité diélectrique qui consiste à appliquer une tension spécifiée entre l'âme conductrice et une feuille métallique appliquée autour de l'isolation, dans les conditions spécifiées à l'Article 15.

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9.2.4 Gaines de câbles souples

A l'intérieur du **dispositif de commande**, la gaine d'un câble souple ne doit être utilisée comme **isolation supplémentaire** qu'à l'endroit où elle n'est pas soumise à des conditions mécaniques ou thermiques excessives et dans la mesure où ses propriétés isolantes ne sont pas inférieures à celles spécifiées pour les gaines des câbles souples dans l'IEC 60227-1 ou dans l'IEC 60245-1.

La conformité est vérifiée par examen et, si nécessaire, par des essais portant sur les gaines des câbles souples, conformément à l'IEC 60227-1 ou à l'IEC 60245-1.

9.2.5 Impédance de protection

Les **impédances de protection** doivent être constituées d'au moins deux composants d'impédance de résistance équivalente en série, lesquelles sont connectées entre les **parties actives** et les **parties accessibles**. Elles doivent consister en des composants dont la probabilité de diminution d'impédance au cours de la durée de vie peut être ignorée et dont la possibilité de court-circuit est négligeable.

De tels composants sont:

– *les résistances détaillées en Note c du Tableau 14,*

Une variante consiste à devoir assurer la conformité des résistances aux exigences de l'IEC 60065:2014, 14.2.

– *les condensateurs.*

Les condensateurs doivent satisfaire à la classe Y de l'IEC 60384-14.

L'utilisation d'un seul condensateur Y1 est admise lorsque celui-ci est conforme à l'IEC 60384-14 et approprié à la **tension de service** de l'application dans laquelle il est utilisé.

La conformité est vérifiée:

a) *en ouvrant successivement le circuit de chaque composant d'impédance;*

b) *en court-circuitant les composants d'impédance susceptibles de subir une défaillance en cas de court-circuit (conformément à 13.1);*

c) *en appliquant une condition de **panne** conformément à 13.1 à tout élément d'un circuit qui pourrait influencer le **courant de contact** maximal avec l'**impédance de protection** intacte.*

*Le fonctionnement d'un dispositif de protection ou la perte d'un pôle de l'alimentation doivent aussi être considérés comme des **pannes**.*

Dans ces conditions, le matériel doit continuer à se conformer aux exigences de 6.1.9.

9.2.6 Protection contre les chocs électriques par l'utilisation de la TBTS ou de la TBTP

Voir Annexe P.

9.2.7 Connexions entre circuits TBTS/TBTP internes et externes

Des mesures appropriées doivent être prises pour empêcher l'interconnexion d'un circuit **TBTS** intégré à un circuit **TBTP** externe et vice versa.

L'alimentation d'un **dispositif de commande de la classe III** à partir d'une source **TBTS** externe au moyen d'un raccordement séparable ne doit être possible qu'au moyen d'un **système** de fiche et de socle dédié qui ne peut pas être monté sur ou interconnecté avec d'autres **systèmes** de raccordement.

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La conformité est vérifiée par examen.

9.2.8 Protection contre les surintensités

Les **dispositifs de commande** doivent être capables d'acheminer les courants susceptibles de circuler dans des conditions anormales pendant des périodes de temps équivalant à celles déterminées par les caractéristiques du dispositif de protection contre les surintensités. Pour les **dispositifs de commande intégrés** ou les **dispositifs de commande incorporés**, si le dispositif de protection contre les surintensités est externe au dispositif de commande, il doit être déclaré dans le Tableau 1, exigence 68.

La conformité est vérifiée par l'essai de 26.2.

9.3 Manœuvre et fonctionnement

9.3.1 Coupure totale de circuit

Les dispositifs de commande dont certaines positions sont déclarées comme produisant une **coupure totale de circuit** doivent être conçus de façon que, dans les positions déclarées, la séparation des contacts soit assurée pour tous les pôles d'alimentation autres que la terre, à une valeur au moins égale aux valeurs correspondantes de l'Article 11. La séparation des contacts peut être obtenue par action automatique ou action manuelle, mais toute action automatique ultérieure ne doit pas faire en sorte qu'une quelconque séparation de contacts soit réduite en dessous de la valeur minimale spécifiée.

Si la déconnexion est aussi déclarée produire une **coupure sur tous les pôles**, le **fonctionnement** des contacts dans chaque pôle d'alimentation doit être pratiquement simultané.

La conformité est vérifiée par examen et par les essais des Articles 15 et 11, si nécessaire.

9.3.2 Microcoupure

Les **dispositifs de commande** dont certaines positions sont déclarées comme produisant une **microcoupure** de circuit doivent être conçus de façon que, dans les positions déclarées, la séparation des contacts soit assurée pour au moins un pôle d'alimentation pour satisfaire aux exigences de rigidité diélectrique de l'Article 15, mais aucune valeur de **distance dans l'air** n'est spécifiée. La séparation des contacts peut être obtenue par **action automatique** ou **action manuelle**, mais toute modification ultérieure de la **grandeur de manœuvre** entre les limites déclarées dans le Tableau 1, exigence 30, ou de la température de la **tête de commande** entre les limites déclarées dans le Tableau 1, exigence 15, ne doit pas provoquer un **fonctionnement** qui réduirait la séparation des contacts de façon que les exigences de l'Article 15 ne soient plus satisfaites.

La conformité est vérifiée par examen et, si nécessaire, par les essais de l'Article 15, exécutés aux limites de température déclarées.

9.3.3 Boutons de réarmement

Les boutons de réarmement des **dispositifs de commande** doivent être disposés ou protégés de façon qu'il soit peu probable qu'ils puissent être réarmés accidentellement.

Cette exigence ne s'applique pas aux **dispositifs de commande** à réarmement manuel avec actions à **déclenchement libre**.

La conformité est vérifiée par examen.

NOTE Cette exigence exclut par exemple les boutons de réarmement montés dans une position telle qu'ils puissent être réarmés en poussant le **dispositif de commande** contre un mur ou en poussant un meuble contre le **dispositif de commande**.

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9.3.4 Réglage par le fabricant

Les organes destinés au **réglage** des **dispositifs de commande** par le fabricant doivent être fixés de façon à empêcher un déplacement accidentel après **réglage**.

La conformité est vérifiée par examen.

9.3.5 Contacts

9.3.5.1 Généralités

Les contacts dont la capacité de coupure en courant continu est supérieure à 0,1 A et qui peuvent être **manœuvrés** doivent être conçus de telle manière que les vitesses de rapprochement et d'écartement des surfaces de contact soient indépendantes de la vitesse de **manœuvre**.

La conformité est vérifiée par examen.

NOTE Cette exigence n'est pas applicable aux contacts qui sont explicitement exclus de 9.3.7.

9.3.5.2 Systèmes de fonctions de commande de classe C

9.3.5.2.1 Les **systèmes** de **fonctions de commande de classe C** doivent comprendre au moins deux éléments de commutation pour mettre directement hors tension les bornes de sécurité.

NOTE Un seul relais actionnant deux contacts indépendants est considéré comme un seul élément de commutation.

– Des mesures doivent être prises pour éviter les erreurs de cause commune et ainsi assurer la protection contre les **défaillances** de deux éléments de commutation (au moins), en raison d'une cause commune, par un court-circuit externe qui pourrait empêcher l'**arrêt de sécurité** du **dispositif de commande**.

Les méthodes acceptables sont, par exemple:

– une protection contre les surintensités,
– une limitation du courant, ou
– des moyens de détection des **pannes** internes.

La pertinence des mesures de maintien de la capacité à interrompre la mise sous tension des bornes de sortie de sécurité par au moins un élément de commutation ou l'interruption d'un dispositif de protection contre les surintensités doit être vérifiée par l'essai suivant.

Les bornes de sortie de sécurité du dispositif de commande sont connectées à un interrupteur permettant de commander le courant de court-circuit. Cet interrupteur étant ouvert, le dispositif de commande est connecté comme indiqué en 13.1.3 avec les sorties mises sous tension afin de simuler un fonctionnement normal (contacts des éléments de commutation internes fermés).

Le matériel d'essai doit présenter les caractéristiques suivantes:

a) si des dispositifs de protection contre les surintensités sont utilisés, le réseau d'alimentation du **dispositif de commande** doit être en mesure de fournir un courant de court-circuit d'au moins 500 A;
b) si des techniques de limitation du courant sont utilisées comme mesure de protection (un transformateur, par exemple), le réseau d'alimentation du **dispositif de commande** ne doit pas limiter le courant de court-circuit déclaré (Tableau 1*,* exigence 67).

9.3.5.2.2 Un court-circuit est appliqué entre les bornes de sortie de sécurité du **dispositif de commande** en fermant l'interrupteur.

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L'essai est réalisé pendant 1 h ou jusqu'à ce que le courant ne traverse plus l'interrupteur, selon ce qui se produit en premier.

Si un dispositif de protection contre les surintensités peut être remplacé et qu'il a fonctionné pendant l'essai, il doit être remplacé et l'essai répété deux fois de plus en essayant de redémarrer le ***dispositif de commande*** *et en maintenant l'interrupteur fermé.*

L'essai est répété à l'aide du même échantillon ou sur un échantillon différent, l'interrupteur étant maintenu en position fermée avant la première séquence de démarrage.

9.3.5.2.3 Si une fonction de détection de **panne** du **dispositif de commande** ouvre les éléments de commutation ou déclenche l'**arrêt de sécurité**, l'essai est répété deux fois en essayant de redémarrer le **dispositif de commande** tout en maintenant le court-circuit externe.

La conformité est vérifiée conformément à 13.1.3.8 et à l'Article H.17.

Après l'essai, au moins un élément de commutation du ***dispositif de commande*** *doit être en mesure de mettre hors tension les bornes de sortie de sécurité ou un dispositif de protection contre les surintensités non remplaçable a définitivement interrompu l'alimentation des bornes de sortie de sécurité.*

9.3.6 Contacts pour coupure totale de circuit et microcoupure

Les contacts produisant une **coupure totale de circuit** ou une **microcoupure** dont la capacité de coupure en courant continu ne dépasse pas 0,1 A ou qui coupent des courants alternatifs, et qui peuvent être **manœuvrés**, doivent être conçus de telle manière qu'ils ne prennent au repos que des positions ouvertes ou des positions fermées.

La conformité est vérifiée par examen et, dans le cas d'une position fermée, par application des exigences de température de l'Article 16 et, dans le cas d'une position ouverte, par application des exigences de l'Article 15 concernant les ***microcoupures****. Cependant, lorsque l'****organe de manœuvre*** *peut occuper une* ***position intermédiaire*** *voisine d'une* ***position repérée*** *déclarée pour une* ***coupure totale de circuit****, les essais des Articles 15 et 11 concernant les* ***coupures totales de circuit*** *sont applicables à cette* ***position intermédiaire****.*

9.3.7 Exclusions pour 9.3.5.1 et 9.3.6

9.3.7.1 Les exigences de 9.3.5.1 et 9.3.6 ne doivent pas s'appliquer aux contacts dont l'examen montre qu'ils ne peuvent fonctionner ou ne sont pas destinés à fonctionner en charge, ni aux contacts qui ne produisent pas d'arc dans les conditions d'**usage normal**.

La conformité est vérifiée par examen et, si nécessaire, par l'essai de 9.3.7.2.

9.3.7.2 *Une tension continue égale à la* ***tension maximale de service*** *est appliquée aux contacts en série avec une résistance telle que le courant se produisant en* ***usage normal*** *soit obtenu. Il ne doit pas être possible de maintenir un arc par l'ouverture lente des contacts.*

9.3.8 Position de repos des contacts

Dans toute position de repos de l'**organe de manœuvre**, les contacts doivent être, soit dans leur position prévue ouverte ou fermée, soit dans une position ne présentant aucun **danger** à l'intérieur du dispositif ou du matériel.

La conformité est vérifiée par examen.

NOTE 1 Le terme "position de repos de l'**organe de manœuvre**" couvre toute position, qu'elle soit repérée, intermédiaire ou de **réglage par l'utilisateur**.

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NOTE 2 Afin d'essayer d'obtenir une **position intermédiaire** de l'**organe de manœuvre**, entre toutes les positions indexées, marquées ou de repos prévu, l'**organe de manœuvre** peut être actionné comme en **usage normal**. Maintenir l'**organe de manœuvre** en position n'est pas une **manœuvre**.

9.3.9 Dispositifs de commande à traction

Les **dispositifs de commande à traction** doivent être conçus de façon qu'après une manœuvre du **dispositif de commande** suivie du relâchement du **cordon de traction**, les parties concernées du mécanisme ne puissent normalement manquer de revenir à une position permettant l'exécution immédiate du mouvement suivant du cycle de **manœuvre** du **dispositif de commande**.

La conformité est vérifiée par examen et par l'essai suivant.

*Les **dispositifs de commande à traction** peuvent être manœuvrés d'une **position repérée** à la suivante par une traction temporaire et uniforme exercée sur le cordon avec une force verticale de 45 N ou une force oblique à 45° de 70 N, le **dispositif de commande** étant monté dans n'importe quelle position déclarée.*

NOTE Les forces de manœuvre des **dispositifs de commande** manœuvrés par un moyen autre qu'un **cordon de traction** ne sont pas spécifiées. L'attention est attirée sur la norme du matériel correspondant où de telles exigences sont données.

9.3.10 Voir J.9.3.10.

9.4 Actions

9.4.1 Actions combinées

Un **dispositif de commande** comportant plusieurs actions, dont l'une est conçue pour fonctionner après la **défaillance** d'une ou d'autres actions, doit être construit de telle façon que cette action reste opérante après la **défaillance** d'une portion quelconque spécifique de toutes autres actions.

La conformité est vérifiée par examen et, si nécessaire, par des essais après avoir rendu toutes les autres actions inopérantes.

9.4.2 Réglage par le fabricant

Une **action de type 2** pour laquelle il a été prévu un réglage par le fabricant de sa valeur de fonctionnement, de son temps de fonctionnement ou de sa séquence de fonctionnement, doit être conçue de façon qu'il soit possible de voir si le réglage initial a été ou non modifié ultérieurement.

La conformité est vérifiée par examen.

9.4.3 Action de type 2

Toute **action de type 2** doit être conçue de manière à confiner la **tolérance de fabrication** et la **dérive** de sa **valeur de fonctionnement**, de son **temps de fonctionnement** ou de sa **séquence de fonctionnement** dans la limite déclarée dans le Tableau 1, exigence 35 et exigence 36.

La conformité est vérifiée par les essais des Articles 17 à 19 inclus.

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9.4.4 Action de type 1.A ou 2.A (Fonctionnement se traduisant par une coupure totale de circuit)

Une action de type 1.A ou 2.A doit fonctionner de façon à satisfaire aux exigences de rigidité diélectrique et de **distance dans l'air** spécifiées pour une **coupure totale de circuit**.

La conformité est vérifiée par les essais de l'Article 15 et les exigences appropriées de l'Article 11.

9.4.5 Action de type 1.B ou 2.B (Fonctionnement se traduisant par une microcoupure)

Une action de type 1.B ou 2.B doit fonctionner de façon à satisfaire aux exigences de rigidité diélectrique spécifiées pour une **microcoupure**.

La conformité est vérifiée par l'essai de l'Article 15 et les exigences appropriées de l'Article 11.

9.4.6 Action de type 1.C ou 2.C (Fonctionnement se traduisant par une micro-interruption)

Une action de type 1.C ou 2.C doit fonctionner de façon à interrompre le circuit par une **micro-interruption**.

La conformité est vérifiée par les exigences appropriées de l'Article 11.

9.4.7 Action de type 1.D ou 2.D (mécanisme à déclenchement libre ne pouvant être, même momentanément, réarmé en présence d'une panne)

Une action de type 1.D ou 2.D doit être conçue de façon que la coupure ne puisse être ni empêchée ni gênée par un éventuel mécanisme de réarmement et qu'après la coupure, il ne soit pas possible de refermer le circuit, même temporairement, tant que la condition de dépassement ou de **panne** persiste.

La conformité est vérifiée par examen et par essai.

9.4.8 Action de type 1.E ou 2.E (mécanisme à déclenchement libre n'empêchant pas l'ouverture ou le maintien fermé de ses contacts tant que la panne persiste)

Une action de type 1.E ou 2.E doit être conçue de façon que la coupure ne puisse être ni empêchée ni gênée par un éventuel mécanisme de réarmement et que les contacts ne puissent être ni empêchés de s'ouvrir, ni maintenus fermés tant que la condition de dépassement ou de **panne** persiste.

EXEMPLE **Dispositif de commande sensible** au courant qui est tenu de, ou peut, être réenclenché momentanément pour détecter si le courant de **panne** persiste.

La conformité est vérifiée par examen et par essai.

9.4.9 Action de type 1.F ou 2.F (action d'un dispositif qui ne peut être réenclenchée qu'à l'aide d'un outil)

Une action de type 1.F ou 2.F doit être conçue de façon qu'après le montage du **dispositif de commande** conformément aux instructions du fabricant, il ne puisse être réarmé qu'à l'aide d'un **outil**.

La conformité est vérifiée par examen.

NOTE Cette exigence est considérée comme satisfaite si le montage dans le matériel est tel qu'un **outil** soit exigé pour accéder au **dispositif de commande**.

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9.4.10 Action de type 1.G ou 2.G (action d'un dispositif qui n'est pas destinée à être réenclenchée dans les conditions de charge électrique)

Une action de type 1.G ou 2.G doit être conçue de façon qu'il soit possible de réarmer le **dispositif de commande**, après qu'il a fonctionné (fonctionnement non intentionnel) dans les conditions de charge électrique.

La conformité est vérifiée par examen et en réarmant une fois le dispositif de commande à sa tension assignée et à son courant assigné.

9.4.11 Action de type 1.H ou 2.H (mécanisme à déclenchement libre dans lequel l'ouverture des contacts ne peut être empêchée, et qui peut être remis à la position fermée après rétablissement des conditions de fonctionnement normal si le moyen de réarmement est maintenu en position "réarmement")

Une action de type 1.H ou 2.H doit être conçue de façon que l'ouverture des contacts ne puisse être empêchée et que la remise automatique des contacts en position fermée puisse se faire si le moyen de réarmement est maintenu en position de réarmement. Le **dispositif de commande** ne doit pas se réarmer automatiquement à une température supérieure à –35 °C avec le mécanisme de réarmement en position normale.

La conformité est vérifiée par examen et par essai.

NOTE L'essai est indiqué dans la Partie 2 applicable.

9.4.12 Action de type 1.J ou 2.J (mécanisme à déclenchement libre dans lequel l'ouverture des contacts ne peut être empêchée et pour lequel le fonctionnement du dispositif de commande en tant que dispositif à réarmement automatique n'est pas admis si le moyen de réarmement est maintenu en position réarmement ou mise en marche)

Une action de type 1.J ou 2.J doit être conçue de façon que l'ouverture des contacts ne puisse être empêchée, et que le fonctionnement du **dispositif de commande** en tant que dispositif automatique de réarmement ne soit pas admis si le moyen de réarmement est maintenu en position de réarmement. Le **dispositif de commande** ne doit pas se réarmer automatiquement à une température supérieure à 0 °C ou –35 °C.

La conformité est vérifiée par examen et par essai.

NOTE L'essai est indiqué dans la Partie 2 applicable.

9.4.13 Action de type 1.K ou 2.K (pour les actions basées sur la détection d'une grandeur, pas d'accroissement de la valeur de fonctionnement résultant de la rupture de l'élément sensible ou des parties reliant l'élément sensible à la tête de commande)

Une action de type 1.K ou 2.K doit être conçue de façon qu'en cas d'une rupture dans l'**élément sensible**, ou dans toute autre partie entre l'**élément sensible** et la **tête de commande**, la coupure déclarée intervienne avant que la **valeur**, le **temps** ou la **séquence de fonctionnement** déclarés ne soient dépassés.

NOTE L'essai est indiqué dans la Partie 2 applicable.

9.4.14 Action de type 1.L ou 2.L (action qui n'exige pas de source d'énergie auxiliaire externe d'alimentation électrique pour le fonctionnement envisagé)

Une action de type 1.L ou 2.L doit être conçue de façon qu'en cas de **défaillance** dans l'alimentation électrique, le dispositif accomplisse la fonction prévue indépendamment de toute source d'énergie ou d'alimentation électrique externe ou auxiliaire.

La conformité est vérifiée par examen.

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NOTE Un ressort ou un poids simple à action directe n'est pas considéré comme une source d'énergie ou d'alimentation électrique externe ou auxiliaire.

9.4.15 Action de type 1.M ou 2.M (action qui fonctionne après une période de vieillissement déclarée)

Une action de type 1.M ou 2.M doit être conçue de façon que le dispositif fonctionne de la manière prévue après la procédure de vieillissement déclarée.

La conformité est vérifiée par l'essai de 19.6.

9.4.16 Action de type 1.Y ou 2.Y (fonctionnement se traduisant par une coupure électronique)

9.4.16.1 Une action de type 1.Y ou 2.Y doit fonctionner pour assurer la **coupure électronique**.

La conformité est vérifiée conformément à 9.4.16.2 et 9.4.16.3.

9.4.16.2 L'essai est effectué avec le **dispositif de commande** raccordé à sa charge maximale déclarée, alimenté à la tension assignée, et pour la température T_{max}.

9.4.16.3 Le courant traversant la **coupure électronique** ne doit pas dépasser 5 mA ou 10 % du courant assigné, suivant la valeur la plus basse.

9.4.17 Voir J.9.4.17.

9.5 Ouvertures dans les enveloppes

Les trous d'écoulement éventuels doivent avoir une section minimale de 20 mm^2, une section maximale de 40 mm^2 et une dimension minimale de 3 mm.

La conformité est vérifiée par examen.

NOTE 1 Les exigences supplémentaires de résistance à l'humidité sont contenues à l'Article 14.

NOTE 2 Les **dispositifs de commande** classés IPX7 peuvent comporter un moyen pour ouvrir un trou d'écoulement.

9.6 Montage des dispositifs de commande

9.6.1 Les **dispositifs de commande** doivent être conçus de façon que le montage selon les méthodes déclarées par le fabricant ne compromette pas la conformité aux exigences du présent document.

9.6.2 Les méthodes de montage déclarées doivent interdire toute rotation ou tout déplacement du **dispositif de commande**, qui ne peut en outre être démonté du matériel qu'à l'aide d'un **outil**, si un tel déplacement ou démontage risque d'affecter la conformité au présent document. Si un démontage ou démontage partiel est nécessaire au bon fonctionnement du **dispositif de commande**, les exigences des Articles 6, 15 et 11 doivent être satisfaites avant et après un tel démontage.

La conformité à 9.6.1 et 9.6.2 est vérifiée par examen et par un essai manuel.

NOTE Les **dispositifs de commande** autres que ceux à **manœuvre** rotative, qui sont fixés à l'aide d'un écrou se vissant sur une seule traversée concentrique par rapport à la **liaison de manœuvre**, sont considérés comme satisfaisant à cette exigence à condition que le serrage de l'écrou exige un **outil** et que les parties concernées aient une robustesse suffisante. Un **dispositif de commande incorporé** monté par une fixation sans vis est considéré comme satisfaisant à cette exigence s'il ne peut être enlevé du matériel qu'à l'aide d'un **outil**.

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9.6.3 Montage de dispositifs de commande à montage indépendant

9.6.3.1 Les **dispositifs de commande à montage indépendant** autres que ceux prévus pour montage en panneau doivent:

– soit équiper une boîte normale comme annoncé;

– soit être fournis avec une boîte de conduits si une boîte spéciale de conduits est exigée;

– soit être prévus pour montage en saillie sur une surface plane.

9.6.3.2 Si une boîte spéciale de conduits est exigée, elle doit être fournie en même temps que le **dispositif de commande** et la boîte doit être prévue avec les entrées pour conduits spécifiées dans l'IEC 60423.

9.6.3.3 Les **dispositifs de commande à montage indépendant** pour montage en saillie, utilisés en installation enterrée (câblage caché) sans boîte de sortie doivent être dotés de trous convenables à l'arrière du **dispositif de commande**, permettant une installation et une connexion faciles aux bornes.

9.6.3.4 Les **dispositifs de commande à montage indépendant** pour montage en saillie, utilisés en câblage exposé, doivent être dotés d'entrées de câble ou de conduit, de parois défonçables ou de presse-étoupes qui permettent la connexion de modèles appropriés de câble ou de conduits répondant aux normes IEC les concernant.

9.6.3.5 Les **dispositifs de commande à montage indépendant** pour montage en saillie ou les sous-bases pour de tels **dispositifs de commande** doivent être construits de façon que les bornes pour **conducteurs externes** soient accessibles et puissent être utilisées lorsque le **dispositif de commande** ou la sous-base est correctement fixé à son support et que son **couvercle** (ou le **dispositif de commande**) est retiré.

9.6.3.6 Les **dispositifs de commande** pour montage sur une boîte de sortie ou enveloppe similaire doivent avoir les bornes de câblage, les autres **parties actives** et les parties métalliques tranchantes, mises à la terre ou non, situées et protégées de façon à ne pas être appliquées contre le câblage dans la boîte ou l'enveloppe pendant l'installation du **dispositif de commande**.

9.6.3.7 Dans le cas où des bornes de câblage situées à l'arrière sont utilisées, elles doivent être encastrées ou protégées par des écrans à proximité, des matériaux isolants, ou l'équivalent, qui empêchent le contact avec le câblage installé dans la boîte.

9.6.3.8 *La conformité à 9.6.3.1 à 9.6.3.7 inclus est vérifiée par examen.*

Des bornes qui, à l'intérieur de la boîte ne dépassent pas le plan du bord de la face de la boîte sont acceptables.

Les dispositifs de protection des bornes de câblage qui s'étendent de 6,5 mm au moins au-delà de ces bornes, avec un dispositif de protection correspondant entre les deux pôles de mécanismes, sont acceptables.

9.7 Fixation des câbles

9.7.1 Câbles souples

9.7.1.1 Les câbles souples des **dispositifs de commande intercalés dans un câble souple** et **séparés** doivent être capables de supporter le nombre de flexions susceptibles de se produire en **usage normal**. Si un dispositif de protection du câble est nécessaire pour satisfaire à cette exigence, il ne doit pas faire partie intégrante du câble souple si celui-ci utilise une **fixation** du **type X**.

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9.7.1.2 *La conformité est vérifiée en soumettant le **dispositif de commande** équipé du câble souple ou du jeu de câbles souples prévu à l'essai de 20.8.*

9.7.2 Dispositifs d'arrêt de traction et de torsion

9.7.2.1 Les **dispositifs de commande** autres que les **dispositifs intégrés** et **incorporés** destinés à recevoir des **câbles souples fixés à demeure** doivent comporter les dispositifs d'arrêt de traction et de torsion tels que les conducteurs soient protégés contre les efforts de traction, y compris de torsion, à l'endroit où ils sont raccordés aux bornes, et tels que les gaines soient protégées contre l'abrasion. La façon prévue de réaliser la protection contre la traction et la protection contre la torsion doit être facile à reconnaître.

9.7.2.2 Les dispositifs d'arrêt de traction et de torsion pour les **dispositifs de commande de la classe II** doivent être en matériau isolant ou, s'ils sont en métal, séparés des parties métalliques accessibles ou d'une feuille métallique sur des surfaces accessibles non métalliques, par une isolation conforme aux exigences de l'**isolation supplémentaire**.

9.7.2.3 Les dispositifs d'arrêt de traction et de torsion pour **dispositifs de commande** autres que ceux de la classe II doivent être en matériau isolant, ou équipés d'une enveloppe isolante, si une **panne** d'isolement sur le câble peut rendre les parties métalliques accessibles actives. Le revêtement isolant éventuel doit être fixé au dispositif d'arrêt de traction et de torsion à moins qu'il ne s'agisse d'une traversée faisant partie du dispositif de protection des câbles prévue pour satisfaire aux exigences de 9.7.1.

9.7.2.4 Les dispositifs d'arrêt de traction et de torsion doivent être conçus de façon que:

– le câble ne puisse entrer en contact avec des vis de serrage de ces dispositifs d'arrêt de traction et de torsion si ces vis sont des parties métalliques accessibles;
– le câble ne soit pas maintenu par une vis métallique qui appuie directement sur le câble;
– pour les **fixations du type X** et **du type M**, au moins une partie soit fixée de façon sûre au **dispositif de commande**;
– pour les **fixations du type X** et **du type M**, le remplacement du câble souple n'exige pas d'**outil spécial**;
– pour les **fixations du type X**, ils soient efficaces pour les différents types de câbles souples qui peuvent être raccordés;
– pour les **fixations du type X**, ils soient conçus et disposés de façon que le remplacement du câble souple puisse être effectué facilement.

9.7.2.5 Pour les fixations autres que les **fixations du type Z**, les procédés de fortune tels que la fixation du câble par un nœud ou la fixation des extrémités par une ficelle ne doivent pas être employés.

9.7.2.6 Les presse-étoupes ne doivent pas être utilisés comme dispositifs d'arrêt de traction et de torsion pour les **dispositifs de commande intercalés dans un câble souple** ayant des **fixations du type X**, à moins que ne soient prévus des moyens permettant le serrage de tous les types et toutes les sections de câble mentionnés en 10.1.4.

9.7.2.7 Les vis éventuelles qui doivent être manœuvrées lors du remplacement du câble ne doivent pas servir à fixer d'autres éléments sauf si, lorsqu'elles sont oubliées ou remplacées de façon incorrecte, le **dispositif de commande** ne fonctionne plus ou est manifestement incomplet, ou si l'élément destiné à être fixé par ces vis ne peut être enlevé sans l'aide d'un **outil** lors du remplacement du câble souple.

9.7.2.8 *La conformité aux spécifications de 9.7.2.1 à 9.7.2.7 inclus est vérifiée par examen et par les essais de 20.9 inclus. Les dispositifs de commande incorporés et **intégrés** qui sont destinés au raccordement de câbles souples sont soumis à essai conformément à la norme applicable pour le matériel dans lequel ils sont intégrés où incorporés.*

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9.8 Dimensions des câbles souples fixés à demeure

9.8.1 Les **câbles souples fixés à demeure** doivent être au moins des câbles sous gaine ordinaire de caoutchouc (désignation IEC 60245 53) ou des câbles sous gaine légère de polychlorure de vinyle (désignation IEC 60227 53). L'utilisation d'un câble souple autre que ceux susmentionnés est admissible si elle est autorisée dans la norme particulière du matériel ou pour la connexion à des dispositifs **TBTS** externes (capteurs/unités).

La conformité est vérifiée par examen.

9.8.2 Les **dispositifs de commande** équipés de **câbles souples fixés à demeure** doivent l'être avec des câbles dont les conducteurs ont des sections au moins égales aux valeurs du Tableau 7.

Tableau 7 – Sections minimales de conducteurs de câble souple

Courant dans le circuit applicable[a] A	**Section nominale** mm^2
Jusqu'à 6 inclus [b]	0,75
Au-dessus de 6, jusqu'à 10 inclus	1
Au-dessus de 10, jusqu'à 16 inclus	1,5
Au-dessus de 16, jusqu'à 25 inclus	2,5
Au-dessus de 25, jusqu'à 32 inclus	4
Au-dessus de 32, jusqu'à 40 inclus	6
Au-dessus de 40, jusqu'à 63 inclus	10

[a] Des exigences pour les applications supérieures à 63 A sont à l'étude.

[b] Les sections inférieures à 0,75 mm^2 sont admises pour les **dispositifs de commande de la classe III** ou si la norme particulière du matériel ou d'installation autorise de telles sections.

La conformité est vérifiée par examen.

9.8.3 Dans les **dispositifs de commande**, l'espace intérieur prévu pour le logement des câbles souples doit être suffisant pour que leur introduction et leur connexion soient faciles, les **couvercles** éventuels devant pouvoir être refermés sans **risque** de dommage pour les conducteurs ou leurs gaines isolantes. Il doit être possible de vérifier le montage correct des conducteurs avant la remise en place du **couvercle**.

La conformité est vérifiée par examen et par un essai de montage de la plus forte section de conducteur mentionnée en 8.1.5.

9.9 Entrées

9.9.1 Les entrées de câbles souples externes doivent être conçues et profilées ou doivent être équipées de traversées de telle façon que le revêtement du câble puisse être introduit sans **risque** de détérioration.

La conformité est vérifiée par examen.

9.9.2 Les entrées de conduit et les parois défonçables des **dispositifs de commande à montage indépendant** doivent être conçues ou situées de telle manière que la pénétration de l'embout de conduit, ou de ses accessoires n'affecte pas la protection contre les chocs électriques ni ne réduise les **lignes de fuite** ou **distances dans l'air** en dessous des valeurs spécifiées à l'Article 11.

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La conformité est vérifiée par examen.

9.9.3 En l'absence d'une traversée, l'entrée du câble doit être en matériau isolant.

9.9.4 Lorsque l'entrée est équipée d'une traversée, celle-ci doit être en matériau isolant et

– doit être de forme telle qu'elle ne puisse endommager le câble;
– doit être fixée de façon sûre;
– ne doit pas pouvoir être enlevée sans l'aide d'un **outil**;
– ne doit pas faire partie intégrante du câble si une **fixation de type X** est utilisée.

9.9.5 Une traversée ne doit pas être en caoutchouc, sauf dans le cas des **fixations du type M**, **du type Y** et **du type Z** pour les **dispositifs de commande des classes 0**, **0I** ou **I** où le caoutchouc est admis si la traversée fait partie intégrante d'une gaine en caoutchouc naturel.

La conformité aux spécifications de 9.9.1 à 9.9.5 inclus est vérifiée par examen et par un essai manuel.

9.9.6 Les enveloppes des **dispositifs de commande à montage indépendant** prévus pour être reliés en permanence au **câblage fixe** doivent avoir des entrées de câble, des entrées de conduit, des parois défonçables ou des presse-étoupes qui permettent la connexion du conduit, du câble ou du câble souple appropriés.

La conformité est vérifiée par examen.

9.10 Socles de connecteurs et prises

9.10.1 Les socles et les prises destinés à être utilisés par l'**utilisateur** pour l'interconnexion des **dispositifs de commande** et des matériels associés doivent être conçus de manière à rendre improbable leur engagement mutuel ou avec des socles et des prises destinées à établir des connexions avec d'autres **systèmes**, si un tel engagement représente un risque d'incendie, de blessure ou de choc électrique pour les personnes ou un dommage pour le matériel ou son environnement.

La conformité est vérifiée par examen.

9.10.2 Les **dispositifs de commande intercalés dans un câble souple** équipés d'un socle ou d'une prise doivent avoir des caractéristiques assignées ou doivent être protégés de façon à éviter une surcharge accidentelle du **dispositif de commande**, des socles ou des prises en **usage normal**.

La conformité est vérifiée par examen et en effectuant l'essai de 26.2.1.

9.10.3 Les **dispositifs de commande** équipés de broches, lames ou autres moyens de branchement/adaptation, destinés à être introduits dans des prises fixes, doivent être conformes aux exigences du **système** de prise approprié.

Dans des **dispositifs de commande intercalés dans un câble souple** équipés d'une fiche et d'un socle de prise de courant, dans lesquels la fiche peut être connectée à un socle de courant de charge assigné supérieur à celui du **dispositif de commande**, le **dispositif de commande** doit être équipé d'un fusible incorporé ou d'un dispositif de protection pour limiter le courant à la valeur assignée du **dispositif de commande**. Les essais de la fonction de protection sont faits dans la séquence d'essais selon 26.2.

La partie fiche-prise de courant du **dispositif de commande** doit être conforme à l'IEC 60884-1 et l'IEC 60884-2-5 ou à la norme appropriée pour le **système** de fiche et de socle. En outre, la partie **commande** doit être conforme au présent document.

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La conformité est vérifiée par examen et par les essais basés sur les circuits spécifiés pour le ***système*** *de prise.*

9.11 Exigences pendant le montage, l'utilisation et les opérations de maintenance et d'entretien

9.11.1 Capots et leurs fixations

9.11.1.1 Pour les **dispositifs de commande** autres qu'intégrés, le fait d'enlever un **capot** ou un **couvercle**, incluant le **couvercle** du compartiment de pile, prévu pour être enlevé lors du montage ou pendant les opérations de **maintenance** et d'**entretien** du **dispositif de commande** ou du matériel par l'utilisateur ne doit pas changer les **réglages** initiaux du **dispositif de commande** si cela risque d'affecter la conformité au présent document.

9.11.1.2 La fixation de ces **couvercles** doit être telle qu'ils ne puissent être ni déplacés ni remontés de façon incorrecte si cela pouvait induire en erreur l'**utilisateur** ou affectait la conformité au présent document. La fixation des **couvercles** prévus pour être enlevés pour montage ne doit pas servir à maintenir des éléments autres que les **organes de manœuvre** ou des joints.

La conformité à 9.11.1.1 et 9.11.1.2 est vérifiée par examen.

9.11.1.3 Parties non détachables

9.11.1.3.1 Les parties non détachables fournissant le degré de protection nécessaire contre les chocs électriques, l'humidité ou le contact avec les parties mobiles doivent être fixées de façon sûre et doivent résister aux efforts mécaniques se produisant en **usage normal**.

Les dispositifs encliquetables utilisés pour la fixation des parties non détachables doivent avoir une position verrouillée évidente. Les propriétés de fixation des dispositifs encliquetables utilisés dans les pièces susceptibles d'être démontées pendant l'installation ou l'**entretien** ne doivent pas se dégrader.

La conformité est vérifiée par les essais décrits de 9.11.1.3.2 à 9.11.1.3.4.

9.11.1.3.2 Les pièces susceptibles d'être démontées pendant l'installation ou l'**entretien** sont démontées et remontées 10 fois avant d'effectuer l'essai.

NOTE L'**entretien** inclut le changement du câble souple d'alimentation.

9.11.1.3.3 Pour les essais de 9.11.1.3.4, le **dispositif de commande** doit être à température ambiante. Cependant, dans les cas où la conformité peut être affectée par la température, l'essai est aussi effectué aussitôt après que le **dispositif de commande** a fonctionné dans les conditions spécifiées à l'Article 16.

9.11.1.3.4 Une force est appliquée sans secousse dans la direction la plus défavorable pendant 10 s, aux zones du **couvercle** ou de la pièce susceptibles d'être faibles. La force à appliquer doit être comme suit:

– *Force de poussée* *50 N*

– *Force de traction, comme suit:*

  a) *Si la forme de la pièce est telle que le bout des doigts ne peut pas glisser facilement* *50 N*

  b) *Si la partie dépassant de la pièce pour la saisir est inférieure à 10 mm dans la direction de démontage* *30 N*

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La force de poussée est appliquée au moyen d'un doigt d'épreuve rigide aux dimensions semblables à celles du doigt d'épreuve normal de la Figure 5.

La force de traction est appliquée par tout moyen convenable (par exemple, une ventouse) qui n'affecte pas les résultats d'essai.

Pendant que l'essai de traction de type a) ou b) est exécuté, l'ongle d'épreuve de la Figure 6 *est inséré dans toutes les ouvertures ou jointures avec une force de 10 N. L'ongle d'épreuve est ensuite poussé latéralement avec une force de 10 N; il n'est ni tourné ni utilisé comme levier.*

Si la forme de la pièce est telle qu'une traction axiale est improbable, aucune traction n'est appliquée mais l'ongle d'épreuve de la Figure 6 *est inséré dans toutes les ouvertures ou jointures avec une force de 10 N, il est ensuite tiré pendant 10 s au moyen de la boucle avec une force de 30 N dans la direction du démontage.*

Si le ***couvercle*** *ou la pièce est susceptible d'être soumis à une torsion, un couple comme détaillé ci-dessous doit être appliqué en même temps que la traction ou la poussée:*

– *pour des dimensions maximales inférieures ou égales à 50 mm 2 Nm;*
– *pour des dimensions maximales supérieures à 50 mm 4 Nm.*

Le couple est aussi appliqué quand l'ongle d'épreuve est tiré au moyen de la boucle.

Si la partie dépassant de la pièce pour la saisir est inférieure à 10 mm, le couple ci-dessus est réduit de 50 % de sa valeur.

9.11.1.3.5 Pendant et après les essais de 9.11.1.3.4, les parties ne doivent pas se séparer et doivent rester en position verrouillée, sinon elles sont considérées comme des **parties amovibles**.

9.11.1.4 Un **couvercle**, qui peut être ôté à la main, ne doit pas se séparer quand une force d'écrasement ne dépassant pas 45 N combinée à une force de l'essai de traction ne dépassant pas 15 N est appliquée en deux points quelconques séparés au maximum par 125 mm, mesurée par une bande tendue fermement sur cette portion de la surface du **couvercle** qui peut être entourée par la paume de la main. L'essai est effectué avant et après 10 démontages et remontages.

9.11.2 Moyens de fixation du couvercle

Les vis de fixation des **capots** ou des **couvercles** qui doivent être enlevées lors du montage et pour les opérations de **maintenance** ou d'**entretien par l'utilisateur** doivent être imperdables.

La conformité est vérifiée par examen.

NOTE Cette exigence est considérée comme satisfaite si les vis en question sont équipées de rondelles serrantes de carton ou d'une matière analogue. Voir 10.1.5.

9.11.3 Organe de manœuvre

9.11.3.1 Le montage et l'enlèvement de l'**organe de manœuvre** d'un **dispositif de commande** conformément à la méthode prévue ne doivent causer aucun dommage.

9.11.3.2 Si les limites supérieure et inférieure de la plage de **réglage** par le fabricant ou **par l'utilisateur** d'une **action de type 2** sont matérialisées par des moyens mécaniques associés à un **organe de manœuvre**, ce dernier ne doit pas être démontable sans l'aide d'un **outil**.

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9.11.3.3 Si un **organe de manœuvre** d'un **dispositif de commande** à **action de type 1** comportant une position "ARRÊT" ou un **organe de manœuvre** d'un **dispositif de commande** quelconque à **action de type 2** est utilisé pour indiquer l'état du **dispositif de commande**, il ne doit pas être possible de monter cet **organe de manœuvre** dans une position incorrecte.

*La conformité aux spécifications de 9.11.3.1 à 9.11.3.3 inclus est vérifiée par examen et, pour les **organes de manœuvre** qui n'exigent pas d'**outil** pour leur démontage, par l'essai de 20.7.*

NOTE Dans certaines normes de matériel, il n'est pas admis qu'un **organe de manœuvre** utilisé pour indiquer l'état d'un **dispositif de commande** puisse être monté d'une manière incorrecte.

9.11.4 Parties qui servent d'isolation supplémentaire ou d'isolation renforcée

Les parties des **dispositifs de commande** qui servent d'**isolation supplémentaire** ou d'**isolation renforcée** et qui sont susceptibles d'être oubliées lors du remontage du dispositif de commande après des opérations de **maintenance** ou d'**entretien par l'utilisateur**, doivent être fixées de telle manière qu'il soit impossible de les enlever sans dommages sérieux, ou conçues de telle manière qu'il soit impossible de les remonter dans une position incorrecte et que leur omission rende le dispositif de commande inopérant ou manifestement incomplet.

La conformité est vérifiée par examen.

NOTE Une enveloppe métallique recouverte d'une couche de vernis ou d'un revêtement du même genre s'enlevant aisément par grattage n'est pas considérée comme satisfaisant à cette exigence.

9.11.5 Manchons utilisés comme isolation supplémentaire

Des manchons isolants utilisés comme **isolation supplémentaire** sur des **conducteurs intégrés** doivent être maintenus en position par des moyens sûrs.

La conformité est vérifiée par examen et par un essai manuel.

NOTE Un manchon est considéré comme étant fixé par des moyens sûrs s'il ne peut être enlevé qu'après avoir été cassé ou coupé, ou s'il est serré.

9.11.6 Cordons de traction

Un **cordon de traction** doit être isolé des **parties actives** et le **dispositif de commande** doit être conçu de telle manière qu'il soit possible de monter ou de remplacer le **cordon de traction** sans que les **parties actives** deviennent accessibles.

La conformité est vérifiée par examen.

9.11.7 Revêtements isolants

Les revêtements et cloisons isolants et autres éléments analogues doivent avoir une résistance mécanique adéquate et doivent être fixés de façon sûre.

La conformité est vérifiée par examen.

9.12 Dispositifs de commande utilisant des logiciels

Voir H.9.12.

9.12.1 Exigences relatives à l'architecture

Voir H.9.12.1.

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9.12.2 Mesures pour commander les pannes/erreurs

Voir H.9.12.2.

9.12.3 Mesures pour éviter les erreurs

Voir H.9.12.3.

9.12.4 Fonctions de commande à distance

9.12.4.1 Les fonctions de commande à distance peuvent être raccordées à des dispositifs séparés et indépendants, pouvant eux-mêmes contenir des fonctions de commande ou fournir d'autres informations. Les fonctions de commande actionnées à distance peuvent être critiques pour la sécurité ou non en fonction de l'application, comme indiqué ci-dessous.

a) Les conditions suivantes sont considérées comme critiques pour la sécurité car elles peuvent nuire à la sécurité du dispositif de commande ou de l'appareil:

   1) si un logiciel ou des données, faisant partie d'une **fonction de commande de classe B** ou **de classe C**, sont respectivement téléchargé ou échangées;

   2) si un logiciel ou des données, comprenant des changements paramétriques (par exemple, constantes, algorithmes, synchronisation utilisée pour un fonctionnement normal) qui peuvent altérer les critères de conformité du document en raison de modifications non autorisées ou d'erreurs de transmission, sont respectivement téléchargé ou échangées;

      EXEMPLE Un logiciel téléchargé ou un jeu de paramètres qui régule ou limite les échauffements normaux maximaux dans l'Article 16.

   3) si un logiciel, qui n'affecte que la partie du logiciel qui n'est pas couverte par les cas 1) ou 2) ci-dessus, mais pour laquelle la conformité au document peut être altérée en raison d'une séparation ou d'un partitionnement incorrect du logiciel ou des données car il concerne les conditions 1) ou 2), est téléchargé.

b) Tout logiciel téléchargé ou toute donnée qui répond aux critères de tout élément en a) doit être conforme à H.9.12.4.

c) Les types de communication à distance (téléchargement de logiciel ou échange de données) non énumérés en a) étant considérés comme ne compromettant pas la conformité au document, aucune exigence supplémentaire n'est spécifiée. Des exemples sont donnés ci-dessous:

   – dispositifs de commande assurant une **communication à distance** et/ou un **fonctionnement à distance**, lorsque toutes les mesures pour se conformer au document sont indépendantes du logiciel;

   – dispositifs de commande utilisant une **communication à distance** par l'intermédiaire des **réseaux publics** uniquement pour l'envoi de données;

   – dispositifs de commande qui fournissent uniquement une surveillance à distance push ou pilotée par événement.

9.12.4.2 Échange de données

9.12.4.2.1 Généralités

Les **fonctions de commande à distance** peuvent être raccordées à des dispositifs séparés et indépendants, pouvant eux-mêmes contenir des fonctions de **commande** ou fournir d'autres informations. Tout échange de données entre ces dispositifs ne doit pas compromettre l'intégrité de la **fonction de commande de classe B** ou de la **fonction de commande de classe C**.

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9.12.4.2.2 Type de données

Les types de messages relatifs à l'échange de données dans une ou des fonctions de **commande** doivent être affectés à la **fonction de commande de classe A**, la **fonction de commande de classe B** ou la **fonction de commande de classe C**. Concernant la sécurité ou la pertinence ou influence de la protection, les types de messages ou l'échange de données ne doivent être affectés qu'aux **fonctions de commande de classe B** ou aux **fonctions de commande de classe C** (voir Tableau 8).

Tableau 8 – Échange de données

Données	Relatives à la sécurité	Non relatives à la sécurité
Données de fonctionnement	Messages tels que "REINITIALISATION à partir de l'état de sécurité"	Messages tels qu'instructions de démarrage/arrêt, informations relatives à la température ambiante
Paramètres de configuration	Messages modifiant les paramètres qui déterminent la **fonction de commande de classe B** ou la **fonction de commande de classe C** associée	Messages modifiant les paramètres qui déterminent les fonctions relatives aux performances
Modules de logiciel	Modules téléchargés dans un **système**, qui déterminent la **fonction de commande de classe B** ou la **fonction de commande de classe C** associée	Modules téléchargés dans un **système**, qui déterminent les fonctions relatives aux performances

9.12.4.2.3 Communication des données relatives à la sécurité

Voir H.9.12.4.2.3.

9.12.4.2.4 Durée ou limites de fonctionnement

Pour le fonctionnement de la **fonction de commande à distance**, la durée ou les limites de fonctionnement doivent être établies avant l'activation, à moins qu'une désactivation automatique ne soit réalisée à la fin d'un cycle ou que le **système** ne soit conçu pour un fonctionnement permanent (fonctionnement pendant plus de 24 h sans interruption ni nouveau cycle).

*La conformité est vérifiée par **examen** du logiciel.*

9.12.4.3 Priorité des fonctions de commande

Des précautions doivent être prises pour que la priorité donnée aux fonctions de **commande** n'engendre pas de condition dangereuse.

*La conformité est vérifiée par **examen**.*

9.12.4.4 Action de réarmement à distance

9.12.4.4.1 L'action de réarmement à distance doit être initiée manuellement. Lorsque la fonction de réarmement est initiée par un dispositif portatif, au moins deux actions manuelles sont exigées pour activer un réarmement.

NOTE Les deux **actions manuelles** sont considérées comme étant discrètes et séparées.

9.12.4.4.2 Les fonctions de **réarmement** doivent pouvoir effectuer la réinitialisation du **système** comme prévu.

9.12.4.4.3 Des réarmements intempestifs à partir de l'état de sécurité ne doivent pas se produire.

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9.12.4.4.4 Toute **panne** de la fonction de **réarmement** ne doit pas engendrer une condition dangereuse pour le **dispositif de commande** ou la fonction commandée. Dans ce cas, la fonction de **réarmement** doit être conforme aux exigences de la classe B (voir H.13.2.2).

9.12.4.4.5 Pour les fonctions de **réarmement** initiées par une action manuelle non réalisée dans le champ visible de l'appareil, les exigences supplémentaires suivantes s'appliquent:

– l'état réel et les informations appropriées du processus commandé doivent être visibles à l'**utilisateur** avant, pendant et après l'action de réarmement;
– le nombre maximal d'actions de réarmement au cours d'une période donnée doit être spécifié (par exemple, 5 actions pendant une durée de 15 min). Ensuite, tout autre réarmement doit être refusé à moins que l'appareil ne fasse l'objet d'une vérification physique.

9.12.4.4.6 Pour les **dispositifs de commande intégrés** et les **dispositifs de commande incorporés**, la fonction de réarmement doit être évaluée dans l'application finale.

NOTE 1 Les exigences de **réarmement** à distance dépendent des exigences du produit final (norme de chaudière, par exemple).

NOTE 2 Tous les types de fonctions de **réarmement** à distance ne se révèlent pas appropriés pour certaines applications.

Si le réarmement est initié par activation manuelle d'un dispositif, cette fonction doit être spécifiée par le fabricant et être adaptée à l'application finale.

9.12.4.4.7 Les **dispositifs de commande à montage indépendant** réalisant les fonctions de **réarmement** à distance doivent être soumis à essai pendant un minimum de 1 000 actions de réarmement. Pour les dispositifs intégrés et incorporés, sauf indication contraire, le nombre minimal de cycles de réarmement doit être déclaré par le fabricant. A l'issue de l'essai, le dispositif de réarmement doit pouvoir procéder au réarmement du **système** comme prévu. Des **réarmements** intempestifs ne doivent pas se produire.

9.13 Dispositifs de commande de protection et éléments constituants des systèmes de commande de protection

9.13.1 Dispositifs de commande de protection

Les **dispositifs de commande de protection** doivent

– être conçus et construits pour être sûrs et aptes pour l'usage auquel ils sont destinés, et prendre en compte les spécifications d'entretien et d'essais des dispositifs, quand c'est possible;
– être indépendants des autres fonctions, sauf si leur fonction de sécurité ne peut être affectée par aucune des autres fonctions;
– être conformes aux règles appropriées de conception en vue d'obtenir une protection sûre et efficace.

Ces règles comprennent, en particulier, les modes de sécurité intrinsèque, la redondance, la diversité, et l'autodiagnostic.

La conformité est vérifiée par les essais appropriés spécifiés dans le présent document et dans la Partie 2 concernée.

9.13.2 Dispositifs limiteurs de pression

Ces dispositifs doivent être conçus de façon que la pression dans l'application commandée n'excède pas la pression maximale admise; cependant, une surpression de courte durée de 10 % de la pression maximale admise est acceptable, dans les cas où cela est possible, ou lorsqu'elle n'est pas spécifiée dans la norme appropriée relative à l'application commandée.

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9.13.3 Dispositifs de surveillance de la température

Ces dispositifs doivent avoir un temps de réponse approprié pour les aspects sécurité et cohérent avec la fonction de mesure.

9.13.4 Piles

9.13.4.1 Les **dispositifs de commande** comportant des piles doivent être conçus pour réduire le **risque** d'incendie, d'explosion et de fuites de produits chimiques en conditions normales et après une première **panne** dans le **dispositif de commande**. Pour les piles remplaçables par l'**utilisateur**, la conception doit réduire la probabilité d'inversion de polarité si cela risque d'engendrer un **danger**.

9.13.4.2 Les circuits de pile conçus pour une capacité totale de pile > 1 000 mAh doivent être conçus de sorte que:

– les caractéristiques de sortie d'un circuit de charge de pile soient compatibles avec sa pile rechargeable; et

– pour les piles non rechargeables, un régime de décharge supérieur aux recommandations du fabricant de pile et une charge non intentionnelle soient évités; et

– pour les piles rechargeables, un régime de charge et de décharge supérieur aux recommandations du fabricant de pile, et une charge inversée, soient évités; et

– les piles remplaçables doivent

  - avoir des contacts qui ne peuvent pas être mis en court-circuit avec le doigt d'épreuve (Figure 5); ou
  - être intrinsèquement protégées pour empêcher d'engendrer un **danger** au sens du document.

NOTE Une inversion de charge d'une pile rechargeable se produit lorsque la polarité du circuit de charge est inversée et favorise la décharge de la pile.

9.13.4.3 Lorsqu'une pile d'une capacité > 1 000 mAh contient de l'électrolyte liquide ou en gel, un bac support de piles doit être fourni et capable de contenir toute fuite de liquide éventuelle résultant de l'accumulation de pression interne dans la pile. L'exigence de fourniture d'un bac support de piles ne s'applique pas si la construction de la pile rend peu probable une fuite de l'électrolyte.

NOTE Un exemple de construction de pile rendant peu probable une fuite d'électrolyte est le type de **cellule** à soupape étanche ou de dégazage.

Si un bac support de piles est exigé, sa capacité doit être au moins égale au volume de l'électrolyte de toutes les **cellules** de la pile ou au volume d'une seule **cellule** si la conception de la pile rend peu probable une fuite simultanée de plusieurs **cellules**.

NOTE Si un boîtier simple contient plusieurs **cellules** (par exemple, les six **cellules** dans un accumulateur au plomb 12 V), sa cassure risque d'entraîner un plus grand volume de fuite que celui généré par une **cellule** simple.

9.13.4.4 *La conformité aux spécifications de 9.13.4.1 à 9.13.4.3 est vérifiée par examen et évaluation des données fournies par le* ***fabricant de matériel*** *et le fabricant de pile.*

En l'absence de données appropriées, la conformité est vérifiée par les essais de a) à e) et 9.13.4.5. Cependant, les piles à sécurité intrinsèque dans les conditions spécifiées ne sont pas soumises à essai dans ces conditions. Les piles de consommation courante, carbone/zinc ou alcalines non rechargeables sont considérées comme sûres en conditions de court-circuit. Elles ne sont par conséquent pas soumises à un essai de décharge ni à un essai d'étanchéité dans des conditions de stockage.

Les piles non rechargeables sont soumises aux essais de a) et d). La pile utilisée pour les essais doit être une pile non rechargeable neuve fournie ou recommandée par le fabricant pour utilisation avec le ***dispositif de commande****.*

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Les batteries rechargeables sont soumises aux essais de b) à d). La pile utilisée pour les essais doit être une pile rechargeable neuve, entièrement chargée, fournie ou recommandée par le fabricant pour utilisation avec le ***dispositif de commande****.*

NOTE Certains des essais spécifiés peuvent être dangereux pour les personnes chargées de les réaliser; il convient donc de prendre toutes les mesures appropriées pour protéger le personnel contre d'éventuels **dangers** d'ordre chimique ou d'explosion.

a) Mise en charge non intentionnelle d'une pile non rechargeable: la pile est chargée tout en faisant l'objet d'une rapide simulation d'une **défaillance** de composant susceptible de se produire dans le circuit de charge et de donner lieu à une mise en charge non intentionnelle de la pile. Pour réduire le plus possible la durée de l'essai, la **défaillance** retenue est celle qui provoque le courant de charge le plus élevé. La pile est ensuite chargée pendant une seule période de 7 h en maintenant la **défaillance** simulée.

b) Surcharge d'une pile rechargeable: la pile est chargée dans chacune des conditions suivantes à la fois.

   1) Le circuit de charge de pile est réglé, avec la pile déconnectée, pour obtenir 106 % de la tension de sortie assignée du chargeur, ou la tension maximale de charge disponible à partir du chargeur (sans simulation de **pannes**), selon la valeur la plus élevée qu'il est possible d'atteindre. La pile est ensuite chargée pendant 7 h.

   2) Le circuit de charge de pile est réglé, avec la pile déconnectée, pour obtenir 100 % de la tension de sortie assignée du chargeur. La pile est chargée tout en faisant rapidement l'objet d'une simulation d'une simple **défaillance** de composant susceptible de se produire dans le circuit de charge et donnant lieu à une surcharge de la pile. Pour réduire le plus possible la durée de l'essai, la **défaillance** choisie est celle qui engendre le courant de surcharge le plus élevé. La pile est ensuite chargée pendant une seule période de 7 h en maintenant la **défaillance** simulée.

c) Inversion de charge d'une pile rechargeable: la pile est mise en charge inversée tout en faisant rapidement l'objet d'une simulation d'une simple **défaillance** de composant susceptible de se produire dans le circuit de charge et donnant lieu à une inversion de charge de la pile. Pour réduire le plus possible la durée de l'essai, la **défaillance** choisie est celle qui engendre le courant d'inversion de charge le plus élevé. La pile est ensuite mise en charge inversée pendant une seule période de 7 h en maintenant la **défaillance** simulée.

d) Régime de décharge excessif d'une pile rechargeable ou non rechargeable: la pile est soumise à une décharge rapide en mettant en circuit ouvert ou en court-circuit tout composant limiteur de courant ou de tension dans le circuit de charge de la pile en essai.

e) La conformité aux essais de a) à d) ne doit en aucun cas donner lieu aux résultats suivants:

   – fuites de produits chimiques dues à des fissures, ruptures ou éclatement de l'enveloppe de la pile, si ces fuites risquent d'affecter l'isolation exigée; ou

   – débordement de liquide provenant de tout limiteur de pression dans la pile, à moins que ce débordement ne soit contenu par le **dispositif de commande** sans **risque** de dommage à l'isolation ou **dommage** pour l'**utilisateur**; ou

   – explosion de la pile, si cette explosion risque de blesser un **utilisateur**; ou

   – émission de flamme ou éjection de métal fondu vers l'extérieur de l'enveloppe du **dispositif de commande**.

9.13.4.5 A l'issue des essais de 9.13.4.4a) à 9.13.4.4d), le matériel est soumis aux essais de rigidité diélectrique de 15.2.

9.13.5 Dispositifs de commande activés intelligents

9.13.5.1 Un **dispositif de commande activé intelligent** doit être conçu de sorte que les signaux de communication externe (données ou puissance appelée) ne remplacent pas de manière involontaire les paramètres de fonctionnement d'un **dispositif de commande à action de type 2**, ni ne perturbent aucune fonction de protection du **dispositif de commande**.

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Il est admis qu'un **dispositif de commande activé intelligent** modifie les paramètres de fonctionnement d'un **dispositif de commande à action de type 2** dans des limites définies tant que les fonctions de protection demeurent intactes.

9.13.5.2 Un **dispositif de commande activé intelligent** qui intègre des fonctions d'exploitation et de protection doit être évalué comme étant un **dispositif de commande de protection**.

9.13.5.3 Tout transmetteur ou module de communication externe au **dispositif de commande** et qui sert d'interface entre le **dispositif de commande** et le réseau de télécommunication doit satisfaire à l'IEC 62151 ou l'IEC 62368-1. Les mesures visant à assurer la protection contre les chocs électriques définie dans le présent document (par exemple, Annexe P) doivent néanmoins être satisfaites.

9.13.5.4 Tout transmetteur ou module de communication faisant partie intégrante du **dispositif de commande activé intelligent** doit satisfaire aux exigences du présent document.

9.13.5.5 La conformité de 9.13.5 est vérifiée par évaluation du **dispositif de commande** conformément aux exigences de 13.1 et aux autres exigences pertinentes du présent document.

10 Parties filetées et connexions

10.1 Parties filetées déplacées lors du montage et des opérations d'entretien

10.1.1 Les parties filetées, électriques ou autres, qui sont susceptibles d'être manœuvrées lors du montage ou de l'**entretien** du **dispositif de commande** doivent être capables de résister aux efforts mécaniques qui se produisent en **usage normal**.

NOTE Les parties filetées qui sont manœuvrées lors du montage ou de l'**entretien** du **dispositif de commande** comprennent les vis des bornes, les vis des dispositifs d'arrêt de traction et de torsion, les vis de fixation et de montage, les écrous, les bagues taraudées et les vis de fixation des **couvercles** et des capots.

10.1.2 Ces parties doivent être faciles à remonter après qu'elles ont été dévissées complètement.

NOTE Les constructions qui empêchent l'enlèvement complet d'une partie filetée sont considérées comme remplissant cette exigence.

10.1.3 Ces parties filetées doivent avoir un filetage métrique ISO ou un filetage d'efficacité équivalente.

NOTE Les filetages SI, BA et unifiés sont considérés comme ayant une efficacité équivalente aux filetages métriques ISO.

10.1.4 Si une telle partie filetée est une vis et qu'elle crée un filetage dans une autre partie, elle ne doit pas être du type à filet coupant. Elle peut être du type autotaraudeuse. Il n'existe pas d'exigence pour le type de filet ainsi produit.

10.1.5 Ces vis peuvent être du type à filet gros (tôle), à condition qu'elles soient équipées d'un dispositif approprié empêchant le desserrage.

NOTE Les dispositifs appropriés empêchant le desserrage des vis à filet gros comprennent des écrous élastiques et autres éléments d'élasticité analogues ou un filetage en matière élastique.

10.1.6 Ces parties filetées ne doivent pas être en matière non métallique si leur remplacement par une vis métallique de dimensions similaires peut compromettre la conformité aux exigences des Articles 15 ou 11.

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10.1.7 Ce type de vis ne doit pas être fabriqué dans un métal tendre ou sujet à fluage, tel que le zinc ou l'aluminium.

Cette exigence ne s'applique pas aux parties utilisées soit comme **couvercle** pour limiter l'accès aux moyens de **réglage** soit comme moyen de **réglage** tel que le réglage de pression ou de débit des **dispositifs de commande** de gaz.

10.1.8 Les vis s'engageant dans un filetage en matière non métallique doivent avoir une forme telle que l'introduction correcte de la vis dans la partie correspondante soit assurée.

NOTE L'exigence concernant l'introduction correcte d'une vis métallique dans un filetage en matière non métallique est satisfaite si l'introduction en biais est évitée, par exemple au moyen d'un guidage prévu sur la vis ou la partie à fixer par un retrait dans le filetage de l'écrou ou par l'emploi d'une vis dont le début du filet a été enlevé.

10.1.9 Ces parties filetées destinées à transmettre la pression de contact et d'un diamètre nominal inférieur à 3 mm doivent se visser dans une partie métallique. Si elles sont en matière non métallique, elles doivent avoir un diamètre nominal d'au moins 3 mm et ne doivent être utilisées pour aucune liaison électrique.

10.1.10 La conformité aux spécifications de 10.1.1 à 10.1.9 inclus est vérifiée par examen et en effectuant les essais de 10.1.11 à 10.1.15 inclus.

10.1.11 Les parties filetées sont serrées et desserrées:

– *10 fois si l'une des parties filetées est en matériau non métallique, ou*

– *cinq fois si les deux pièces sont en matériau métallique.*

10.1.12 *Les vis s'engageant dans un filetage en matière non métallique sont à chaque fois retirées complètement et engagées à nouveau. Pour l'essai des vis et écrous de bornes, un conducteur de la plus forte section spécifiée en 8.1.5 ou de la section nominale spécifiée en 8.2.1 est placé dans la borne.*

10.1.13 *Il convient d'adapter la forme du tournevis à la tête de la vis à soumettre à essai.*

10.1.14 *Le conducteur est déplacé après chaque desserrage de la partie filetée. Pendant l'essai, aucune détérioration qui nuirait à l'emploi ultérieur des parties filetées, telle que rupture des vis ou dommages aux têtes à fente ou aux rondelles, ne doit être constatée.*

10.1.15 *L'essai est effectué à l'aide d'un tournevis ou d'une clé appropriée en appliquant le couple de torsion, sans secousses, indiqué dans le Tableau 9.*

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Tableau 9 – Valeurs d'essai de couple des parties filetées

Diamètre nominal du filetage mm	**Couple** Nm		
	I	**II**	**III**
Jusqu'à 1,7 inclus	0,1	0,2	0,2
Au-dessus de 1,7, jusqu'à 2,2 inclus	0,15	0,3	0,3
Au-dessus de 2,2, jusqu'à 2,8 inclus	0,2	0,4	0,4
Au-dessus de 2,8, jusqu'à 3,0 inclus	0,25	0,5	0,5
Au-dessus de 3,0, jusqu'à 3,2 inclus	0,3	0,6	0,6
Au-dessus de 3,2, jusqu'à 3,6 inclus	0,4	0,8	0,6
Au-dessus de 3,6, jusqu'à 4,1 inclus	0,7	1,2	0,6
Au-dessus de 4,1, jusqu'à 4,7 inclus	0,8	1,8	0,9
Au-dessus de 4,7, jusqu'à 5,3 inclus [a]	0,8	2,0	1,0
Plus de 5,3 [a]	–	2,5	1,25

Utiliser la colonne I – pour les vis métalliques sans tête qui ne font pas saillie par rapport à l'écrou après serrage complet ou qui limitent la largeur du tournevis au diamètre extérieur de la vis.

Utiliser la colonne II – pour les autres vis métalliques et pour les écrous:

• à tête cylindrique avec un évidement pour **outil spécial** dont le diamètre du cercle circonscrit dépasse le diamètre extérieur du filetage;

• à tête à fente simple ou en croix, ayant une longueur dépassant 1,5 fois le diamètre extérieur du filetage;

– pour les vis non métalliques à tête hexagonale dont le diamètre du cercle inscrit dépasse le diamètre extérieur du filetage.

Utiliser la colonne III – pour d'autres vis en matériau non métallique.

[a] Les écrous et les bagues taraudées d'un diamètre supérieur à 4,7 mm qui sont utilisés pour un montage à manchon simple sont soumis à essai avec un couple de 1,8 Nm, à l'exception des **dispositifs de commande** à manchons simples utilisant des matériaux thermoplastiques et sur lesquels aucun couple n'est exercé au montage pour le **réglage** ou le réarmement (c'est-à-dire pour **coupe-circuit thermiques**), pour lesquels le filet pour le montage est soumis à essai au couple maximal déclaré par le fabricant qui, en aucun cas, ne doit être inférieur à 0,5 Nm.

10.2 Connexions transportant le courant et connexions assurant la continuité de la mise à la terre de protection

10.2.1 Les connexions transportant le courant et les connexions assurant la continuité de la mise à la terre de protection qui n'ont pas été interrompues lors du montage ou de l'**entretien** du dispositif de commande, et dont l'efficacité et la sécurité dépendent de la pression d'une vis, d'une partie filetée, d'un rivet ou d'un élément analogue doivent être capables de supporter les contraintes mécaniques, thermiques et électriques qui se produisent en **usage normal**.

10.2.2 Les connexions transportant le courant qui sont également soumises à des efforts de torsion en **usage normal** (c'est-à-dire les connexions faisant partie intégrante des **bornes à serrage sous tête de vis** ou reliées de façon rigide à de telles bornes, etc.) doivent comporter un blocage adéquat empêchant tout mouvement susceptible d'affecter la conformité aux exigences des Articles 15 ou 11.

NOTE 1 L'exigence concernant le blocage des éléments d'une connexion transportant le courant n'implique pas l'interdiction de toute rotation ou tout déplacement, mais la limitation convenable de ces mouvements de manière qu'ils ne puissent affecter la conformité du dispositif de commande aux exigences du présent document.

NOTE 2 Les connexions réalisées au moyen d'une seule vis, d'un rivet ou d'un élément analogue sont suffisantes si le mouvement des parties concernées est convenablement limité par une interaction mécanique des parties entre elles ou par des rondelles élastiques ou des moyens analogues.

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NOTE 3 Cette exigence est considérée comme satisfaite si la connexion est réalisée au moyen d'un rivet à tige non circulaire ou échancrée passant dans des trous de forme correspondante des parties transportant le courant. Les connexions réalisées avec plusieurs vis ou rivets satisfont aussi à cette exigence.

NOTE 4 Les matériaux de remplissage peuvent être utilisés si les parties avec lesquelles ils sont en contact ne sont soumises à aucune contrainte en **usage normal**.

10.2.3 Les connexions transportant le courant doivent être conçues de manière que la continuité du circuit ne soit pas maintenue par une pression transmise par l'intermédiaire de matériaux non métalliques autres que la céramique ou de matériaux non métalliques présentant des caractéristiques au moins équivalentes, sauf si un retrait éventuel ou une déformation de la matière non métallique est susceptible d'être compensé par une élasticité suffisante des parties métalliques.

NOTE La pertinence d'un matériau non métallique est jugée en fonction de sa stabilité dimensionnelle dans la plage de températures applicable au **dispositif de commande**.

10.2.4 Les connexions transportant le courant ne doivent pas faire usage de vis à filet gros, sauf si ces vis serrent directement les parties transportant le courant l'une contre l'autre et sont équipées d'un dispositif de blocage approprié.

Les vis à filet gros peuvent être utilisées pour assurer la continuité de la mise à la terre de protection à condition que deux vis au moins soient utilisées pour chaque connexion.

10.2.5 Les connexions transportant le courant peuvent faire usage de vis autotaraudeuses par enlèvement de matière si ces vis donnent naissance à un filetage normal.

Les vis autotaraudeuses par enlèvement de matière peuvent être utilisées pour assurer la continuité de la mise à la terre de protection à condition que deux vis au moins soient utilisées pour chaque connexion.

10.2.6 Lorsque dans une connexion transportant le courant, la continuité électrique dépend de la pression exercée sur les pièces en contact, toutes leurs surfaces doivent avoir une résistance à la corrosion au moins égale à celle du laiton. Cette exigence ne s'applique pas aux éléments dont les caractéristiques essentielles peuvent être altérées par la présence d'un revêtement nuisible à leur fonctionnement, tels que les bilames qui, lorsqu'ils ne sont pas protégés par un revêtement, doivent être serrés contre des pièces dont la résistance à la corrosion est adéquate. La résistance à la corrosion peut être obtenue par l'application d'un revêtement ou par un traitement similaire.

10.2.7 La conformité aux spécifications de 10.2.1 à 0 inclus est vérifiée par examen. De plus, la conformité à 10.2.3 et 0 est vérifiée par examen des parties métalliques élastiques après que les essais de l'Article 19 ont été effectués.

11 Lignes de fuite, distances dans l'air et distances à travers l'isolation solide

11.1 Généralités

Les **dispositifs de commande** doivent être construits de façon que les **lignes de fuite**, les **distances dans l'air** et les distances à travers l'isolation solide soient appropriées à la résistance aux contraintes électriques qui peuvent être attendues.

Les cartes de circuits imprimés conformes à toutes les exigences de protection de type 2 comme spécifié dans l'IEC 60664-3 doivent répondre aux exigences minimales de 11.4 pour l'isolation solide. L'espacement entre les conducteurs placés avant la protection ne doit pas être inférieur aux valeurs indiquées dans l'IEC 60664-3. Voir également Annexe M.

Les **lignes de fuite** et les **distances dans l'air** entre bornes pour la connexion des **conducteurs externes** ne doivent pas être inférieures à 2 mm ou à la limite spécifiée, selon la plus grande de ces valeurs. Cette exigence ne s'applique pas à de telles bornes si elles sont

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seulement utilisées pour la fixation en usine des conducteurs ou si elles sont utilisées pour le raccordement de circuits **TBT**.

Les **lignes de fuite**, **distances dans l'air** et distances à travers l'isolation solide dans les alimentations en mode de commutation et autres circuits de commutation haute fréquence où la fréquence fondamentale est supérieure à 30 kHz et inférieure à 10 MHz doivent être dimensionnées conformément à l'IEC 60664-4.

Les valeurs tabulées de l'Article 11 sont des valeurs minimales absolues qui doivent être maintenues pendant toutes les conditions de fabrication et pendant toute la durée de vie du matériel.

Une ligne de fuite ne doit pas être inférieure à la distance dans l'air associée. La plus petite ligne de fuite possible est égale à la distance dans l'air exigée.

La conformité est vérifiée par examen, par des mesures et par les essais du présent article.

NOTE 1 Les exigences et les essais sont basés sur l'IEC 60664-1 où des informations complémentaires peuvent être obtenues.

NOTE 2 Voir Annexe O pour obtenir des recommandations.

Les **lignes de fuite**, les **distances dans l'air** et les distances à travers l'isolation doivent être conformes

– pour une **impédance de protection** aux exigences de **double isolation** ou d'**isolation renforcée**;
– pour chaque composant séparé d'une **impédance de protection** aux exigences d'**isolation supplémentaire**.

11.2 Distances dans l'air

11.2.1 Les **distances dans l'air** ne doivent pas être inférieures aux valeurs indiquées dans le Tableau 11 dans le cas A, en tenant compte du **degré de pollution** et de la **tension assignée de choc** exigée pour satisfaire aux catégories de surtension du Tableau 10, excepté que, pour l'**isolation principale** et l'**isolation fonctionnelle**, des distances inférieures peuvent être utilisées si le **dispositif de commande** satisfait à l'essai de résistance en surtension de 11.2.14 et si les parties sont rigides ou tenues par moulage ou si la construction est telle qu'il n'est pas envisageable que les distances soient réduites par distorsion ou par déplacement des parties (par exemple en **fonctionnement** ou en cours d'assemblage) mais en aucun cas les **distances dans l'air** ne doivent être inférieures aux valeurs données par le Tableau 11 dans le cas B.

La conformité est vérifiée par examen, par des mesures et, si nécessaire, par l'essai de 11.2.14.

NOTE Il est attendu que les **dispositifs de commande** satisfassent aux exigences de la **catégorie de surtension** du matériel dans lequel ils sont utilisés à moins que des circonstances spéciales déterminent d'autres catégories correspondantes. Des recommandations sont fournies à l'Annexe D.

*Les **parties amovibles** sont enlevées. Les **distances dans l'air** sont mesurées avec les parties mobiles et les parties telles que des écrous hexagonaux qui peuvent être assemblées dans différentes orientations sont placées dans la position la plus défavorable.*

*Une force est appliquée aux conducteurs nus et aux **surfaces accessibles** de façon à tenter de réduire les **distances dans l'air** en faisant la mesure.*

Cette force est de: 2 N pour les conducteurs nus,
*30 N pour les **surfaces accessibles**.*

La force est appliquée au moyen du doigt d'épreuve de la Figure 5. Les ouvertures sont supposées être couvertes par une pièce métallique plate.

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Après application de la force, les distances dans l'air sont mesurées selon les méthodes et hypothèses données dans l'Annexe B.

Tableau 10 – Tension assignée de choc pour les matériels alimentés directement par le réseau (provenant de l'IEC 60664-1:2007, Tableau F.1)

Tension nominale du réseau d'alimentation basée sur l'IEC 60038 [a] [b] V		**Tension phase-neutre déduite selon les tensions nominales AC ou DC jusqu'à et y compris** V	**Tension assignée de choc exigée selon la catégorie de surtension** [c] V			
Système triphasé à quatre fils [a]	**Systèmes monophasés** [d]		**I**	**II**	**III**	**IV**
		50	330	500	800	1 500
		100	500	800	1 500	2 500
	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] La première valeur énumérée est la tension phase-neutre ou tension phase-terre, la deuxième valeur est la tension entre phases.

[b] Pour les **dispositifs de commande** capables de générer une surtension aux bornes du **dispositif de commande**, par exemple des dispositifs de commutation, la **tension assignée de choc** implique que le **dispositif de commande** ne doit pas générer une surtension supérieure à cette valeur lors d'une utilisation selon la norme correspondante et selon les instructions du fabricant.

[c] Voir Annexe D pour une explication relative aux **catégories de surtension** et l'Annexe E à titre de recommandation. La **catégorie de surtension** peut être spécifiée dans une Partie 2 ou dans la norme finale du matériel.

[d] Voir Annexe C pour d'autres **systèmes** d'alimentation (par exemple, noter que certains **systèmes** de câblage triphasés à trois fils exigent une **tension assignée de choc** supérieure à celle des **systèmes** triphasés à quatre fils de tension similaire).

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Tableau 11 – Distances dans l'air pour la coordination de l'isolement (provenant de l'IEC 60664-1:2007, Tableau F.2)

Tension assignée de choc du Tableau 10[a]	Distances dans l'air jusqu'à 2 000 m au-dessus du niveau de la mer[b] mm							
	Cas A				Cas B (essai de choc électrique exigé – voir 11.2.14)			
	Degré de pollution [c]				Degré de pollution [c]			
kV	1	2	3	4	1	2	3	4
0,33	0,01	0,20	0,8	1,6	0,01	0,2	0,8	1,6
0,50	0,04				0,04			
0,80	0,10				0,1			
1,5	0,5	0,5			0,3	0,3		
2,5	1,5	1,5	1,5		0,6	0,6		
4,0	3	3	3	3	1,2	1,2	1,2	
6,0	5,5	5,5	5,5	5,5	2	2	2	2
8,0	8	8	8	8	3	3	3	3

NOTE Pour les faibles valeurs de **distances dans l'air**, l'uniformité du champ électrique peut se dégrader en présence de **pollution**, rendant nécessaire l'accroissement des valeurs des **distances dans l'air** au-dessus de celles du cas B.

[a] Pour l'**isolation fonctionnelle**, la **tension assignée de choc** est donnée par la valeur de la colonne III du Tableau 10 qui couvre les tensions mesurées à travers la **distance dans l'air**, sauf déclaration et justification différentes du fabricant. Si l'enroulement secondaire du transformateur abaisseur est mis à la terre, ou s'il y a un écran mis à la terre entre les enroulements primaire et secondaire, la référence pour la **tension assignée de choc** pour les **distances dans l'air** de l'**isolation principale** du côté du secondaire doit être un niveau en dessous de celle qui couvre la tension d'entrée assignée du côté primaire du transformateur.

L'utilisation d'un transformateur d'isolement sans un **écran de protection** mis à la terre n'autorise pas une diminution de la **tension assignée de choc**.

[b] Pour les altitudes de plus de 2 000 m au-dessus du niveau de la mer, les valeurs de **distance dans l'air** doivent être multipliées par le facteur de correction indiqué dans l'IEC 60664-1:2007, Tableau A.2.

[c] Voir Annexe F pour une explication des **degrés de pollution**.

11.2.2 Les **distances dans l'air** de l'**isolation principale** doivent être suffisantes pour résister aux surtensions susceptibles de se produire en utilisation, en prenant en compte la **tension assignée de choc**. Les valeurs du Tableau 11, cas A s'appliquent à l'exception de ce qui est permis par 11.2.9.

La conformité est vérifiée par des mesures.

11.2.3 Si le **dispositif de commande** est alimenté par une pile dédiée ne disposant pas d'un moyen de charge par une alimentation réseau externe, la **tension assignée de choc** doit être supposée égale à 71 V crête.

11.2.4 Pour l'**isolation fonctionnelle**, le Tableau 11, cas A s'applique

– à l'exception de ce qui est permis par 11.2.9;

ou

– excepté que les **distances dans l'air** pour les **dispositifs de commande électronique** ne sont pas spécifiées si les exigences de 13.1.3.8 sont respectées avec les **distances dans l'air** court-circuitées.

11.2.5 La conformité avec 11.2 est vérifiée par des mesures en utilisant les méthodes de mesure données à l'Annexe B et la Figure 18.

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11.2.5.1 Pour les **dispositifs de commande** équipés d'un socle ou d'une prise, les mesures sont faites deux fois, une fois avec un connecteur ou une fiche appropriés insérés, et une fois sans fiche ou connecteur insérés.

11.2.5.2 Pour les bornes prévues pour le raccordement de **conducteurs externes**, les mesures de telles bornes sont faites deux fois, une fois équipées de conducteurs de la section maximale utilisée en 8.1.5, et une fois sans être équipées de conducteurs.

11.2.5.3 Pour les bornes prévues pour le raccordement de **conducteurs internes**, les mesures de telles bornes sont faites deux fois, une fois équipées de conducteurs de la section minimale utilisée en 8.2.1, et une fois sans être équipées de conducteurs.

11.2.6 Les distances à travers les fentes et les ouvertures des surfaces de matériau isolant sont mesurées avec une feuille métallique en contact avec la surface. La feuille est poussée dans les coins et endroits analogues au moyen du doigt d'épreuve représenté à la Figure 5, mais n'est pas pressée dans les ouvertures.

11.2.7 Le doigt d'épreuve représenté à la Figure 5 est appliqué aux ouvertures comme spécifié en 6.1, la distance à travers l'isolation entre **parties actives** et la feuille métallique ne doit pas alors être réduite en dessous des valeurs spécifiées.

11.2.8 Si nécessaire, une force est appliquée à un point quelconque des **parties actives** nues qui sont accessibles avant que le **dispositif de commande** soit monté, et à l'extérieur des surfaces qui sont accessibles après que le **dispositif de commande** est monté, dans une tentative de réduire les **distances dans l'air**, les **lignes de fuite** et les distances à travers l'isolation lors de la prise des mesures.

La force est appliquée au moyen du doigt d'épreuve représenté à la Figure 5 et a une valeur de:

– *2 N pour les **parties actives*** nues,

– *30 N pour les **surfaces accessibles***.

La conformité est vérifiée par des mesures et par un essai si nécessaire.

11.2.9 Pour l'**isolation principale** et l'**isolation fonctionnelle**, des distances inférieures sont permises si le **dispositif de commande** satisfait à l'essai de résistance au choc électrique de 11.2.14 et si les parties sont rigides ou tenues par moulage ou si la construction est telle qu'il n'est pas probable que les distances soient réduites par distorsion, déplacement des parties ou en cours d'assemblage, mais en aucun cas les **distances dans l'air** ne doivent être inférieures aux valeurs du cas B.

La conformité est vérifiée par l'essai de 11.2.14.

Lors de la vérification de l'**isolation fonctionnelle**, la tension de choc est appliquée à la **distance dans l'air**.

NOTE Lors de l'exécution de l'essai de choc électrique, il peut être nécessaire de déconnecter les parties ou les éléments constituants du **dispositif de commande**.

a) Pour les **microcoupures** et les **micro-interruptions**, il n'est pas spécifié de distance minimale pour les distances dans l'air entre les contacts et entre les parties transportant le courant pour lesquelles les distances dans l'air varient avec le mouvement des contacts.

b) Pour les **coupures totales de circuit**, les valeurs spécifiées au Tableau 11, cas A, s'appliquent aux parties séparées par l'élément de commutation comprenant les contacts, quand les contacts sont dans la position d'ouverture complète.

11.2.10 Les **distances dans l'air** pour l'**isolation supplémentaire** ne doivent pas être inférieures à celles spécifiées pour l'**isolation principale** au Tableau 11, cas A.

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La conformité est vérifiée par des mesures.

11.2.11 Les **distances dans l'air** pour l'**isolation renforcée** ne doivent pas être inférieures à celles du Tableau 11, cas A, mais en utilisant comme référence le niveau supérieur suivant pour la **tension assignée de choc**.

NOTE Pour la **double isolation**, quand il n'y a pas de partie conductrice intermédiaire entre l'**isolation principale** et l'**isolation supplémentaire**, les **distances dans l'air** sont mesurées entre les **parties actives** et la **surface accessible** ou les parties métalliques accessibles. Le **système** d'isolation est traité comme une **isolation renforcée**.

La conformité est vérifiée par des mesures.

11.2.12 Pour les **dispositifs de commande** ou les portions de **dispositifs de commande** alimentés par transformateur à **double isolation**, les **distances dans l'air** de l'**isolation fonctionnelle** et de l'**isolation principale** du côté secondaire sont basées sur la tension du secondaire du transformateur qui est utilisée comme tension nominale du Tableau 10.

NOTE 1 L'utilisation d'un transformateur à enroulements séparés seul n'autorise pas un changement de la **catégorie de surtension**.

Dans le cas de tensions d'alimentation dérivées de transformateurs sans enroulements séparés, la **tension assignée de choc** doit être déterminée à partir du Tableau 10 basée sur la tension primaire de transformateurs abaisseurs et basée sur la valeur efficace maximale mesurée de la tension secondaire des transformateurs élévateurs.

D'autres critères peuvent être spécifiés par des Parties 2 pour certaines situations, par exemple les sources d'allumage haute tension.

Le Tableau F.2 de l'Annexe F de l'IEC 60664-1:2007 donne la valeur des **distances dans l'air** pour une **tension assignée de choc** supérieure.

NOTE 2 Voir également les références à l'Article 12.

La conformité est vérifiée par des mesures ou par un essai si nécessaire.

11.2.13 Pour les circuits **TBT** dérivés de l'alimentation au moyen d'une **impédance de protection**, les **distances dans l'air** de l'**isolation fonctionnelle** sont déterminées à partir du Tableau 10 basées sur la valeur maximale mesurée de la **tension de service** du circuit **TBT**.

11.2.14 L'essai de tension de choc, si nécessaire, est appliqué conformément à l'IEC 60664-1:2007, 6.1.2.2.1.

Les conditions d'essai d'environnement peuvent être spécifiées dans une Partie 2.

*La tension de choc est appliquée entre les **parties actives** et les parties métalliques séparées par une **isolation principale** ou **fonctionnelle**.*

NOTE Dans le cas de l'**isolation fonctionnelle**, il peut être nécessaire de déconnecter les parties ou les éléments constituants du **dispositif de commande**.

11.2.15 Si le secondaire d'un transformateur est mis à la terre ou s'il y a un écran mis à la terre entre les enroulements primaire et secondaire, les **distances dans l'air** de l'**isolation principale** du côté secondaire ne doivent pas être inférieures à celles spécifiées au Tableau 11 mais utilisant la valeur de la **tension assignée de choc** immédiatement inférieure comme référence.

NOTE L'utilisation d'un transformateur d'isolement sans **écran de protection** mis à la terre ou secondaire mis à la terre ne permet pas une diminution de la **tension assignée de choc**.

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Pour les circuits alimentés avec une tension inférieure à la tension assignée, par exemple sur le secondaire d'un transformateur, les **distances dans l'air** de l'**isolation fonctionnelle** sont basées sur la **tension de service**, laquelle est utilisée comme tension nominale pour le Tableau 10.

11.3 Lignes de fuite

11.3.1 Les lignes de fuite doivent être basées sur la tension, le groupe de matériaux et le degré de pollution.

Affectation du groupe de matériaux à l'indice de résistance au cheminement (IRC):

– matériau du groupe de matériaux IIIb ayant un IRC de 100 et au-dessus, jusqu'à 175 exclu;
– matériau du groupe de matériaux IIIa ayant un IRC de 175 et au-dessus, jusqu'à 400 exclu;
– matériau du groupe de matériaux II ayant un IRC de 400 et au-dessus, jusqu'à 600 exclu;
– matériau du groupe de matériaux I ayant un IRC de 600 et au-dessus.

Les matériaux dont la valeur d'IRC a précédemment satisfait à ces groupes de matériaux sont acceptables sans autre essai.

Les valeurs d'IRC ci-dessus se réfèrent aux valeurs obtenues selon l'IEC 60112:2020 et soumises à essai avec la solution A.

*Les **parties amovibles** sont enlevées. Les **lignes de fuite** sont mesurées avec les parties mobiles et les parties qui peuvent être assemblées dans différentes orientations sont placées dans la position la plus défavorable.*

*Une force est appliquée aux conducteurs nus et aux **surfaces accessibles** de façon à tenter de réduire les **lignes de fuite** lors de la mesure.*

Cette force est de: 2 N pour les conducteurs nus,
*30 N pour les **surfaces accessibles**.*

La force est appliquée au moyen du doigt d'épreuve de la Figure 5. Les ouvertures sont supposées être couvertes par une pièce métallique plate.

*Après application de la force, les **lignes de fuite** sont mesurées selon Annexe B.*

11.3.2 Les **lignes de fuite** de l'**isolation principale** ne doivent pas être inférieures à celles spécifiées au Tableau 12 pour la **tension assignée** en tenant compte du groupe de matériaux et du **degré de pollution**.

La conformité est vérifiée par examen et par des mesures.

11.3.3 Les **lignes de fuite** de l'**isolation fonctionnelle** ne doivent pas être inférieures à celles spécifiées au Tableau 13 pour la **tension de service** en tenant compte du groupe de matériaux et du **degré de pollution**.

Les lignes de fuite inférieures à celles spécifiées dans le Tableau 13 sont autorisées, si:

– la conformité à 13.1.3.8 concernant la sécurité intrinsèque est respectée;
– pour les **fonctions de commande de classe B** et **de classe C**, le mode de **panne** indiqué dans le Tableau 14 pour la carte de circuit imprimé est pris en compte.

La conformité est vérifiée par examen et par des mesures.

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D’autres critères peuvent être spécifiés par des Parties 2 pour certaines situations, par exemple les sources d’allumage haute tension.

Tableau 12 – Lignes de fuite minimales pour l’isolation principale

Tension assignée jusque et y compris V	**Lignes de fuite** [a] [b] mm											
	Degré de pollution											
	Matériau de câblage imprimé [c]		**1**	**2**			**3**			**4**		
	Degré de pollution			**Groupe de matériaux**			**Groupe de matériaux**			**Groupe de matériaux**		
	1 [d]	**2** [e]		**I**	**II**	**III** [f]	**I**	**II**	**III** [f]	**I**	**II**	**III** [f]
50	0,025	0,04	0,2	0,6	0,9	1,2	1,5	1,7	1,9	2,0	2,5	3,2
125	0,16	0,25	0,3	0,8	1,1	1,5	1,9	2,1	2,4	2,5	3,2	4,0
250	0,56	1	0,6	1,3	1,8	2,5	3,2	3,6	4,0	5,0	6,3	8,0
400	1	2	1,0	2,0	2,8	4,0	5,0	5,6	6,3	8,0	10,0	12,5
500	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0	10,0	12,5	16,0
630	1,8	3,2	1,8	3,2	4,5	6,3	8,0	9,0	10,0	12,5	16,0	20,0
800	2,4	4	2,4	4,0	5,6	8,0	10,0	11,0	12,5	16,0	20,0	25,0

[a] Les conducteurs émaillés pour enroulements sont considérés comme des conducteurs nus mais il n’est pas exigé que les **lignes de fuite** soient supérieures aux **distances dans l’air** associées spécifiées dans le Tableau 11.

[b] Pour le verre, les céramiques et les autres matériaux isolants non organiques qui n’ont pas de cheminement, les **lignes de fuite** peuvent ne pas être supérieures aux **distances dans l’air** correspondantes pour la coordination de l’isolement.

[c] Lorsque les cartes de circuits imprimés sont revêtues ou protégées selon l’Annexe L ou selon l’Article M.1 respectivement et que le revêtement ou la protection a un IRC d’au moins 175, les valeurs spécifiées pour le degré de pollution 1 sont autorisées.

[d] Groupes de matériaux I, II, IIIa et IIIb.

[e] Groupes de matériaux I, II et IIIa.

[f] Groupe de matériaux III comprend IIIa et IIIb. Le groupe de matériaux IIIb n’est pas autorisé pour utilisation en **degré de pollution** 4 ou pour utilisation à plus de 630 V.

La conformité est vérifiée par des mesures.

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Tableau 13 – Lignes de fuite minimales pour l'isolation fonctionnelle

Tension de service efficace[a] V	Lignes de fuite[b] [c] mm											
	Degré de pollution											
	Matériau de câblage imprimé [d]		1	2			3			4		
	Degré de pollution			Groupe de matériaux			Groupe de matériaux			Groupe de matériaux		
	1[e]	2[f]		I	II	III	I	II	III[g]	I	II	III[g]
10	0,025	0,04	0,08	0,40	0,40	0,40	1	1	1	1,6	1,6	1,6
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05	1,6	1,6	1,6
16	0,025	0,04	0,1	0,45	0,45	0,45	1,1	1,1	1,1	1,6	1,6	1,6
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2	1,6	1,6	1,6
25	0,025	0,04	0,125	0,5	0,5	0,5	1,25	1,25	1,25	1,7	1,7	1,7
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3	1,8	1,8	1,8
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8	1,9	2,4	3
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9	2	2,5	3,2
63	0,04	0,063	0,2	0,63	0,9	1,25	1,6	1,8	2	2,1	2,6	3,4
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1	2,2	2,8	3,6
100	0,1	0,16	0,25	0,71	1	1,4	1,8	2	2,2	2,4	3	3,8
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4	2,5	3,2	4
160	0,25	0,4	0,32	0,8	1,1	1,6	2	2,2	2,5	3,2	4	5
200	0,4	0,63	0,42	1	1,4	2	2,5	2,8	3,2	4	5	6,3
250	0,56	1	0,56	1,25	1,8	2,5	3,2	3,6	4	5	6,3	8
320	0,75	1,6	0,75	1,6	2,2	3,2	4	4,5	5	6,3	8	10
400	1	2	1	2	2,8	4	5	5,6	6,3	8	10	12,5
500	1,3	2,5	1,3	2,5	3,6	5	6,3	7,1	8	10	12,5	16
630	1,8	3,2	1,8	3,2	4,5	6,3	8	9	10	12,5	16	21
800	2,4	4	2,4	4	5,6	8	10	11	12,5	16	20	25

[a] Pour des **tensions de service** supérieures, les valeurs de l'IEC 60664-1:2007, Tableau F.4, s'appliquent.

[b] Pour le verre, les céramiques et les autres matériaux non organiques qui n'ont pas de cheminement, les **lignes de fuite** peuvent ne pas être supérieures aux **distances dans l'air** associées.

[c] Il n'y a pas d'exigences pour la **micro-interruption** autres que celles entre les bornes et **connexions**. Entre les bornes et les **connexions**, les exigences sont telles que spécifiées dans le présent tableau.

[d] Lorsque les cartes de circuits imprimés sont revêtues ou protégées selon l'Annexe L ou selon l'Article M.1 respectivement et que le revêtement ou la protection a un IRC d'au moins 175, les valeurs spécifiées pour le **degré de pollution** 1 sont autorisées.

[e] Groupes de matériaux I, II, IIIa et IIIb.

[f] Groupes de matériaux I, II et IIIa.

[g] Groupe de matériaux III comprend IIIa et IIIb. Le groupe de matériaux IIIb n'est pas autorisé pour utilisation en **degré de pollution** 4 ou pour utilisation à plus de 630 V.

La conformité est vérifiée par examen.

11.3.4 Les **lignes de fuite** de l'**isolation supplémentaire** ne doivent pas être inférieures aux lignes de fuite correspondantes pour l'**isolation principale** en tenant compte du groupe de matériaux et du **degré de pollution**.

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La conformité est vérifiée par examen et par des mesures.

11.3.5 Les **lignes de fuite** de l'**isolation renforcée** ne doivent pas être inférieures au double des lignes de fuite correspondantes pour l'**isolation principale** en tenant compte du groupe de matériaux et du **degré de pollution**.

La conformité est vérifiée par examen et par des mesures.

11.4 Isolation solide

11.4.1 L'isolation solide doit être capable de supporter durablement aussi bien les contraintes mécaniques et électriques que les influences thermiques ou liées à l'environnement qui peuvent se produire pendant la durée de vie espérée du matériel.

11.4.2 Il n'y a pas d'exigence concernant l'épaisseur de l'**isolation principale** ou l'**isolation fonctionnelle**.

11.4.3 La distance à travers l'isolation pour les **isolations supplémentaires** et **renforcées**, pour les **tensions de service** jusqu'à 300 V inclus, entre pièces métalliques, ne doit pas être inférieure à 0,7 mm.

NOTE Cela n'implique pas que cette distance doit être dans le matériau isolant seul. Cette isolation peut être constituée d'un matériau solide et d'une ou de plusieurs couches d'air.

Pour les **dispositifs de commande** ayant des parties avec **double isolation** où il n'y a pas de métal entre l'**isolation principale** et l'**isolation supplémentaire**, les mesures sont faites comme s'il y avait une feuille métallique entre les deux couches d'isolation.

11.4.4 L'exigence de 11.4.3 ne s'applique pas si l'isolation est appliquée sous forme d'une feuille mince, autre que du mica ou un autre matériau en lamelles similaire.

– Pour l'**isolation supplémentaire**, elle consiste en au moins deux couches, sous réserve que chacune des couches résiste à l'essai de rigidité diélectrique de 15.2 pour l'**isolation supplémentaire**.
– Pour l'**isolation renforcée**, elle consiste en au moins trois couches, sous réserve que deux couches ensemble résistent à l'essai de rigidité diélectrique de 15.2 pour l'**isolation renforcée**.

La conformité est vérifiée par examen et par essai.

11.4.5 L'exigence de 11.4.3 ne s'applique pas si l'**isolation supplémentaire** ou l'**isolation renforcée** est inaccessible et répond à l'un des critères suivants.

– La température maximale déterminée pendant les essais du paragraphe 13.1 ne dépasse pas la valeur permise spécifiée dans le Tableau 17.
– L'isolation, après un conditionnement de 168 h dans une étuve maintenue à une température dépassant de 25 K la température maximale déterminée pendant les essais de l'Article 16, résiste à l'essai de rigidité diélectrique de 15.2, cet essai étant fait sur l'isolation à la température de l'étuve et après refroidissement à approximativement la température ambiante.

Pour les optocoupleurs, la procédure de conditionnement est effectuée avec une température dépassant de 25 K la température maximale mesurée sur l'optocoupleur pendant les essais du paragraphe 13.1 et de l'Article 16, l'optocoupleur étant manœuvré dans les conditions les plus défavorables se produisant pendant ces essais.

La conformité est vérifiée par examen et par essai.

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12 Éléments constituants

12.1 Transformateurs

12.1.1 Les transformateurs autres que ceux utilisés dans un SMPS, destinés à alimenter un circuit **TBTS** ou un circuit **TBTP** doivent être du type isolant de sécurité et doivent être conformes aux exigences correspondantes de l'IEC 61558-2-6.

12.1.2 Les **dispositifs de commande** auxquels est incorporé un transformateur de sécurité comme source d'alimentation d'un circuit **TBTS** ou **TBTP** sont soumis à un essai de sortie avec le primaire alimenté à la pleine tension assignée comme indiqué en 19.2.2, 19.2.3 a) et 19.2.3 b).

a) Dans des conditions quelconques de charge non capacitive (depuis une charge nulle jusqu'au court-circuit de n'importe laquelle ou de toutes les bornes de câblage secondaires d'installation **TBTS** ou **TBTP**) et sans perturber les connexions internes, la tension de sortie ne doit pas être plus grande que celle qui est définie en 3.1.5.
b) La puissance de sortie secondaire aux bornes d'un **circuit secondaire limité isolé** ne doit pas être supérieure à 100 VA et le courant de sortie secondaire ne doit pas être supérieur à 8 A, après 1 min de **fonctionnement** avec la protection contre les surintensités, si elle existe, court-circuitée.

12.2 Alimentations en mode de commutation et convertisseurs

12.2.1 Exigences

12.2.1.1 Si un convertisseur ou une alimentation en mode de commutation est utilisé comme source d'alimentation d'un circuit **TBTS** ou **TBTP**, les dispositions de l'Article P.3 s'appliquent.

12.2.1.2 Les alimentations en mode de commutation et les transformateurs utilisés dans des alimentations en mode de commutation doivent satisfaire aux exigences de l'IEC 61558-2-16 ou aux exigences pertinentes du présent document.

12.2.1.3 Les alimentations en mode de commutation non couvertes par 12.8.2, y compris leurs circuits périphériques, utilisées dans les **dispositifs de commande électronique** doivent satisfaire aux essais de 12.2.2 et à toutes les exigences applicables du présent document.

NOTE Les critères de conformité pour les essais sont donnés au paragraphe 12.2.2.11.

12.2.2 Essais de surcharge pour les alimentations en mode de commutation

12.2.2.1 *Le circuit d'alimentation en mode de commutation est connecté à sa source d'alimentation et de fréquence à la tension assignée. Chaque enroulement de sortie, ou section d'un enroulement à gradins, est surchargé un à la fois tandis que les autres enroulements sont maintenus à l'état chargé ou non chargé, selon la condition de charge en* ***usage normal*** *qui représente le cas le plus défavorable*.

12.2.2.2 *La surcharge est réalisée en raccordant une résistance variable (ou une charge électronique) par l'enroulement ou la sortie redressée. La résistance est réglée le plus rapidement possible et de nouveau réglée, si nécessaire, au bout de 1 min afin de maintenir la surcharge applicable. Aucun autre réajustement n'est ensuite autorisé.*

12.2.2.3 *Pour cet essai, tout dispositif de protection tel qu'un fusible, protecteur de circuit à réarmement manuel, protecteur thermique, etc. est autorisé à rester dans le circuit*.

12.2.2.4 *Si une protection contre les surintensités est assurée par un disjoncteur, le courant d'essai de surcharge correspond au courant maximal que le dispositif de protection contre les surintensités peut supporter pendant 1 h. Si cette valeur ne peut pas être obtenue de la spécification, elle doit être établie par essai.*

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12.2.2.5 *En l'absence de protection contre les surintensités, la surcharge maximale correspond à la puissance utile maximale que peut fournir l'alimentation.*

12.2.2.6 En cas de repli de tension, la surcharge est augmentée lentement jusqu'au point qui provoque la chute de la tension de sortie de 5 %. La surcharge est ensuite établie au point de reprise de la tension de sortie et maintenue pendant la durée de l'essai.

12.2.2.7 *La durée de l'essai est de 1 h ou jusqu'à l'obtention des résultats finaux.*

12.2.2.8 *La tension maximale en circuit ouvert de chaque enroulement (directement au niveau de l'enroulement du transformateur ou au niveau de la liaison en courant continu) et le courant maximal de charge sont mesurés et enregistrés afin de déterminer la puissance de sortie maximale.*

12.2.2.9 Les mesures de la tension maximale en circuit ouvert doivent être réalisées pendant le **fonctionnement** normal et en condition d'une **défaillance** de composant, voir Tableau 14.

12.2.2.10 *Pour les applications **TBTS**, pour lesquelles la tension maximale en circuit ouvert mesurée directement à l'enroulement secondaire du transformateur (ou au niveau de la liaison en courant continu) dépasse les limites spécifiées en 3.1.5, la mesure de la tension maximale de sortie de chaque enroulement peut être réalisée après certaines **impédances de protection**. Dans ce cas, les limites doivent être conformes à 6.1.10.*

12.2.2.11 *A la suite de chaque essai (toujours en condition chaude), l'alimentation en mode de commutation est à soumettre à l'essai de rigidité diélectrique de 15.2.*

La conformité doit s'appliquer selon les points a), b), c), d), e) et f) de 13.1.3.8.

12.3 Condensateurs

Les condensateurs reliés entre deux conducteurs de phase ou entre un conducteur de phase et le neutre, ou entre des **parties actives dangereuses** et la terre de protection, doivent être conformes à l'IEC 60384-14 et doivent être utilisés conformément à leurs valeurs assignées.

12.4 Fusibles

Les fusibles doivent répondre aux exigences de la série IEC 60127 ou de la série IEC 60269.

12.5 Varistances

12.5.1 Les varistances sont utilisées comme dispositifs de protection contre les chocs et doivent être choisies de manière à résister aux impulsions correspondant à la classe d'installation (déclarées dans le Tableau 1, exigence 43) pour laquelle le dispositif est destiné à être utilisé.

12.5.2 Les varistances connectées au réseau d'alimentation doivent satisfaire à l'IEC 61051-1, l'IEC 61051-2 ou l'IEC 61051-2-2.

12.6 Thermistances

12.6.1 Si une **thermistance** est utilisée, J.12.8.2 s'applique ou 12.6.2 doit être satisfait.

12.6.2 L'Annexe J ne s'applique pas aux **thermistances** utilisées dans un circuit qui satisfait aux exigences suivantes de a) à d) ou à l'exigence énoncée en e):

a) **dispositif de commande** de type 1 tel que spécifié dans le Tableau 1, exigence 33;

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b) raccordement à un circuit **TBTS**/**TBTP** tel que spécifié à l'Article P.1, ou protection contre le risque de choc électrique par une isolation double ou renforcée ou au moyen d'une **impédance de protection**;

c) circuit de faible puissance tel que spécifié en 13.1.2, ou le **dispositif de commande** ou le matériel terminal est conforme à 13.1 lorsque la **thermistance** est ouverte ou court-circuitée;

d) **dispositif de commande** avec **fonctions de commande de classe A** tel que spécifié dans le Tableau H.1, exigence H.12;

e) les **thermistances** utilisées dans des fonctions de **commande** dans lesquelles sont mises en œuvre des mesures supplémentaires visant à assurer la sécurité au sein du **dispositif de commande**.

12.7 Relais

Les relais à contacts guidés (reliés mécaniquement) doivent être conformes aux exigences de l'IEC 61810-3.

12.8 Autres composants

12.8.1 Les composants autres que ceux cités de 12.7 à 12.1 sont vérifiés en effectuant les essais du présent document.

12.8.2 Pour les composants qui ont préalablement satisfait à une norme de sécurité IEC correspondante, pour une réduction des essais nécessaires, l'évaluation est limitée à ce qui suit:

a) l'application du composant dans le **dispositif de commande** est vérifiée pour s'assurer qu'il est couvert par des essais préalables correspondants à la norme de sécurité IEC;

b) les essais, selon le présent document, de toutes les conditions qui ne sont pas prévues par les essais préalables de la norme de sécurité IEC.

13 Évaluation des pannes sur les circuits électroniques

13.1 Évaluation des pannes pour la sécurité intrinsèque

13.1.1 Généralités

Les circuits ou **dispositifs de commande électronique**, tels que spécifiés aux points a) et b) ci-dessous, doivent être évalués conformément aux exigences de 13.1.3 du point de vue des effets d'une **défaillance** ou d'un mauvais fonctionnement des composants du circuit, conformément aux conditions de **panne** spécifiées dans le Tableau 14.

a) Circuits électroniques qui ne satisfont pas aux exigences d'un circuit de faible puissance conformément à 13.1.2.

b) Circuits à basse puissance dans lesquels la protection contre les chocs électriques, les **dangers** d'incendie, les **dangers** mécaniques ou un mauvais fonctionnement dangereux d'autres parties du **dispositif de commande** dépend du fonctionnement correct de ce circuit.

Les circuits alimentés par des batteries rechargeables sont soumis aux essais de 13.1.

Les composants non électroniques tels que les interrupteurs, les relais et les transformateurs qui sont évalués selon l'Article 12 ou selon les exigences appropriées du présent document ne sont pas soumis aux essais de 13.1.

Pendant les essais de 13.1.1, pour un **dispositif de commande** assurant une **coupure électronique** (type 1.Y ou 2.Y), n'importe quelle **défaillance** du dispositif, décrit à la Note l du Tableau 16 est permise.

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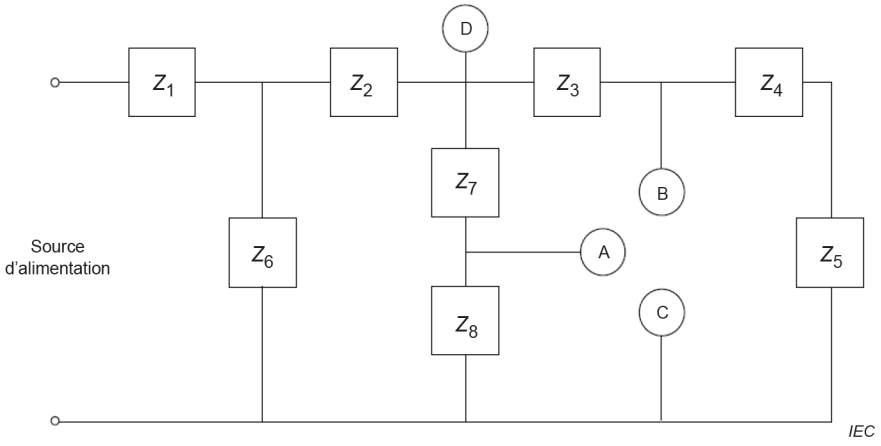
13.1.2 Essai de mesure des points à faible puissance

Un circuit à basse puissance est déterminé comme suit et expliqué en détail à la Figure 3.Le ***dispositif de commande*** *est mis en fonctionnement à la tension assignée ou à la limite supérieure de la plage de tensions assignées et une résistance variable, réglée à sa valeur maximale, est raccordée entre le point à étudier et le pôle opposé de la source d'alimentation.*

La résistance est alors diminuée jusqu'à ce que la puissance consommée par la résistance atteigne un maximum. Tout point le plus proche de la source, auquel la puissance maximale délivrée à cette résistance n'excède pas 15 W après 5 s est appelé point à basse puissance. La partie du circuit plus éloignée de la source d'alimentation que le point à basse puissance est considérée comme étant un circuit à basse puissance.

Les mesures sont effectuées à partir d'un seul pôle de la source d'alimentation, de préférence celui qui donne le plus petit nombre de points à basse puissance.

NOTE Lors de la détermination des points à basse puissance, commencer par les points les plus proches de la source d'alimentation. La puissance consommée par la résistance variable est mesurée selon une méthode appropriée, par exemple par un wattmètre.



D est le point le plus éloigné de la source d'alimentation où la puissance maximale délivrée à une charge extérieure est supérieure à 15 W.

A et B sont les points les plus proches de la source d'alimentation où la puissance maximale délivrée à une charge extérieure n'est pas supérieure à 15 W. Ce sont des points à basse puissance.

Figure 3 – Exemple d'un circuit électronique comportant des points à basse puissance

13.1.3 Évaluation des pannes de composant

13.1.3.1 Lignes directrices pour les essais de 13.1.3.2

Pour éviter des essais inutiles, il convient de s'efforcer d'évaluer les conditions qui peuvent résulter en une non-conformité aux exigences de 13.1.3.2. Une telle évaluation doit consister en l'étude des schémas des circuits et la simulation des conditions de ***panne*** *correspondantes, afin de vérifier si ces conditions se produisent. Pour les* ***dispositifs de commande*** *utilisant des logiciels, l'analyse de* ***panne*** *de 13.1.3.2 doit être liée à l'analyse de* ***panne*** *du logiciel déclarée dans le Tableau H.1, exigence H.5.*

Toutes les conditions résultant de l'introduction de ***panne*** *d'un circuit électronique comme spécifié en 13.1.3.8 sont considérées comme étant une* ***panne****.*

Les conducteurs des circuits imprimés qui révèlent des signes de détérioration pendant les essais sont considérés comme étant susceptibles d'avoir des défaillances.

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13.1.3.2 Procédure d'essai

Le dispositif de commande doit être mis en fonctionnement dans les conditions suivantes.

a) *A la tension la plus défavorable pour*

   i) les dispositifs de commande alimentés avec du courant du réseau, dans la plage 0,9 à 1,1 fois la tension assignée d'alimentation;

   ii) les dispositifs de commande alimentés par batterie, dans la plage de 0 à 100 % de la tension assignée en circuit ouvert.

b) *Avec le type de charge, dans la limite des paramètres mesurés ou déclarés, produisant l'effet le plus sévère.*

c) *A une température ambiante de (20 ± 5) °C, à moins qu'il y ait des raisons valables (comme au cours de l'essai du point b) de 13.1.3.8) pour effectuer l'essai à une autre température de la plage déclarée par le fabricant.*

d) *Connecté à une source d'alimentation de puissance ayant des caractéristiques assignées de coupe-circuit à fusible telles que le résultat de l'essai n'est pas influencé par le* ***fonctionnement*** *du coupe-circuit à fusible.*

e) *Avec tout* ***organe de manœuvre*** *placé dans la position la plus défavorable.*

f) *Le réseau d'alimentation du dispositif de commande doit être en mesure de fournir un courant de court-circuit d'au moins 500 A.*

g) *Les composants qui présentent une défaillance du fait d'une contrainte cumulative sont remplacés si nécessaire.*

h) *Pour les* ***dispositifs de commande intercalés dans un câble souple****,* ***séparés et à montage indépendant****, l'enveloppe est enveloppée dans du papier de soie. Pour tous les autres dispositifs de commande, le papier de soie est placé sur le dispositif à soumettre à essai.*

i) *Le* ***dispositif de commande*** *est mis en fonctionnement jusqu'à atteindre un régime établi ou pendant 1 h, selon la durée la plus courte.*

13.1.3.3 Conditions de panne pour les circuits électroniques

Pour les besoins de 13.1 et H.13.2, les modes de **défaillance** applicables sont donnés par le Tableau 14.

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Tableau 14 – Modes de panne des composants électriques/électroniques

Type de composant	Court [a]	Ouvert [b]	Remarques
Résistances			
Film mince [c]		X	Comprend le type CMS
Film épais [c]		X	Comprend le type CMS
Enroulement [c] (simple couche) émaillé ou convenablement enrobé		X	
Potentiomètre/trimmer à enroulement (simple couche)		X	
Autres types	X [d]	X	Comprend les varistances à oxyde métallique et les résistances sensibles à la tension
Condensateurs			
Types X1 et Y selon l'IEC 60384-14		X	
Film métallisé selon l'IEC 60384-16 et l'IEC 60384-17		X	
Autres types	X	X	
Inductances			
Enroulement		X	
Autres types	X	X	
Diodes			
Tous types	X	X	
Dispositifs du type à semiconducteur comme les transistors			
Tous types (par exemple, bipolaire; LF; RF; micro-ondes; FET; thyristor; Diac; Triac; unijonction)	X [d]	X	e
Circuit hybride	f	f	
Circuits intégrés			
Tous types non couverts par H.9.12	X [g]	X	Pour sorties de circuit intégré, la Note e s'applique
Optocoupleurs			
Selon l'IEC 60747-5-5	X [h]	X	
Relais			
Bobines		X	
Contacts	X [l, p]	X	
Relais à lames souples	X	X	Contacts seulement
Transformateurs			
Selon l'IEC 61558-2-6 ou l'IEC 61558-2-16		X	
Autres types	X [d]	X	
Quartz	X	X	j
Interrupteurs	X	X	k
Connexions (bretelles)		X	l
Câble souple et fils		X	
Conducteurs de circuits imprimés Selon la série IEC 62326	X [m]	X [n]	

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Type de composant	Court [a]	Ouvert [b]	Remarques
Capteurs			
Thermistances polymères	X	X	o
Thermistances céramiques		X	

[a] Les conditions qui ont mené à la conception de **lignes de fuite** et **distances dans l'air** selon l'Article 11 pour l'assemblage pour lequel l'exclusion du mode de **panne** "court" est revendiquée doivent être maintenues pendant toute la durée de vie du **dispositif de commande**.

Ces conditions doivent être déclarées ou documentées comme suit.

Degré de pollution du dispositif de commande (déclaré dans le Tableau 1, exigence 44).

Degré de pollution du **microenvironnement** de la **ligne de fuite** ou de la **distance dans l'air**, si plus propre que celle du dispositif de commande, et conception (documentation) (déclarés dans le Tableau 1, exigence 59).

Tension assignée de choc du dispositif de commande (déclarée dans le Tableau 1, exigence 55).

Tension assignée de choc pour la **ligne de fuite** ou **distance dans l'air**, si différente de celle du **dispositif de commande**, et comment elle est réalisée (documentation) (déclarée dans le Tableau 1, exigence 60).

Les valeurs prévues pour les tolérances des distances pour lesquelles l'exclusion du mode de **panne** "court" est revendiquée (déclaration et documentation) (déclarées dans le Tableau 1, exigence 61).

[b] Ouverture seule d'une broche à n'importe quel moment.

[c] Ces composants peuvent être utilisés en impédance de protection, si les composants satisfont à 11.3.3 et résistent à l'essai de tension de choc de 11.2.15 pour une catégorie de surtension III au moins.

[d] Mise en court-circuit de deux broches tour à tour avec chacune des autres broches; seulement deux broches à la fois.

[e] Pour les dispositifs de type à thyristors discrets ou intégrés tels que Triacs et SCR, les conditions de **pannes** doivent inclure le court-circuit de toutes les bornes avec la troisième borne en circuit ouvert. L'effet de tout dispositif électronique de type à onde pleine, tel qu'un Triac passant en condition de demi-onde commandée ou non commandée (thyristor ou diode, respectivement) doit être pris en compte.

La **défaillance** d'un dispositif de commutation de puissance électronique à effet de champ (FET, MOSFET, IGBT) par perte de commande* de porte (base) entraînant un mode de mise en marche partielle, induisant un état indéfini doit être prise en compte. Les critères d'essai et d'évaluation doivent correspondre à la fonction et aux circuits de commande spécifiques. Des recommandations peuvent être données dans les Parties 2.

* La perte de commande de porte peut se produire en raison, par exemple, d'une connexion soudée insuffisante du FET.

[f] Les modes de **défaillance** pour les composants individuels du **circuit hybride** sont applicables comme décrit pour les composants individuels dans ce tableau.

[g] Le court-circuit de deux bornes adjacentes quelconques et le court-circuit de

– chaque borne de l'alimentation du circuit intégré, si applicable au circuit intégré;

– chaque borne à la borne de mise à la terre du circuit intégré, si applicable au circuit intégré.

Le nombre des essais impliqués pour les **circuits intégrés** peut normalement rendre impossible l'application de toutes les conditions de **pannes** correspondantes ou l'évaluation des **dangers** possibles à partir d'une étude du schéma du **circuit intégré**.

Il est donc admis d'analyser d'abord en détail toutes les **pannes** mécaniques, thermiques et électriques possibles qui peuvent se manifester dans le **dispositif de commande** à proprement parler ou dans sa sortie du fait d'un mauvais fonctionnement, individuellement ou dans une combinaison quelconque, des dispositifs électroniques ou des autres composants de circuits.

Excepté pour les types évalués par H.9.12, une analyse par arbre de **panne** doit être effectuée pour inclure les résultats de conditions de fonctionnements continus multiples aux bornes bidirectionnelles programmées dans le but d'identifier les conditions de **pannes** supplémentaires pour leur prise en compte. Le mode de **défaillance** en court-circuit est exclu entre sections isolées pour les circuits intégrés ayant des sections isolées. L'isolation entre les sections doit satisfaire aux exigences de 15.2 pour l'**isolation fonctionnelle**.

[h] Si des optocoupleurs satisfont à 11.4.5, le court-circuit entre les broches d'entrée et de sortie n'est pas pris en compte.

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[i] Le mode de défaut en court-circuit est exclu pour les relais où le contact contrôle une fonction de **commande** de classe A ou B et les contacts de relais ne fonctionnent pas durant l'essai de l'Article 16, à condition qu'il ait été contrôlé par essai avec succès selon l'Article 19 dans les conditions suivantes:

Pour les fonctions de **commande de classe A**, le nombre de cycles déclaré dans le Tableau 1, exigence 20 en appliquant la charge de sortie déclarée dans le Tableau 1, exigence 8.

Pour les **fonctions de** commande **de classe B**, un minimum de 100 000 cycles ou tel que déclaré dans le Tableau 1, exigence 20, selon la valeur la plus élevée, en appliquant la charge de sortie déclarée dans le Tableau 1, exigence 8.

Pour les **fonctions** de commande **de classe C**, le mode de court-circuit est exclu pour les relais où

- la fonction de contact passe en fonctionnement normal sans charge (pas de courant lors de l'ouverture ou de la fermeture);
- la fonction de contact déconnecte la charge en fonctionnement anormal du **système de commande** pour atteindre l'**arrêt de sécurité**;
- le relais satisfait à l'Article 19 à un minimum de 100 000 cycles ou tel que déclaré dans le Tableau 1, exigence 20, selon la valeur la plus élevée, en appliquant la charge de sortie déclarée dans le Tableau 1, exigence 8.

[j] Pour les horloges à quartz, il convient de prendre en compte la variation des fréquences harmoniques et sous-harmoniques affectant les temporisations.

[k] Si des interrupteurs sont utilisés pour la sélection de temps de sécurité, de temps de purge, de programmes et/ou d'autres **réglages** liés à la sécurité, il convient que ces dispositifs fonctionnent de façon telle qu'en cas d'ouverture, la condition la plus sûre possible se produise (par exemple, dans un **système de commande** de brûleur, le temps de sécurité le plus court ou le temps de purge le plus long).

Le mode de court-circuit est exclu pour les interrupteurs dont le contact contrôle une fonction de **commande** de classe A ou B, à condition qu'il ait été soumis à essai conformément à l'Article 19 dans les conditions suivantes:

Pour les fonctions de **commande de classe A**, le nombre de cycles déclaré par le fabricant ou certifié pour l'application.

Pour les **fonctions de** commande **de classe B**, au moins 6 000 cycles pour l'**action manuelle** ou 100 000 cycles pour l'action automatique ou nombre de cycles spécifié par la norme de produit ou certifié pour l'application.

Pour les **fonctions de commande classe C**, le mode de court-circuit n'est pas exclu.

[l] Les exigences sont les mêmes que pour la Note n, excepté qu'elles s'appliquent aux bretelles prévues pour l'attache de la sélection d'un **réglage**.

[m] Le mode de **défaillance** en court-circuit est exclu si les exigences de l'Article 11 sont satisfaites.

[n] Le mode de **défaillance** en circuit ouvert, c'est-à-dire l'interruption d'un conducteur, est exclu si

- l'épaisseur du conducteur est supérieure ou égale à une valeur nominale de 35 µm avec une tolérance de –30 % au plus de la valeur nominale admise et la largeur du conducteur est supérieure ou égale à une valeur nominale de 0,3 mm avec une tolérance de –30 % au plus de la valeur nominale admise; ou
- le conducteur présente des précautions supplémentaires contre l'interruption, par exemple l'étamage, etc.

Si un court-circuit sur les bornes de sortie provoque l'ouverture d'un conducteur de circuit imprimé, ce conducteur doit être soumis à une analyse de **panne** en circuit ouvert.

Lors de l'acceptation des sections de conducteurs liées, pour les conditions de courant et de température, voir IEC 62326 (toutes les parties).

[o] Pour les composants de capteur destinés à mesurer les grandeurs de manœuvre telles que la température, la pression, etc., les modes de **panne** complémentaires aux modes en circuit ouvert ou en court-circuit doivent être pris en compte. Ces modes de **panne** peuvent comprendre la dérive progressive de résistance, un composant non conforme et un écart d'exactitude de composant.

[p] Pour les relais à contacts guidés conformément à l'IEC 61810-3, le mode de **panne** "contacts de fermeture et d'ouverture simultanément en position fermée" est exclu car cette défaillance en position fermée des contacts n'est pas possible en raison de la liaison mécanique des contacts.

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13.1.3.4 Critères – arrêt par un circuit électronique

Si l'essai se termine par la mise en fonctionnement d'un circuit électronique afin de se conformer à 13.1.3.8, les dispositions suivantes doivent s'appliquer:

a) cette fonction du circuit électronique est désactivée sans affecter le fonctionnement normal de la commande et l'essai est répété avec la même **panne** que celle qui a provoqué la mise en fonctionnement du circuit électronique; ou

b) si cette fonction du circuit électronique ne peut pas être désactivée sans affecter le fonctionnement normal du dispositif de commande, alors il convient que la condition de **panne** la plus lourde, telle que spécifiée dans le Tableau 14, soit appliquée au circuit électronique qui s'est mis en fonctionnement; ou

c) si cette fonction du circuit électronique comprend un composant programmable et que cette fonction ne peut pas être désactivée sans affecter le fonctionnement normal du dispositif de commande, alors le composant programmable doit être conforme aux exigences pour une **fonction de commande de classe B** de l'Annexe H.

13.1.3.5 Critères – arrêt par une partie intentionnellement faible

Si l'essai est arrêté par la mise en fonctionnement d'une partie intentionnellement faible autre qu'un dispositif de protection contre les surintensités, les critères suivants doivent être respectés, en plus de 13.1.3.8:

a) Pour assurer la cohérence et la répétabilité, l'essai doit être répété sur deux échantillons supplémentaires, le même composant terminant l'essai.

b) Afin de garantir une déconnexion fiable, un potentiel électrique correspondant à l'**isolation fonctionnelle**, comme spécifié dans le Tableau 16, doit être appliqué aux bornes du composant "en fonctionnement". Chaque échantillon doit satisfaire aux critères de 15.2. Les chemins parallèles pouvant compromettre les résultats de l'essai de rigidité diélectrique doivent être coupés.

Pour garantir la reproductibilité des résultats d'essai, les informations suivantes doivent être consignées: spécifier le composant en indiquant son type, ses caractéristiques assignées et toutes autres informations techniques pertinentes.

13.1.3.6 Critères – arrêt par un tracé intentionnellement fragile

Si l'essai se conclut par la mise en fonctionnement d'un **tracé intentionnellement fragile**, le tracé ouvert doit être soumis à une analyse et le dispositif de commande doit satisfaire aux critères des points a), c) et d) de 13.1.3.8. L'analyse du tracé ouvert doit comprendre au minimum les éléments suivants:

a) Après la mise en fonctionnement, un potentiel électrique correspondant à l'**isolation fonctionnelle** spécifiée dans le Tableau 16 doit être appliqué aux bornes des deux extrémités du tracé ouvert. Chaque échantillon doit satisfaire aux critères de 15.2.

b) Pour assurer la cohérence et la répétabilité, l'essai doit être répété sur deux échantillons supplémentaires avec des résultats conformes.

Pour garantir la reproductibilité des résultats d'essai, les informations suivantes doivent être consignées:

– spécifier les dimensions du tracé fragile (largeur, longueur, épaisseur, forme);

– indiquer le matériau du PCB;

– préciser toutes autres informations techniques pertinentes.

NOTE Le FR4, le CEM1, le CEM3 sont des exemples de matériaux, type et épaisseur de revêtement de protection, etc.

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13.1.3.7 Critères – commande pour les charges par moteurs

Si la charge comprend un moteur et si la défaillance ou le mauvais fonctionnement d'un composant d'un circuit électronique provoque une modification dans la forme d'onde alimentant le moteur commandé, le dispositif de commande doit être soumis aux essais suivants.

a) La charge doit être ajustée dans les conditions de forme d'onde normales à six fois la charge assignée ou la puissance assignée rotor bloqué déclarée par le fabricant.

b) Puis, les conditions de **panne** doivent être introduites.

c) L'essai est effectué dans les conditions détaillées aux points a), c), d) et e) de 13.1.3.2.

Le dispositif de commande doit faire l'objet d'une évaluation conformément aux points a) à e) inclus de 13.1.3.8, suivant ce qui convient au composant à évaluer.

13.1.3.8 Critères de conformité

Avec chaque **panne** décrite au Tableau 14, simulée ou appliquée à un composant de circuit à la fois, le **dispositif de commande** doit satisfaire:

– aux points suivants a) à g) inclus. Pour les composants conformes à l'IEC 60065:2014, Article 14, les **dispositifs de commande** ont seulement à satisfaire aux points a), c), d), f) et g);

– à tout critère de conformité supplémentaire, comme spécifié dans les paragraphes appropriés de la Partie 2; et

– aux exigences de la classe de logiciel spécifiée, si elles sont déclarées.

a) Les **dispositifs de commande** ne doivent pas émettre de flammes, de particules chaudes de métal ou de plastique, et ne doivent provoquer aucune explosion.

   Il ne doit pas y avoir de combustion du papier de soie. A l'intérieur de l'enveloppe, certaines pièces peuvent rougir momentanément et il peut y avoir une émission temporaire de fumée ou de flamme. Le papier de soie doit être conforme à l'ISO 4046-4:2016, 4.215, c'est-à-dire un papier de soie léger et souple, généralement compris entre 12 g/m^2 et 30 g/m^2.

b) La température de l'**isolation supplémentaire** et de l'**isolation renforcée** ne doit pas dépasser 1,5 fois les valeurs appropriées spécifiées de l'Article 16, sauf dans le cas des matériaux thermoplastiques.

   Il n'y a pas de limite de température spécifique pour l'**isolation supplémentaire** et l'**isolation renforcée** des matériaux thermoplastiques; leur température doit cependant être enregistrée dans le cadre de l'Article 21.

c) Tout changement des sorties commandées doit être comme déclaré dans le Tableau 1, exigence 52.

d) Le **dispositif de commande** doit satisfaire aux exigences de l'Article 6 et de 15.2 pour l'**isolation principale**.

e) Il ne doit y avoir aucune détérioration des différentes parties du **dispositif de commande** pouvant résulter dans la non-conformité aux exigences de l'Article 11.

f) Un fusible sur l'alimentation, extérieur au **dispositif de commande** en essai et tel que décrit au point d) de 13.1.3.2 ne doit pas fondre à moins qu'un dispositif interne de protection fonctionne aussi, en étant seulement accessible après utilisation d'un **outil**.

   Aucun dispositif de protection interne n'est exigé si l'échantillon continue à satisfaire aux exigences suivantes après remplacement du fusible sur l'alimentation:

   – points a), b) et d) de 13.1.3.8;

   – exigences de l'Article 11 pour les **distances dans l'air** et **lignes de fuite** entre **parties actives** et surfaces du **dispositif de commande** accessibles quand le **dispositif de commande** est monté comme en utilisation prévue.

g) La forme d'onde de sortie doit être telle que déclarée dans le Tableau 1, exigence 51.

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13.2 Évaluation des pannes pour assurer la sécurité fonctionnelle

Voir H.13.2.

14 Résistance à l'humidité et à la poussière

14.1 Protection contre la pénétration de l'eau et de la poussière

14.1.1 Les **dispositifs de commande** doivent procurer le degré de protection contre la pénétration de l'eau et de la poussière approprié à leur classification IP selon l'IEC 60529 lorsqu'ils sont montés ou utilisés de la manière déclarée.

14.1.2 *La conformité est vérifiée d'abord en préparant le dispositif de commande de la manière indiquée de 14.1.3 à 14.1.6, puis en effectuant l'essai approprié spécifié dans l'IEC 60529. Immédiatement après l'essai approprié, le dispositif doit satisfaire à l'essai de rigidité diélectrique de 15.2 et un examen doit montrer que l'eau qui a pénétré dans le dispositif ne compromet pas la conformité au présent document: en particulier, il ne doit pas y avoir de traces d'eau, sur les isolations, qui pourraient entraîner une réduction des lignes de fuite et des distances dans l'air en dessous des valeurs spécifiées à l'Article 11.*

14.1.3 *Les **dispositifs de commande** sont placés pendant 24 h dans une salle d'essai à atmosphère normale avant d'être soumis à l'essai approprié.*

14.1.4 Les ***dispositifs de commande*** *équipés d'un **câble souple non fixé à demeure** sont équipés d'un socle de connecteur et d'un câble souple appropriés; les **dispositifs de commande** équipés d'un **câble souple fixé à demeure** ayant des **fixations du type X** sont équipés des conducteurs appropriés avec le câble le plus fin spécifié en 9.8, dans la plage déclarée dans le Tableau 1, exigence 27. Les **dispositifs de commande** équipés d'un **câble souple fixé à demeure** ayant des **fixations du type M**, **du type Y** ou **du type Z** sont soumis à essai avec les câbles déclarés ou livrés avec les échantillons.*

14.1.5 *Les **parties amovibles** sont enlevées et soumises, s'il y a lieu, en même temps que la partie principale, aux essais correspondants.*

14.1.6 *Les bagues d'étanchéité des presse-étoupes et les autres moyens éventuels permettant d'assurer l'étanchéité sont vieillis dans une atmosphère qui a la composition et la pression de l'air ambiant, en les suspendant librement dans une étuve à air chaud renouvelé par tirage naturel. Ils sont maintenus pendant 10 jours (240 h) dans l'étuve à une température de (70 ± 2) °C.*

Immédiatement après le traitement de vieillissement, les parties sont retirées de l'étuve et laissées au repos, à la température de l'air ambiant et à l'abri de la lumière du jour, pendant au moins 16 h avant d'être réassemblées. Les presse-étoupes et les autres moyens d'assurer l'étanchéité sont alors serrés avec un couple égal aux deux tiers de celui donné dans le Tableau 9 ou tel que spécifié dans les instructions du fabricant.

14.2 Protection contre les conditions d'humidité

14.2.1 Tous les **dispositifs de commande** doivent résister aux conditions d'humidité qui peuvent se produire en **usage normal**.

14.2.2 La conformité est vérifiée par la séquence d'essais décrite en 14.2.3, après l'épreuve hygroscopique décrite de 14.2.5 à 14.2.9 inclus.

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14.2.3 *Pour les **dispositifs de commande intercalés dans un câble souple**, les **dispositifs de commande séparés** et les **dispositifs de commande à montage indépendant**, l'essai de 15.2 est effectué immédiatement après l'épreuve hygroscopique, immédiatement suivie de l'essai de 15.1. Pour les **dispositifs de commande incorporés** et intégrés, l'essai de 15.2 est effectué immédiatement après l'épreuve hygroscopique. Ces essais doivent être effectués de telle sorte qu'il ne se produise pas de condensation sur une surface quelconque des échantillons d'essai.*

14.2.4 Le **dispositif de commande** ne doit présenter aucun dommage qui compromettrait la conformité au présent document.

14.2.5 *Les entrées de conducteurs, s'il en existe, et les trous d'écoulement sont laissés ouverts. Si un **dispositif de commande** classé IPX7 comporte un trou d'écoulement, ce dernier est ouvert.*

14.2.6 *Les **parties amovibles** sont enlevées et soumises, s'il y a lieu, en même temps que la partie principale à l'épreuve hygroscopique.*

14.2.7 *Avant d'être placé dans l'enceinte humide, l'échantillon est amené à une température comprise entre t et (t + 4) °C, comme spécifié en 14.2.8. L'échantillon est alors maintenu dans l'enceinte humide pendant:*

– *2 jours (48 h) pour les **dispositifs de commande** IPX0*;

– *7 jours (168 h) pour tous les autres **dispositifs de commande***.

NOTE Pour porter l'échantillon à la température spécifiée, il est possible, dans la plupart des cas, de le laisser séjourner à cette température pendant 4 h au moins avant l'épreuve hygroscopique.

14.2.8 *L'épreuve hygroscopique est effectuée dans une enceinte humide contenant de l'air avec une humidité relative comprise entre 91 % et 95 %. La température de l'air, en tout endroit où les échantillons peuvent être placés, est maintenue entre (t – 1 K) et (t + 1 K), où t est une valeur appropriée comprise entre 20 °C et 30 °C.*

14.2.9 *Après ce traitement, les essais de l'Article 15 applicables en fonction du type de dispositif de commande, sont effectués soit dans l'enceinte humide, soit dans un local où les dispositifs ont été entreposés pour les porter à la température spécifiée après le remontage des **parties amovibles** éventuellement démontées avant l'épreuve hygroscopique.*

14.3 Essai de courant de contact pour dispositifs de commande intercalés dans un câble souple et dispositifs de commande séparés

14.3.1 Pour les **dispositifs de commande intercalés dans un câble souple** et pour les **dispositifs de commande séparés**, un échantillon est soumis à l'essai de 14.3.2 à 14.3.6 inclus avant de subir les autres essais de l'Article 14.

Les **dispositifs de commande de la classe III** ne sont pas soumis aux essais de ces paragraphes.

14.3.2 *Le **dispositif de commande** est relié à une tension d'alimentation égale à 1,06 fois la tension assignée. L'essai est effectué avec le courant assigné maximal et à la température ambiante déclarée maximale.*

14.3.3 *Le **courant de contact** est mesuré entre n'importe quel pôle de l'alimentation et*

– *les parties métalliques accessibles;*

– *une feuille métallique avec une surface ne dépassant pas 20 cm × 10 cm en contact avec les surfaces accessibles en matériau isolant, reliées entre elles.*

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Les mesures doivent être faites individuellement ainsi que collectivement lorsque les surfaces sont accessibles simultanément d'une surface à l'autre.

Lorsqu'une surface est inférieure à 20 cm × 10 cm, la feuille métallique est tenue d'avoir la même dimension que la surface. La feuille métallique n'est pas tenue de rester en place suffisamment longtemps pour affecter la température du dispositif de commande.

Si le dispositif de commande est doté d'une mise à la terre de protection, la connexion de mise à la terre de protection est à déconnecter à la source d'alimentation.

14.3.4 *Les circuits de mesure pour les **dispositifs de commande** utilisant différentes sources d'alimentation sont décrits aux figures mentionnées ci-dessous:*

- *pour un **dispositif de commande** monophasé de tension assignée ne dépassant pas 240 V, ou pour un **dispositif de commande** triphasé utilisé comme un dispositif de commande monophasé;*
  - *s'il est **de la classe II** (voir Figure 19);*
  - *s'il est autre que **de la classe II** (voir Figure 20*);
- *pour un **dispositif de commande** monophasé de tension assignée ne dépassant pas 240 V, ou pour un **dispositif de commande** triphasé non destiné à être utilisé comme un **dispositif de commande** monophasé;*
  - *s'il est **de la classe II** (voir Figure 21);*
  - *s'il est autre que **de la classe II** (voir Figure 22);*
- *pour un **dispositif de commande** monophasé connecté à un **système** de distribution à trois conducteurs avec neutre mis à la terre et prise médiane et de tension assignée ne dépassant pas 120 V, d'une classe autre que la **classe II**, voir Figure 23;*
- *pour un **dispositif de commande** diphasé connecté à un **système** de distribution à trois conducteurs avec neutre mis à la terre et prise médiane et de tension assignée ne dépassant pas 240 V, d'une classe autre que la **classe II**, voir Figure 24.*

*Les **dispositifs de commande** de tension assignée supérieure à 240 V doivent être reliés à deux conducteurs de phase d'un **système** triphasé, le conducteur de phase restant n'étant pas utilisé.*

Les détails du circuit de mesure sont représentés à la Figure K.1 de l'Annexe K.

14.3.5 Pendant les mesures, tous les circuits de **commande** doivent être fermés. Cependant, pour les **dispositifs de commande** soumis à essai conformément à la Figure 20, la Figure 23 et la Figure 24, les **courants de contact** doivent être vérifiés avec l'interrupteur S1 en position ouverte et en position fermée ou avec l'interrupteur en positions "a" et "b", conformément au schéma d'essai applicable.

Il est admis de court-circuiter des points de contact pour simuler des circuits fermés.

14.3.6 Le **courant de contact** maximal, après stabilisation de la température du **dispositif de commande**, ne doit pas dépasser les valeurs données en 15.3.5.

15 Résistance d'isolement et rigidité diélectrique

15.1 Résistance d'isolement

15.1.1 La résistance d'isolement des **dispositifs de commande intercalés dans un câble souple**, **séparés** et **à montage indépendant** doit être adéquate.

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15.1.2 *La conformité est vérifiée par l'essai décrit de 15.1.3 à 15.1.5 inclus. Cet essai est effectué lorsqu'il est spécifié à l'Article 14.*

15.1.3 *Lorsque l'**isolation renforcée** ou l'**isolation supplémentaire** des parties autres que métalliques est mesurée, chaque surface appropriée de l'isolation est recouverte d'une feuille métallique de manière à fournir une électrode pour l'essai.*

15.1.4 *La résistance d'isolement est mesurée avec une tension continue appliquée de 500 V environ, la mesure étant faite 1 min après application de la tension.*

15.1.5 *La résistance d'isolement ne doit pas être inférieure à celle indiquée dans le Tableau 15.*

Tableau 15 – Résistance d'isolement minimale

Isolation à soumettre à essai	Résistance d'isolement MΩ
Isolation fonctionnelle	–
Isolation principale	2
Isolation supplémentaire	5
Isolation renforcée	7

15.2 Rigidité diélectrique

15.2.1 La rigidité diélectrique de tous les **dispositifs de commande** doit être adéquate.

La conformité de la rigidité diélectrique de tous les dispositifs de commande doit être vérifiée par l'essai suivant de 15.2.2 à 15.2.4 inclus, à l'aide des tensions d'essai d'isolation ou de déconnexion représentées dans le Tableau 16.

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Tableau 16 – Tensions d'essai d'isolation ou de déconnexion

Isolation ou déconnexion à soumettre à essai[b c]	**Tension d'essai en fonction de la tension de service (U)**[a o]		
	TBTS/TBTP[d]	**Tension de service** ≤ 50 V [e]	**Tension de service**[e] 50 V < U ≤ 690 V
Isolation fonctionnelle[f]	100	100	2 × U
Isolation principale[g h k]	500	1 250	1 200 + U
Isolation supplémentaire[g h i j k]	–	1 250	1 200 + (U)
Isolation renforcée[g h i j k]	–	2 500	2 400 + (2 × U)
Coupure totale de circuit[m]	N/A	1 250	1 200 + U
Microcoupure[m]	100	100	2 × U
Coupure électronique[l]	100	100	2 × U
Micro-interruption[n]	–	–	–

NOTE 1 Un potentiel en courant continu équivalant à 1,414 fois la tension d'essai spécifiée dans le Tableau 16 s'applique.

NOTE 2 Pour les **dispositifs de commande** destinés à être incorporés dans un appareil ou à être utilisés conjointement avec d'autres matériels, les valeurs d'essai de rigidité diélectrique plus élevées de la norme de matériel peuvent être prises en compte.

[a] Le transformateur de haute tension utilisé pour cet essai doit être conçu de façon que lorsque les bornes de sortie sont en court-circuit après l'ajustement de la tension de sortie à la tension d'essai, le courant de sortie soit au moins égal à 200 mA. Le relais à maximum de courant ne doit pas se déclencher à un courant de sortie de moins de 100 mA. La valeur efficace de la tension d'essai doit être mesurée à ±3 % près.

[b] Les composants spéciaux susceptibles d'empêcher l'exécution de l'essai tels que les parties électroniques, les lampes au néon, les bobines ou les enroulements doivent être déconnectés sur un pôle ou shuntés selon l'isolation soumise à l'essai. Les condensateurs doivent être shuntés, sauf pour les essais pour l'**isolation fonctionnelle** lorsqu'un pôle est déconnecté. Si cette façon de procéder se révèle inapplicable, les essais des Articles 17 à 19 inclus sont considérés comme suffisants.

[c] Pour les **dispositifs de commande des classes I** et **0I** et pour les **dispositifs de commande** destinés à du matériel de **classe** I, une attention particulière doit être accordée au maintien d'une **distance dans l'air** suffisante entre la feuille métallique et les parties métalliques accessibles pour éviter de dépasser les limites admissibles pour l'isolation entre les **parties actives** et les parties métalliques mises à la terre.

[d] S'applique aux circuits connectés à des **schémas TBTS** ou des **schémas TBTP**. Dans le cas de dispositifs de commande reliés à des **schémas TBTP**, l'exigence d'**isolation principale** entre le circuit et la terre n'est pas applicable.

[e] S'applique aux **dispositifs de commande** galvaniquement reliés à l'alimentation.

[f] L'**isolation fonctionnelle** des cartes de circuits imprimés soumise en **usage normal** à une tension inférieure ou égale à 50 V n'est pas soumise aux essais de 15.2.

[g] Voir 15.3.2.

[h] Toute pièce métallique en contact avec une pièce métallique accessible est également considérée comme accessible.

[i] Pour les essais d'une **isolation supplémentaire** ou **renforcée**, la feuille métallique est appliquée de telle manière que toute matière de remplissage éventuelle soit soumise à l'essai efficacement sur des surfaces isolantes accessibles.

[j] Pour les **parties accessibles** qui sont protégées au moyen d'une **impédance de protection**, les essais sont effectués les composants étant déconnectés, le point milieu des deux impédances étant considéré comme une partie métallique intermédiaire.

[k] Pour les **dispositifs de commande** qui comportent une **isolation renforcée** et une **double isolation**, il convient de veiller à ce que la tension appliquée à l'**isolation renforcée** ne dépasse pas les limites admissibles pour l'**isolation principale** ou les pièces supplémentaires qui constituent la **double isolation**.

[l] Le dispositif qui effectivement provoque la coupure est d'abord retiré du circuit. Si nécessaire, toute entrée du **dispositif de commande** est connectée de façon que le dispositif provoque la coupure. La tension d'essai est alors appliquée aux bornes et **connexions** du dispositif qui est traversé par le courant de charge.

[m] Pour l'essai des **coupures totales** et des **microcoupures** de circuit, les contacts sont ouverts automatiquement ou manuellement, et soumis à essai dès que possible après l'ouverture pour vérifier que la séparation des contacts et le comportement du support isolant sont satisfaisants.

Dans le cas des **dispositifs de commande thermosensibles**, il peut être nécessaire de fournir des échantillons particuliers spécialement calibrés pour ouvrir entre 15 °C et 25 °C afin de permettre la réalisation de cet essai à la température ambiante immédiatement après leur retrait de l'étuve humidifiante.

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[n] Il n'y a pas d'exigence de rigidité diélectrique pour les **micro-interruptions**, dans la mesure où la satisfaction aux essais des Articles 17 à 19 inclus est considérée comme suffisante. De plus, pour un dispositif de commande qui ne présente aucune **microcoupure** dans une position de sa **liaison de manœuvre** et des **micro-interruptions** dans les autres positions, les positions correspondant aux **micro-interruptions** ne font l'objet d'aucune exigence de rigidité diélectrique.

[o] Toutes les tensions alternatives sont des tensions efficaces à une fréquence de 50 Hz à 60 Hz.

15.2.2 Lorsque l'**isolation renforcée** ou l'**isolation supplémentaire** des parties autres que métalliques est mesurée, chaque surface appropriée de l'isolation est recouverte d'une feuille métallique de manière à fournir une électrode pour l'essai.

15.2.3 L'isolation est soumise à une tension pratiquement sinusoïdale d'une fréquence de 50 Hz ou 60 Hz. La tension dont la valeur est indiquée dans le Tableau 16 est appliquée pendant 1 min à l'isolation ou à la coupure figurant dans ce même tableau.

15.2.4 Au début de l'essai, la tension appliquée ne dépasse pas la moitié de la valeur prescrite, puis elle est amenée rapidement à la pleine valeur. Il ne doit se produire ni contournement ni avarie. Les décharges luminescentes sans chute de tension sont ignorées.

15.3 Essais complémentaires pour dispositifs de commande intercalés dans un câble souple et dispositifs de commande séparés

15.3.1 Pour les **dispositifs de commande intercalés dans un câble souple** et pour les **dispositifs de commande séparés**, après les essais de 15.1 ou 15.2, suivant le cas, l'échantillon qui a été soumis aux essais de 14.3 doit subir les essais de 15.3.2 à 15.3.5 inclus.

Les **dispositifs de commande de la classe III** ne sont pas soumis aux essais de 15.3.2 à 15.3.5.

15.3.2 Une tension d'essai, continue pour les **dispositifs de commande** pour le courant continu seulement et alternative pour tous les autres **dispositifs de commande**, est appliquée entre toutes **parties actives** et

– *les parties métalliques accessibles;*

– *une feuille métallique avec une surface ne dépassant pas 20 cm × 10 cm en contact avec les **surfaces accessibles** en matériau isolant, reliées entre elles.*

Les mesures doivent être faites individuellement ainsi que collectivement lorsque les surfaces sont accessibles simultanément d'une surface à l'autre.

*Lorsqu'une surface est inférieure à 20 cm × 10 cm, la feuille métallique est tenue d'avoir la même dimension que la surface. La feuille métallique n'est pas tenue de rester en place suffisamment longtemps pour affecter la température du **dispositif de commande**.*

*Si le **dispositif de commande** est doté d'une mise à la terre de protection, la connexion de mise à la terre de protection est à déconnecter à la source d'alimentation.*

15.3.3 La tension d'essai est

– *1,06 fois la tension assignée, ou 1,06 fois la limite supérieure de la plage de tensions assignées, pour les **dispositifs de commande** pour courant continu seulement, pour les **dispositifs de commande** monophasés et pour les **dispositifs de commande** triphasés qui conviennent aussi à une alimentation monophasée, si la tension assignée ou la limite supérieure de la plage de tensions assignées ne dépasse pas 240 V;*

– *1,06 fois la tension assignée, ou 1,06 fois la limite supérieure de la plage de tensions assignées, divisée par $\sqrt{3}$, pour les autres **dispositifs de commande**.*

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15.3.4 *Le **courant de contact** est mesuré dans les 5 s qui suivent l'application de la tension d'essai.*

15.3.5 Le **courant de contact** maximal vers les parties métalliques accessibles et la feuille métallique ne doit pas dépasser les valeurs suivantes:

– pour les dispositifs de commande de la classe 0 et de la classe 01 0,5 mA,
– pour les **dispositifs de commande de la classe I** 0,75 mA, et
– pour les **dispositifs de commande de classe II** 0,25 mA.

16 Échauffements

16.1 Les **dispositifs de commande** et leurs supports ne doivent pas atteindre des températures excessives en **usage normal**.

La conformité est vérifiée par les essais décrits de 16.2 à 16.7 inclus.

Pendant cet essai, les températures ne doivent pas dépasser les valeurs spécifiées dans le Tableau 17 et les **dispositifs de commande** ne doivent subir aucune modification telle que la conformité au présent document et en particulier aux Articles 6, 15 et 11 soit compromise.

16.2 Les bornes et les **connexions** destinées au raccordement des **conducteurs externes** autres que ceux des **câbles souples fixés à demeure** ayant des **fixations du type M**, **du type Y** ou **du type Z** doivent être équipées de conducteurs de la section intermédiaire correspondant au type de conducteur et aux caractéristiques assignées utilisés en 8.1.5.

a) Si les **fixations du type M**, **du type Y** ou **du type Z** sont utilisées, le câble déclaré par le fabricant ou livré avec le dispositif de commande doit être utilisé pour l'essai.
b) Si une borne est conçue aussi bien pour des câbles souples que pour des conducteurs fixes, le câble souple approprié est utilisé.
c) Les bornes non destinées au raccordement des **conducteurs externes** doivent être équipées de conducteurs de la section minimale spécifiée en 8.2.1 ou de conducteurs spéciaux si ceux-ci sont déclarés en 5.2.

16.3 Pour cet essai, les **dispositifs de commande** doivent être montés comme indiqué de a) à c).

a) Les **dispositifs de commande intercalés dans un câble souple** et les **dispositifs de commande séparés** sont montés ou posés sur une surface de contreplaqué peinte en noir mat.
b) Les **dispositifs de commande à montage indépendant** sont montés comme en usage normal.
c) Les **dispositifs de commande incorporés** sont montés selon les instructions du fabricant.

16.4 Les dispositifs de commande doivent être reliés à une alimentation ayant la tension la plus défavorable comprise entre 0,90 VR et 1,10 VR. Les circuits non sensibles à la tension sont reliés à une tension inférieure (mais non inférieure de 10 % à VR et chargés de façon telle que le courant le plus défavorable compris entre 0,90 et 1,10 fois le courant assigné circule dans le circuit). Pour les dispositifs de commande alimentés par batterie, l'essai est effectué avec une batterie entièrement chargée.

a) Les circuits et les contacts qui ne sont pas destinés aux charges externes doivent être spécifiés par le fabricant.
b) Les **organes de manœuvre** sont placés dans la position la plus défavorable.

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c) Les contacts devant être initialement fermés pour les besoins de l'essai sont fermés avec le courant et la tension assignés du circuit.

   1) Pour les **dispositifs de commande** thermosensibles, l'**élément** thermosensible est chauffé ou refroidi à une température qui diffère de (5 ± 1) K de la température de fonctionnement mesurée dans les conditions du présent article, de manière que les contacts associés soient en position fermée.

   2) Pour tous les autres types de **dispositifs de commande sensibles**, l'**élément sensible** doit être maintenu dans des conditions telles que les contacts soient fermés, mais aussi près que possible du point d'ouverture.

   3) Il peut être nécessaire d'élever ou d'abaisser, suivant le cas, la valeur de fonctionnement de la **grandeur de manœuvre** au-delà de la **valeur de fonctionnement** de façon à faire **fonctionner** des contacts, puis de ramener la valeur de la **grandeur de manœuvre** au niveau exigé.

   4) Pour les autres **dispositifs de commande automatiques**, la **séquence** ou partie de la **séquence de fonctionnement** la plus difficile doit être choisie.

d) Si le **dispositif de commande** commence à fonctionner pendant l'essai, il est réarmé de manière que ses contacts restent constamment fermés.

Si un réarmement pour refermer les contacts s'avère difficile, l'essai est arrêté. Une nouvelle **valeur de fonctionnement** est déterminée pour recommencer l'essai.

16.5 Les **dispositifs de commande** sont soumis à essai dans un appareil de chauffage et/ou de réfrigération permettant d'obtenir les conditions ambiantes de a) et b).

*Sauf dans le cas des **dispositifs de commande** soumis aux essais dans ou avec les appareils, l'essai doit être effectué dans un environnement protégé des courants d'air. La convection naturelle est autorisée.*

a) La température de la **tête de commande** est maintenue entre T_{max} et soit (T_{max} + 5) °C, soit 1,05 fois T_{max}, en retenant la valeur la plus élevée des deux. La température de toute surface de montage est maintenue entre $T_{s\ max}$ et soit ($T_{s\ max}$ + 5) °C, soit 1,05 fois $T_{s\ max}$, en retenant la valeur la plus élevée si $T_{s\ max}$ est supérieure à T_{max} de plus de 20 K.

b) Les **dispositifs de commande intercalés dans un câble souple**, les **dispositifs de commande à montage indépendant** et les parties des **dispositifs de commande intégrés** et **incorporés** qui sont accessibles lorsque le **dispositif de commande** est monté en position d'**usage normal** doivent être maintenus à une température comprise entre 15 °C et 30 °C, les températures résultantes mesurées étant corrigées pour une température ambiante de référence de 25 °C. Les surfaces accessibles doivent être essayées à une température plus élevée comme indiqué dans le Tableau 1, exigence 15.

16.6 Les températures spécifiées pour la **tête de commande**, les surfaces de montage et l'**élément sensible** doivent être atteintes en 1 h environ.

a) Les conditions électriques et thermiques sont maintenues pendant 4 h ou 1 h après l'obtention d'un régime établi suivant la période la plus courte.

b) Pour les **dispositifs de commande** à fonctionnement limité à des courtes périodes ou à **fonctionnement** intermittent, la ou les périodes de repos déclarées au Tableau 1, exigence 29 doivent être incluses dans la période de 4 h.

16.7 La température du milieu dans lequel se situe la **tête de commande** et la valeur de la **grandeur de manœuvre** à laquelle l'**élément sensible** est exposé doivent être mesurées aussi près que possible du centre de l'espace occupé par les échantillons à une distance d'environ 50 mm du **dispositif de commande**.

a) La température des parties et des surfaces indiquées dans le Tableau 17 doit être déterminée à l'aide de couples thermoélectriques à fil fin ou par des moyens équivalents choisis et disposés de façon à réduire le plus possible leur influence sur la température de la partie en essai.

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b) Les couples thermoélectriques employés pour déterminer la température des surfaces sont fixés sur la face intérieure de plaquettes en cuivre ou laiton noirci, de 15 mm de diamètre et 1 mm d'épaisseur et encastrés de niveau avec la surface. Autant qu'il soit possible, la position du **dispositif de commande** est choisie telle que les parties susceptibles d'atteindre les températures les plus élevées soient en contact avec les plaquettes.

c) Pour la détermination des températures des **organes de manœuvre** et autres poignées, boutons, manettes et organes analogues, sont prises en considération les autres parties qui sont saisies en **usage normal** et, pour les parties en matière non métallique, les parties en contact avec du métal chaud.

d) La température de l'isolation électrique, autre que celle des enroulements, est déterminée à la surface de l'isolation, aux endroits où une **défaillance** pourrait provoquer:

   – un court-circuit;
   – un **danger** d'incendie;
   – un effet néfaste sur la protection contre les chocs électriques;
   – l'établissement d'un contact entre les **parties actives** et des parties métalliques accessibles;
   – un contournement de l'isolation;
   – une réduction des **lignes de fuite** ou des **distances dans l'air** en dessous des valeurs spécifiées à l'Article 11.

Tableau 17 – Températures de chauffage maximales

Parties	**Température maximale admissible** °C
Broches des socles de connecteurs et des dispositifs enfichables [a]:	
– pour conditions très chaudes	155
– pour conditions chaudes	120
– pour conditions froides	70
Enroulements [b c d e] et tôles de noyau en contact avec ceux-ci, si l'isolation des enroulements est:	
– en matière de la classe A	100 [90]
– en matière de la classe E	115 [105]
– en matière de la classe B	120 [110]
– en matière de la classe F	140
– en matière de la classe H	165
Bornes et **connexions** pour **conducteurs externes** [a f g]	85
Autres bornes et **connexions** [a h]	85
Enveloppe isolante en caoutchouc ou en polychlorure de vinyle des conducteurs: [a]	
– si des flexions se produisent ou sont susceptibles de se produire	60
– si des flexions ne se produisent pas ou ne sont pas susceptibles de se produire	75
– avec indication de température ou valeur assignée de la température	valeur indiquée
Gaine de câble utilisée comme **isolation supplémentaire** [i]	60
Caoutchouc autre que synthétique employé pour les bagues d'étanchéité ou autres parties dont la détérioration pourrait réduire la conformité au présent document:	
– lorsqu'il est utilisé comme **isolation supplémentaire** ou comme **isolation renforcée**	65
– dans les autres cas	75
Matériaux utilisés pour l'isolation autres que ceux utilisés pour les fils [i j k]:	
– textiles, papier ou carton imprégnés ou vernis	95
– stratifiés agglomérés avec:	
• résines mélamine-formaldéhyde, phénol-formaldéhyde ou phénol-furfural	110 [200]
• résines à base d'urée-formaldéhyde	90 [175]

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Parties	Température maximale admissible
– matériaux moulés[j]	
• phénol-formaldéhyde à charge cellulosique	110 [200]
• phénol-formaldéhyde à charge minérale	125 [225]
• mélamine-formaldéhyde	100 [175]
• urée-formaldéhyde	90 [175]
• polyester renforcé de fibre de verre	135
• mica pur et matériaux en céramique fortement frittés lorsque ces produits sont utilisés comme **isolation supplémentaire** ou comme **isolation renforcée**	425
• autres matériaux thermodurcissables et tous les matériaux thermoplastiques [l]	–
Toutes les **surfaces accessibles** à l'exception de celles des **organes de manœuvre**, des poignées, des boutons, des manettes et des organes analogues	85
Surfaces accessibles des poignées, des boutons, des manettes et des organes analogues utilisés pour le transport du **dispositif de commande**:	
– en métal	55
– en porcelaine ou matière vitrifiée	65
– en matière moulée caoutchouc ou bois	75
Surfaces accessibles des **organes de manœuvre** ou d'autres poignées, manettes et organes analogues qui ne sont tenus que pendant de courtes périodes:	
– en métal	60
– en porcelaine ou matière vitrifiée	70
– en matière moulée caoutchouc ou bois	85
Autres parties en bois	90
Surfaces en contreplaqué peintes	85
Parties en cuivre ou en laiton destinées à conduire le courant [a m n]	230
Parties en acier conduisant le courant [a]	400
Autres parties transportant le courant [a m]	–

[a] Pour ces parties, les essais de 16.7 sont répétés après les essais de l'Article 19.

[b] La classification est conforme à l'IEC 60085.

Sont considérés comme des exemples de matériaux de la classe A: le coton, la soie naturelle, la soie artificielle et le papier imprégnés, les émaux oléorésineux, ou à base de résines polyamide.

Sont considérés comme des exemples de matériaux de la classe B: la fibre de verre, les résines mélamine-formaldéhyde et phénol-formaldéhyde.

Sont considérés comme des exemples de matériaux de la classe E:

– les résines moulées à charge cellulosique, les stratifiés coton et les stratifiés papier agglomérés avec des résines mélamine-formaldéhyde, phénol-furfural;
– les résines polyester à chaînes transversales, les films de triacétate de cellulose, les films de téréphtalate de polyéthylène;
– les toiles vernies à base de téréphtalate de polyéthylène agglomérées avec des vernis à base de résines alkydes modifiés à l'huile;
– les émaux à base de résines formol-polyvinyle, polyuréthanne ou époxyde.

Des essais de vieillissement accéléré plus importants et, en outre, des essais de compatibilité sont exigés pour des **systèmes** d'isolation de la classe B et des classes de températures plus élevées.

Pour les moteurs fermés utilisant des matériaux des classes A, E et B, les températures peuvent être augmentées de 5 K. Un moteur fermé est un moteur construit de façon à empêcher la circulation de l'air entre l'intérieur et l'extérieur de l'enveloppe, mais non suffisamment enfermé pour être considéré comme hermétique (étanche à l'air).

[c] Pour tenir compte du fait que la température des enroulements des moteurs universels, des relais, des solénoïdes, etc. est généralement inférieure à la moyenne aux points accessibles aux couples thermoélectriques, les valeurs qui ne sont pas entre crochets sont applicables quand la méthode de la résistance est employée et les valeurs entre crochets s'appliquent lorsque des thermocouples sont utilisés. Pour les enroulements des vibreurs et des moteurs à courant alternatif, les valeurs qui ne sont pas entre crochets s'appliquent dans les deux cas.

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[d] La valeur de l'échauffement d'un enroulement en cuivre est calculée à partir de la formule:

$$\Delta t = \frac{R_2 - R_1}{R_1}(234{,}5 + t_1) - (t_2 - t_1)$$

où

Δt est l'échauffement [K];

R_1 est la résistance au début de l'essai [Ω];

R_2 est la résistance à la fin de l'essai [Ω];

t_1 est la température ambiante de service au début de l'essai, à régler sur T_{max} [°C];

t_2 est la température ambiante de service à la fin de l'essai [°C];

Au début de l'essai, les enroulements sont tenus de se trouver à T_{max}.

Il est recommandé de déterminer la résistance des enroulements à la fin de l'essai en effectuant les mesures de résistance aussitôt que possible après l'ouverture du circuit, puis à des intervalles rapprochés, de façon à pouvoir tracer une courbe de variation de la résistance en fonction du temps pour déterminer la résistance au moment de l'ouverture du circuit.

La température maximale atteinte pour les besoins de l'Article 16 est obtenue en ajoutant l'échauffement à T_{max}.

[e] Pour les petits enroulements dont la section n'a pas de plus faible dimension supérieure à 5 mm, la température maximale permise, mesurée par la méthode de la résistance, est:

Classe	°C
A	105
E	120
B	130
F	155
H	180

[f] Pour les **dispositifs de commande** qui sont soumis aux essais montés dans ou sur des matériels, seules les températures des bornes pour conducteurs fixes sont vérifiées, car ce type de matériel n'est généralement pas livré avec des **conducteurs externes**. Pour les matériels équipés de bornes autres que celles pour conducteurs fixes, la température de l'isolation des **conducteurs externes** est relevée au lieu de la température des bornes.

[g] Pour les **dispositifs de commande intégrés** et incorporés, aucune limite de température n'est applicable mais l'attention est attirée sur le fait que la plupart des normes de matériels limitent la température des bornes des appareils fixes à 85 °C, qui est la température maximale admise pour les câbles isolés au PVC ordinaire. Il convient que la température maximale enregistrée ne dépasse pas la valeur déclarée au Tableau 1, exigence 14.

Si un **dispositif de commande** est incorporé/intégré dans un appareil, les bornes des **conducteurs externes** sont, en tant que parties de l'appareil, soumises aux essais spécifiés par la norme de l'appareil et leur conformité vérifiée selon les limites de température de la présente norme.

[h] La température mesurée ne doit pas dépasser 85 °C, à moins qu'une valeur plus élevée n'ait été déclarée par le fabricant.

[i] Les valeurs de température indiquées qui dépendent des matériaux utilisés peuvent être dépassées s'il est reconnu par l'expérience que les matériaux utilisés présentent des propriétés particulières de résistance à la chaleur.

[j] Les valeurs entre crochets s'appliquent aux parties d'un matériau utilisées pour des **organes de manœuvre**, des poignées, des boutons, des manettes et des organes analogues et qui sont en contact avec du métal chaud mais ne sont pas accessibles.

[k] Lorsqu'une pièce métallique est en contact avec une partie en matériau isolant, la température du matériau isolant au point de contact est supposée être la même que celle de la partie métallique.

[l] Les températures maximales admissibles ne doivent pas être supérieures aux températures acceptables démontrées pour les matériaux en question. Ces températures doivent être enregistrées en vue des essais de l'Article 21.

[m] Les températures maximales admissibles ne doivent pas être supérieures aux températures acceptables démontrées pour les matériaux en question.

[n] Des températures plus élevées sont permises pour des alliages cuivre spécifiques si elles sont justifiées par des informations sur les essais liés à une norme reconnue de la métallurgie, fournies par le fabricant d'alliage. Voir également Note m.

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17 Tolérances de fabrication et dérive

La tolérance de fabrication et la dérive sont exigées pour l'**action de type 2** et font partie de la sécurité fonctionnelle comme indiqué à la Figure 2. Voir Article H.17.

18 Contraintes climatiques

18.1 Transport et stockage

Les dispositifs de commande sensibles aux contraintes climatiques de température doivent pouvoir supporter sans inconvénient le niveau de contrainte approprié susceptible de se produire pendant le transport ou le stockage.

*La conformité est vérifiée par les essais appropriés de 18.2 qui sont effectués en maintenant le **dispositif de commande** dans des conditions identiques aux conditions de transport déclarées. En l'absence de telles déclarations, le **dispositif de commande** est soumis à essai avec son **organe** ou sa **liaison de manœuvre** dans la position la plus défavorable.*

18.2 Contrainte climatique de température

18.2.1 *L'effet de la température est vérifié de la manière suivante:*

– *le **dispositif de commande** complet doit être maintenu à une température de (−10 ± 2) °C pendant une période de 24 h;*

– *le **dispositif de commande** complet doit être ensuite maintenu à une température de (60 ± 5) °C pendant une période de 4 h.*

18.2.2 *Pendant ces deux périodes, le **dispositif de commande** n'est pas mis sous tension.*

18.2.3 *Après chaque essai, un **dispositif de commande** comportant un **organe** ou une **liaison de manœuvre** doit pouvoir être manœuvré correctement et assurer le type de coupure déclaré pour autant que cela puisse être déterminé sans démontage du **dispositif de commande**. Cet essai est effectué à la température ambiante normale.*

*Le **dispositif de commande** est maintenu à température ambiante pendant 8 h avant d'être **manœuvré**.*

18.2.4 *De plus, pour les **dispositifs de commande** à **action de type 2**, l'essai approprié de l'Article 17 doit être répété après chacun des essais mentionnés ci-dessus. Pour un même échantillon, la différence entre les valeurs relevées au cours de ces essais et la valeur relevée au cours de l'essai de l'Article H.17 ne doit pas dépasser la **dérive** déclarée dans le Tableau 1, exigence 36.*

19 Endurance

19.1 Exigences générales

19.1.1 Objectifs de l'essai

L'essai d'endurance est destiné

a) à évaluer la robustesse des contacts de commutation et des parties associées qui sont soit intégrés dans le dispositif de commande, soit commandés séparément;

b) à assurer la sécurité intrinsèque et fonctionnelle, suivant le cas, ainsi que le fonctionnement normal du dispositif de commande;

c) aux dispositifs de commande électromécanique à **action de type 1** et **de type 2**;

d) aux **dispositifs de commande électronique** avec des parties mobiles.

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19.1.2 Ensemble des dispositifs de commande

Les **dispositifs de commande**, y compris les dispositifs qui sont soumis aux essais montés sur ou dans un matériel, doivent supporter les contraintes mécaniques, électriques et thermiques susceptibles de se produire en **usage normal**.

19.1.3 Dispositifs de commande électronique

19.1.3.1 Aucun essai d'endurance n'est effectué sur les **dispositifs de commande électronique** à **action de type 1** lorsque les composants associés à des actions manuelles, des relais, etc. sont conformes à l'IEC appropriée ou lorsqu'ils sont conformes à l'IEC appropriée, aux caractéristiques assignées et aux conditions pour l'application spécifique du dispositif de commande.

19.1.3.2 Un essai d'endurance est également effectué sur les **dispositifs de commande électronique** à **action de type 1** lorsque les fonctions d'éléments de commutation intégrés ou des **actions manuelles** ne peuvent pas être réalisées par indépendance du **dispositif de commande électronique** et dépendent de l'électronique ou de la conception du dispositif de commande. Les **dispositifs de commande électronique** à **action de type 2** ne sont pas soumis à un essai d'endurance, mais à un essai thermique cyclique dans les conditions décrites en H.19.1.3.3. Cet essai peut être combiné avec celui de tout composant associé comme ceux à **actions manuelles**, à relais, etc. si cela est possible.

NOTE Les claviers électroniques ne sont pas soumis à un essai d'endurance, sauf s'ils sont utilisés pour actionner manuellement une fonction de sécurité. Les exemples incluent les unités de commande de plaques à induction.

19.1.3.3 Essai thermique cyclique (voir H.19.1.3.3)

19.1.4 Dispositifs de commande à action de type 2

Les dispositifs de commande à **action de type 2** doivent fonctionner de façon que toute valeur, tout temps ou toute séquence de fonctionnement ne varient pas d'une quantité supérieure à la dérive déclarée (voir Article H.17).

19.1.5 Critères de conformité

La conformité à 19.1.2 et 19.1.3 est vérifiée par les essais de 19.1.6 ou comme indiqué en 19.15.

La conformité à 19.1.3 est vérifiée par les essais décrits en 19.1.6.

19.1.6 Séquence et conditions d'essais

19.1.6.1 Sauf indication contraire dans la Partie 2 ou dans la norme de matériel final, la séquence d'essais est

– *un essai de vieillissement selon 19.6 (cet essai ne s'applique qu'aux actions de type 1.M ou 2.M);*

– *un essai de surtension pour **action automatique** à vitesse accélérée selon 19.7;*

– *un essai de fonctionnement pour **action automatique** accélérée selon 19.8;*

– *un essai de fonctionnement pour **action automatique** à faible vitesse selon 19.9 (cet essai n'est applicable qu'aux **actions automatiques à ouverture et fermeture lentes**);*

– *un essai de surtension pour **action manuelle** à vitesse accélérée selon 19.10;*

– *un essai de fonctionnement pour **action manuelle** à faible vitesse selon 19.11;*

– *un essai de fonctionnement pour **action manuelle** à vitesse élevée selon 19.12 (cet essai est applicable uniquement pour les actions multipolaires, et lorsqu'une inversion de polarité se produit pendant le **fonctionnement**);*

– *un essai de fonctionnement pour **action manuelle** à vitesse accélérée selon 19.13.*

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19.1.6.2 Pendant l'essai, les conditions électriques, thermiques et mécaniques doivent être, en général, celles spécifiées en 19.2, 19.3 et 19.4. Les exigences générales d'essai sont données de 19.6 à 19.14 inclus. Les exigences particulières d'essai sont données dans la Partie 2 correspondante.

19.1.6.3 Pour une **action manuelle** faisant partie d'une **action automatique**, les essais correspondants sont normalement spécifiés au paragraphe applicable à l'**action automatique**. Cependant, dans le cas où ces essais ne sont pas spécifiés, 19.10 à 19.13 inclus sont applicables à de telles **actions manuelles**.

19.1.6.4 Après tous les essais spécifiés, les échantillons doivent satisfaire aux exigences de 19.14, sauf spécification contraire dans la Partie 2 appropriée.

19.1.6.5 *Les dispositifs à montage indépendant réalisant les fonctions de **réarmement** à distance doivent être soumis à essai pendant un minimum de 1 000 actions de réarmement. Pour les dispositifs intégrés et incorporés, sauf indication contraire, le nombre minimal de cycles de réarmement doit être déclaré par le fabricant. A l'issue de l'essai, le dispositif de **réarmement** doit pouvoir procéder au réarmement du **système** comme prévu. Des **réarmements** intempestifs ne doivent pas se produire.*

19.2 Conditions électriques pour les essais

19.2.1 Chaque circuit d'un **dispositif de commande** doit être chargé conformément aux valeurs assignées déclarées par le fabricant. Les circuits et les contacts qui ne sont pas destinés à commander des charges externes sont mis en fonctionnement avec les charges indiquées. Certains circuits inverseurs peuvent exiger un essai séparé de chaque partie du circuit si le fabricant le déclare dans ses instructions, particulièrement si les valeurs assignées pour une partie du circuit inverseur dépendent du courant qui circule dans l'autre partie.

19.2.2 Dans tous les pays qui utilisent un essai de surtension, les charges électriques à utiliser sont spécifiées dans le Tableau 18 à la tension assignée V_R, cette tension étant augmentée à 1,15 V_R, pour l'essai de surtension de 19.7 et 19.10.

19.2.3 Dans tous les pays qui utilisent un essai de surcharge, les conditions spécifiées au Tableau 19 et au Tableau 20 s'appliquent. Les essais de surcharge sont effectués sur un seul pôle ou débattement, les autres pôles ou débattements étant à la charge normale.

a) Pour l'essai de surcharge, les tensions d'essai (VT) sont
   - 120 V pour les **dispositifs de commande** ayant une tension assignée comprise entre 110 V et 120 V;
   - 208 V pour les dispositifs de commande ayant une tension assignée comprise entre 200 V et 208 V;
   - 240 V pour les **dispositifs de commande** ayant une tension assignée comprise entre 220 V et 240 V;
   - 277 V pour les **dispositifs de commande** ayant une tension assignée comprise entre 254 V et 277 V;
   - 480 V pour les **dispositifs de commande** ayant une tension assignée comprise entre 440 V et 480 V;
   - 600 V pour les **dispositifs de commande** ayant une tension assignée comprise entre 550 V et 600 V.

b) Si la valeur assignée du **dispositif de commande** ne se situe pas à l'intérieur des plages de tensions indiquées, il est soumis à essai sous sa tension assignée.

19.2.4 Quand il existe un **système** de neutre à la terre, l'enveloppe doit être reliée par un fusible calibré à 3 A au **conducteur de protection** du circuit, et pour les autres **systèmes**, l'enveloppe doit être reliée à travers un fusible de ce calibre au pôle de phase qui risque le moins d'être mis à la terre.

19.2.5 Pour les actions de type 1.G ou 2 G et les autres actions à vide, des interrupteurs auxiliaires sont utilisés pour simuler le **fonctionnement** prévu pendant l'essai.

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Tableau 18 – Conditions électriques pour les essais de surtension et d'endurance

(Ce tableau s'applique à tous les essais conformément à 19.2.2 et aux pays qui utilisent un essai de surtension.)

Type de circuit comme indiqué dans le Tableau 1, exigence 8	**Réalisation des activités opérationnelles**	**Circuit alternatif**			**Circuit continu**		
		V	**A**	**Facteur de puissance** (±0,05)[a]	**V**	**A**	**Constante de temps (±1 ms)**
Charge pratiquement résistive[d]	Fermeture et ouverture	V_R	I_R	0,95	V_R	I_R	Non inductive
Résistive ou inductive [e]	Fermeture [b]	V_R	6,0 I_X ou I_R selon la plus grande valeur arithmétique	0,6 0,95	V_R	2,5 I_X ou I_R selon la plus grande valeur arithmétique	7,5
	Ouverture	V_R	I_X ou I_R selon la plus grande valeur arithmétique	0,95		I_X ou I_R selon la plus grande valeur arithmétique	Non inductive
Charge spécifique déclarée	Fermeture et ouverture	V_R	Selon charge		V_R	Selon charge	
Charge 20 mA	Fermeture et ouverture	V_R	20 mA	0,95	V_R	20 mA	Non inductive
Charge par moteur déclarée	Fermeture et ouverture	V_R	Selon déclaration		V_R	Selon déclaration	
Charge par **mode pilote**	Fermeture [b]	V_R	10 VA/ V_R	0,35		[c]	
	Ouverture	V_R	VA/ V_R	0,95			

Les circuits pour charges inductives seulement peuvent soit être soumis à essai en tant que charge résistive ou inductive en déclarant que la charge résistive est égale à la charge inductive, soit être soumis à essai en tant que charge spécifique déclarée.

Les abréviations suivantes sont utilisées:

V_R est la tension assignée, I_R est le courant assigné dans le cas d'une charge résistive, I_X est le courant assigné dans le cas d'une charge inductive.

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A des fins d'essai, une charge par **mode pilote** se compose d'un électro-aimant représentant le bobinage de l'aimant à commander. Le courant normal est celui qui est déterminé à partir des valeurs assignées de tension et de voltampères de l'électro-aimant. Le courant d'essai est le courant normal et, pour un courant alternatif, le facteur de puissance doit être de 0,35 ou moins et le **courant d'appel** doit être de 10 fois le courant normal. Le contacteur d'essai doit être libre de fonctionner, c'est-à-dire ne pas être bloqué soit en position ouverte, soit en position fermée.

Une valeur assignée par **mode pilote** à courant alternatif peut être déterminée pour un **dispositif de commande** ayant été soumis à essai pour la commande d'un moteur à courant alternatif sur les bases suivantes:

– pendant l'essai de surcharge, un courant d'une valeur équivalente à six fois le courant du moteur à pleine charge à un facteur de puissance de 0,5 ou moins est établi et coupé par le **dispositif de commande**, pendant 50 cycles à une cadence de 6 cycles par minute;
– le **courant assigné d'appel** par **mode pilote** (10 fois le courant normal) ne doit pas être de plus de 67 % de la valeur normale de l'essai de surcharge décrit ci-dessus.

Un interrupteur non prévu d'origine pour fermer et ouvrir le courant du moteur dans les conditions de rotor bloqué, mais qui a un moyen de réglage ou de régulation manuel qui peut lui permettre d'être utilisé ainsi, doit satisfaire aux exigences de 19.7 pour un essai de rotor bloqué.

Pour un interrupteur prévu pour **fonctionner** en courant continu, le nombre de **fonctionnements** doit être de cinq (5), menés à intervalles de 30 s et l'appareil doit aussi satisfaire aux exigences du point a).

[a] Les résistances et les inductances ne sont pas reliées en parallèle, sauf s'il est fait usage d'une inductance à air, auquel cas une résistance absorbant environ 1 % du courant traversant l'inductance est reliée en parallèle avec cette inductance à air. Les inductances à noyau de fer peuvent être utilisées si le courant est pratiquement sinusoïdal. Pour les essais en triphasé, les inductances à noyau triphasé sont utilisées.

[b] Les conditions de fermeture spécifiées sont maintenues pendant une période comprise entre 50 ms et 100 ms avant d'être réduites aux conditions d'ouverture spécifiées au moyen d'un interrupteur auxiliaire. Dans n'importe lequel des essais du présent article, si l'ouverture du contact se produit moins de 2 s après sa fermeture, les conditions spécifiées pour la fermeture sont également utilisées pour l'ouverture.

[c] Ces valeurs ne sont pas applicables.

[d] De tels circuits sont utilisables avec des charges inductives à condition que le facteur de puissance ne soit pas inférieur à 0,8 et que la charge inductive soit limitée à 60 % du courant assigné avec charge résistive. Ces circuits sont également utilisables avec d'autres charges réactives ne dépassant pas 10 VA, à condition que le courant réactif ne dépasse pas 5 % du courant résistif assigné.

[e] Circuits pour charges résistives ou pour charges inductives dont le facteur de puissance n'est pas inférieur à 0,6 ou pour charge mixte (résistive et inductive).

Exemple: le circuit d'un ventilateur qui incorpore à la fois un élément chauffant et un moteur.

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Tableau 19 – Conditions électriques pour les essais de surcharge de 19.7 et 19.10

(ce tableau s'applique à tous les pays qui utilisent un essai de surcharge conformément à 19.1.6.1*)*

Type de circuit comme indiqué dans le Tableau 1, exigence 8	Réalisation des activités opérationnelles	Circuit alternatif			Circuit continu		
		V	A	Facteur de puissance	V	A	
Charge pratiquement résistive	Fermeture et ouverture	V_T	$1{,}5I_R$	1,0	V_T	$1{,}5I_R$	
Inductive (autre que par moteur)	Fermeture et ouverture	V_T	$1{,}5I_X$	0,75 à 0,8	V_T	$1{,}5I_X$	
Charge par moteur déclarée	Fermeture et ouverture	V_T	$6I_m$ ou selon déclaration	0,4 à 0,5 ou selon déclaration	V_T	$10I_m$ ou selon déclaration	
Charge spécifique déclarée	Fermeture et ouverture	V_T	$1{,}5I_X$	0,75 à 0,8	V_T	$1{,}5I_X$	
Charge 20 mA	Fermeture et ouverture	V_T	$1{,}5I_X$	0,95	V_T	20 mA	Non inductive
Charge par **mode pilote**	Fermeture	1,1 V_T	10 VA/ V_T	0,35 au maximum ou selon déclaration	Selon déclaration		
	Ouverture	1,1 V_T	VA/ V_T ou selon déclaration				

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Les abréviations suivantes sont utilisées:

V_R est la tension assignée, V_T est la tension d'essai (voir 19.2.3 a)). Un circuit dans lequel la tension en circuit fermé est 100 % à 110 % de V_T est acceptable pour les essais.

I_m est le courant assigné dans le cas d'une charge par moteur, I_R est le courant assigné dans le cas d'une charge résistive, I_X est le courant assigné dans le cas d'une charge inductive.

A des fins d'essai, une charge par **mode pilote** se compose d'un électro-aimant représentant le bobinage de l'aimant à commander. Le courant normal est celui qui est déterminé à partir des valeurs assignées de tension et de voltampères de l'électro-aimant. Le courant d'essai est le courant normal et, pour un courant alternatif, le facteur de puissance doit être de 0,35 ou moins et le **courant d'appel** doit être de 10 fois le courant normal. Le contacteur d'essai doit être libre de fonctionner, c'est-à-dire ne pas être bloqué soit en position ouverte, soit en position fermée.

Une valeur assignée par **mode pilote** à courant alternatif peut être déterminée pour un **dispositif de commande** ayant été soumis à essai pour la commande d'un moteur à courant alternatif sur les bases suivantes:

– pendant l'essai de surcharge, un courant d'une valeur équivalente à six fois le courant du moteur à pleine charge à un facteur de puissance de 0,5 ou moins est établi et coupé par le **dispositif de commande**, pendant 50 cycles à une cadence de 6 cycles par minute;

– le **courant assigné d'appel** par **mode pilote** (10 fois le courant normal) ne doit pas être de plus de 67 % de la valeur normale de l'essai de surcharge décrit ci-dessus.

Pour les **dispositifs de commande** qui peuvent fermer un circuit moteur en conditions de rotor bloqué mais ne devant jamais ouvrir le circuit dans de telles conditions, ce qui suit s'applique:

a) 100 % V_T en alternatif et 0,5 V_T en courant continu pour 1,5 fois le courant assigné;

b) 100 % V_T pour le courant de rotor bloqué (fermeture seulement).

Un interrupteur non prévu d'origine pour fermer et ouvrir le courant du moteur dans les conditions de rotor bloqué, mais qui a un moyen de réglage ou de régulation manuel qui peut lui permettre d'être utilisé ainsi, doit satisfaire aux exigences de 19.7 pour un essai de rotor bloqué.

Pour un interrupteur prévu pour **fonctionner** en courant continu, le nombre de **fonctionnements** doit être de cinq (5), menés à intervalles de 30 s et l'appareil doit aussi satisfaire aux exigences du point a) ci-dessus.

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Tableau 20 – Conditions électriques pour les essais d'endurance de 19.8, 19.9, 19.11, 19.12 et 19.13

(ce tableau s'applique à tous les pays qui utilisent un essai de surcharge conformément à 19.1.6.1)

Type de circuit comme indiqué dans le Tableau 1, exigence 8	Réalisation des activités opérationnelles	Circuit alternatif			Circuit continu		
		V	A	Facteur de puissance	V	A	
Charge pratiquement résistive	Fermeture et ouverture	V_T	I_R	1	V_T	I_R	
Inductive (autre que par moteur)	Fermeture et ouverture	V_T	I_X	0,75 à 0,8	V_T	I_X	
Charge par moteur déclarée	Fermeture et ouverture	V_T	I_m ou comme déterminé par la charge	0,75 à 0,8 ou selon déclaration	V_T	I_m	
Charge spécifique déclarée	Fermeture et ouverture	V_T	Comme déterminé par la charge[a]		V_T	Comme déterminé par la charge[a]	
Charge 20 mA	Fermeture et ouverture	V_T	20 mA	0,95	V_T	20 mA	Non inductive
Charge par **mode pilote**	Fermeture	V_T	10 VA/ V_T	0,35 au maximum	Selon déclaration		
	Ouverture	V_T	VA/ V_T ou selon déclaration	ou selon déclaration			

Les abréviations suivantes sont utilisées:

V_R est la tension assignée, V_T est la tension d'essai (voir 19.2.3 a)).

I_m est le courant assigné dans le cas d'une charge par moteur, I_R est le courant assigné dans le cas d'une charge résistive, I_X est le courant assigné dans le cas d'une charge inductive.

A des fins d'essai, une charge par **mode pilote** se compose d'un électro-aimant représentant le bobinage de l'aimant à commander. Le courant normal est celui qui est déterminé à partir des valeurs assignées de tension et de voltampères de l'électro-aimant. Le courant d'essai est le courant normal et, pour un courant alternatif, le facteur de puissance doit être de 0,35 ou moins et le **courant d'appel** doit être de 10 fois le courant normal. Le contacteur d'essai doit être libre de fonctionner, c'est-à-dire ne pas être bloqué soit en position ouverte, soit en position fermée.

Pour les **dispositifs de commande** qui peuvent fermer un circuit moteur en conditions de rotor bloqué mais ne devant jamais ouvrir le circuit dans de telles conditions, ce qui suit s'applique 100 % V_T en courant alternatif AC et 0,5 V_T en courant continu.

[a] Un dispositif de commande peut être manœuvré à une cadence plus rapide que 1 cycle à la minute si des charges synthétiques sont utilisées ou si un nombre suffisant de bancs de lampes contrôlés par un interrupteur sont utilisés de telle manière que chaque banc refroidisse pendant au moins 59 s entre des applications successives.

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19.3 Conditions thermiques pour les essais

19.3.1 Les exigences suivantes doivent être applicables à toutes les parties du **dispositif de commande** à l'exception d'un **élément thermosensible**:

– *les parties qui sont accessibles lorsque le **dispositif de commande** est monté selon les instructions du fabricant doivent être exposées à la température ambiante normale (voir 4.3);*

– *la surface de montage du dispositif de commande doit être maintenue entre $T_{s\ max}$, et soit ($T_{s\ max}$ + 5) °C, soit 1,05 fois $T_{s\ max}$, suivant la valeur la plus élevée;*

– *le reste de la **tête de commande** doit être maintenu entre T_{max} et soit (T_{max} + 5) °C, soit 1,05 fois T_{max}, suivant la valeur la plus élevée. Si T_{min} est inférieure à 0 °C, des essais complémentaires doivent être effectués avec la **tête de commande** maintenue entre T_{min} et (T_{min} – 5) °C.*

19.3.2 Pour les essais de 19.8 et 19.13, les températures de 19.3.1 sont applicables à la seconde moitié de chaque essai. Pour la première moitié, la **tête de commande** est maintenue à la température ambiante.

Des échantillons supplémentaires sont exigés si les essais doivent être effectués aux deux températures (T_{max} et T_{min}).

19.4 Conditions manuelles et mécaniques des essais

19.4.1 Pour toutes les **actions manuelles**, chaque cycle de **manœuvre** doit comprendre un mouvement de l'**organe de manœuvre** tel que le **dispositif de commande** prenne successivement toutes les positions correspondant à cette action avec retour à la position initiale, sauf si plusieurs **positions ARRÊT** du **dispositif de commande** ont été prévues, auquel cas chaque **action manuelle** doit comprendre un mouvement d'une **position ARRÊT** à la **position ARRÊT** suivante.

19.4.2 L'**organe de manœuvre** doit être déplacé aux vitesses suivantes:

– *pour l'essai à faible vitesse:*

  (9 ± 1)° par seconde pour les mouvements rotatifs;

  (5 ± 0,5) mm/s pour les mouvements linéaires;

– *pour l'essai à grande vitesse:*

  *l'**organe de manœuvre** doit être déplacé à la main aussi vite que possible. Si un **dispositif de commande** n'est pas équipé d'un **organe de manœuvre**, le laboratoire doit l'équiper d'un **organe de manœuvre** convenable;*

– *pour l'essai à vitesse accélérée:*

  (45 ± 5)° par seconde pour les mouvements rotatifs;

  (25 ± 2,5) mm/s pour les mouvements linéaires.

19.4.3 Pendant l'essai à faible vitesse de 19.4.2:

*L'appareil d'essai doit actionner l'**organe de manœuvre**, sans jeu excessif entre l'appareil d'essai et l'**organe de manœuvre**.*

19.4.4 Pendant l'essai à vitesse accélérée de 19.4.2:

– *l'appareil d'essai détermine le libre déplacement de l'**organe de manœuvre** de façon à ne pas entraver le fonctionnement normal du mécanisme;*

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– *pour les **dispositifs de commande** dans lesquels les mouvements de l'**organe de manœuvre** sont limités:*

  - *il doit y avoir une pause d'au moins 2 s à chaque changement de sens;*
  - *un couple (pour les **dispositifs de commande** rotatifs) ou une force (pour les **dispositifs de commande** non rotatifs) doivent être appliqués à l'extrémité de chaque mouvement pour vérifier la bonne tenue mécanique des butées. Le couple exercé doit avoir une valeur de cinq fois le couple normal de commande ou 1,0 Nm suivant la valeur la plus faible avec un minimum de 0,2 Nm. La force appliquée doit avoir une valeur de cinq fois la force normale de commande ou 45 N, suivant la valeur la plus faible avec un minimum de 9 N. Si le couple normal de commande dépasse 1,0 Nm ou si la force normale de commande dépasse 45 N, le couple ou la force appliqués doivent être égaux au couple ou à la force normaux de commande;*

– *pour les **dispositifs de commande** conçus pour une **manœuvre** rotative dont le mouvement n'est pas limité dans les deux sens, les trois quarts du nombre de cycles de **manœuvre** de chaque essai doivent être effectués dans le sens des aiguilles d'une montre, les autres cycles étant effectués en sens inverse;*

– *pour les **dispositifs de commande** unidirectionnels, l'essai doit être effectué dans le sens spécifié pour autant que les couples mentionnés ci-dessus ne permettent pas de faire tourner l'**organe de manœuvre** dans le sens opposé.*

19.4.5 Le dispositif de commande ne doit pas faire l'objet d'une lubrification supplémentaire au cours de ces essais.

19.5 Exigences concernant la rigidité diélectrique

Après tous les essais du présent article, les exigences de 15.2 doivent s'appliquer, mais les échantillons ne sont pas soumis à l'épreuve hygroscopique avant l'application de la tension d'essai. Les tensions d'essai doivent être de 75 % des valeurs correspondantes de 15.2.

19.6 Essai de vieillissement

19.6.1 Au cours de cet essai, l'**élément sensible** doit être maintenu à la valeur de la **grandeur de manœuvre** qui a été déterminée et utilisée à l'Article 16. Les autres parties du dispositif de commande doivent être maintenues aux températures indiquées en 19.3. Le **dispositif de commande** est chargé électriquement comme décrit en 19.2 pour les conditions de coupure applicables. La durée de l'essai est de (100 + 0,02 y) h, "y" étant la valeur déclarée dans l'exigence 21 du Tableau 1. Cet essai s'applique aux **dispositifs de commande** aux actions de type 1.M ou 2.M.

19.6.2 Si au cours de cet essai, l'action se déclenche, la valeur de la **grandeur de manœuvre** est augmentée ou diminuée de façon à provoquer un **fonctionnement** inverse, puis ramenée à une valeur différant d'une valeur "x" de la première pour permettre la reprise de l'essai. Cette opération peut être répétée autant de fois qu'il est nécessaire pour terminer l'essai ou jusqu'à ce que les limites de la **dérive** déclarée de H.17 soient dépassées, lors de la répétition de la procédure applicable de l'Article 5.2. La valeur de "x" est donnée dans la Partie 2 correspondante.

19.7 Essai de surtension ou essai de surcharge dans tous les pays qui utilisent un essai de surcharge pour action automatique accélérée

19.7.1 Les conditions électriques doivent être celles spécifiées en 19.2 pour une surtension ou pour les conditions de surcharge.

19.7.2 Les conditions thermiques doivent être celles spécifiées en 19.3.

19.7.3 Méthode et vitesse de **fonctionnement**:

– *pour les **actions de type 1**, la vitesse de **fonctionnement** et la méthode de **fonctionnement** doivent faire l'objet d'un accord entre le laboratoire et le fabricant;*

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– *pour les **actions de type 2**, la méthode de **fonctionnement** doit être celle qui résulte de la conception du dispositif. Pour les actions de type 2 basées sur la détection d'une grandeur, le taux de **fonctionnement** peut être augmenté, soit à l'accélération des cycles déclarée dans le Tableau 1, exigence 31, soit de sorte que les taux de variation de la **grandeur de manœuvre** ne dépassent pas α_2 et β_2 déclarées dans ce même paragraphe;*

NOTE 1 La méthode opératoire consiste par exemple à remplacer le capillaire d'un **système** hydraulique par un dispositif pneumatique, ou à remplacer le **moteur primaire** par un moteur à vitesse différente.

– *les **dispositifs de commande** à **action de type 2** sont soumis aux essais avec la **valeur de fonctionnement** la plus défavorable déclarée dans le Tableau 1, exigence 42.*

NOTE 2 Pour les **dispositifs de commande** fonctionnant à la température et à la pression, il s'agit normalement de la valeur maximale.

19.7.4 Pour les actions de type 2 basées sur la détection d'une grandeur, le dépassement à chaque cycle de **fonctionnement** doit être compris dans les limites déclarées en 5.2.

19.7.5 Pour une action basée sur la détection d'une grandeur, le taux de variation de la **grandeur de manœuvre** peut être augmenté, et pour les autres **actions de type 1**, le **moteur primaire** peut être inhibé entre les cycles de **fonctionnement**, pour autant que cela n'affecte pas sensiblement les résultats de l'essai.

19.7.6 Le nombre de cycles automatiques que comporte le présent essai est un dixième du nombre déclaré dans le Tableau 1, exigence 20, ou 200 cycles, suivant la valeur la plus faible.

19.7.7 Pendant l'essai, les **organes de manœuvre** sont placés dans leur position la plus défavorable.

19.8 Essai d'action automatique accélérée

19.8.1 Les conditions électriques doivent être celles spécifiées en 19.2.

19.8.2 Les conditions thermiques doivent être celles spécifiées en 19.3.

19.8.3 La méthode et la vitesse de **fonctionnement** doivent être celles utilisées au cours de l'essai de 19.7.3.

19.8.4 Le nombre de cycles automatiques (sauf pour les **actions automatiques à fermeture et ouverture lentes**, comme indiqué plus loin) doit être celui qui est déclaré en Tableau 1, exigence 20, diminué du nombre de cycles effectivement exécutés au cours de l'essai de 19.7. Pendant cet essai, les **organes de manœuvre** doivent être placés dans leur position la plus défavorable. Pendant l'essai, la **défaillance** d'un composant quelconque d'une **action de type 1** qui n'est pas déterminante au regard des exigences de l'essai et que l'on peut, selon toute vraisemblance, attribuer à l'accélération de l'essai, ne doit pas constituer une cause de rejet, à condition que le composant soit réparable ou remplaçable, ou que l'essai puisse être poursuivi d'une manière différente et convenue, de sorte que le nombre total de cycles automatiques spécifié dans le Tableau 1, exigence 20, puisse être accompli.

Pour les **actions automatiques à fermeture et ouvertures lentes**, le nombre de cycles automatiques spécifiés en 19.8.4 et effectués au cours du présent essai est limité à 75 %. Les 25 % restants correspondent à l'essai de 19.9.

19.9 Essai d'action automatique lente

19.9.1 Les **actions automatiques à fermeture et ouverture lentes** doivent être soumises à essai par l'exécution du 25 % restant de nombre de cycles automatiques spécifiés en 19.8.

19.9.2 Les conditions électriques et thermiques doivent être celles spécifiées en 19.2 et 19.3.

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19.9.3 La méthode de **fonctionnement** consiste soit à imposer une variation à la **grandeur de manœuvre** que détecte l'**élément sensible**, soit à agir sur le **moteur primaire**. Pour les **dispositifs de commande sensibles**, les taux de variation de la **grandeur de manœuvre** doivent être les valeurs α_1 et β_1 déclarées en 5.2. Pour un **dispositif de commande sensible**, il est admis de changer le taux de variation de la **grandeur de manœuvre**; et pour un **dispositif de commande automatique**, il est admis d'inhiber le **moteur primaire** entre deux **fonctionnements**, à condition que cela n'affecte pas sensiblement les résultats. Pour les **dispositifs de commande sensibles**, le dépassement à chaque **fonctionnement** doit être compris entre les valeurs déclarées en 5.2. Pour l'application de cet essai à une **action de type 2**, il est essentiel de surveiller de manière continue et d'enregistrer la **valeur de fonctionnement**, les dépassements ou les séquences de **fonctionnement**.

Cette surveillance est également recommandée pour les autres types de **dispositifs de commande** de façon à déterminer la cohérence des essais.

19.9.4 Si seule la fermeture, ou l'ouverture, est une **action automatique** lente, il est admis, par suite d'accord intervenu entre le laboratoire et le fabricant, d'accélérer le reste de l'action à laquelle les dispositions de 19.8 sont applicables.

19.10 Essai de surtension ou essai de surcharge dans tous les pays qui utilisent l'essai de surcharge pour action manuelle accélérée

19.10.1 Les conditions électriques doivent être celles spécifiées en 19.2 pour une surtension ou pour les conditions de surcharge.

19.10.2 Les conditions thermiques doivent être celles spécifiées en 19.3.

19.10.3 La méthode de **fonctionnement** doit être celle spécifiée en 19.4 pour l'essai à vitesse accélérée. Le nombre de cycles de **manœuvre** doit être un dixième du nombre déclaré en 5.2, ou 100, suivant la valeur la plus faible. Pendant l'essai, les **éléments sensibles** sont maintenus à des valeurs appropriées de la **grandeur de manœuvre** et les **moteurs primaires** sont disposés de manière que la **manœuvre** produise le **fonctionnement** désiré.

19.11 Essai d'action manuelle à faible vitesse

19.11.1 Les conditions électriques doivent être celles spécifiées en 19.2.

19.11.2 Les conditions thermiques doivent être celles spécifiées en 19.3.

19.11.3 La méthode de **fonctionnement** doit être celle spécifiée en 19.4 pour l'essai à faible vitesse.

19.11.4 Le nombre de cycles de **manœuvre** doit être un dixième du nombre déclaré en 5.2, ou 100, suivant la valeur la plus faible. Pendant l'essai, les **éléments sensibles** sont maintenus à des valeurs appropriées de la **grandeur de manœuvre** et les **moteurs primaires** sont disposés de manière que la **manœuvre** produise le **fonctionnement** désiré.

19.12 Essai de fonctionnement pour action manuelle à vitesse élevée multipolaire et entraînant une inversion de polarité

19.12.1 Les conditions électriques sont celles spécifiées en 19.2.

19.12.2 Les conditions thermiques sont celles spécifiées en 19.3.

19.12.3 La méthode de **fonctionnement** est celle spécifiée en 19.4 pour l'essai à grande vitesse.

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19.12.4 Le nombre de cycles de **manœuvre** est 100. Pendant les essais, les **éléments sensibles** sont maintenus à des valeurs appropriées de la **grandeur de manœuvre** et les **moteurs primaires** sont disposés de manière que la **manœuvre** produise le **fonctionnement** désiré.

19.13 Essai d'action manuelle à vitesse accélérée

19.13.1 Les conditions électriques sont celles spécifiées en 19.2.

19.13.2 Les conditions thermiques sont celles spécifiées en 19.3.

19.13.3 La méthode de **fonctionnement** est celle spécifiée en 19.4 pour la vitesse accélérée.

19.13.4 Le nombre de cycles de **manœuvre** est égal au nombre déclaré en 5.2 diminué du nombre de cycles effectués au cours des essais de 19.10, 19.11 et 19.12. Pendant l'essai, les **éléments sensibles** sont maintenus à des valeurs appropriées de la **grandeur de manœuvre** et les **moteurs primaires** sont disposés de manière que la **manœuvre** produise le **fonctionnement** désiré.

19.13.5 Pendant l'essai, la **défaillance** d'un composant quelconque d'une **action de type 1** qui n'est pas déterminante au regard des exigences de l'essai ne doit pas constituer une cause de rejet à condition que le composant soit réparable ou remplaçable ou que l'essai puisse être poursuivi d'une manière différente et convenue telle que le nombre total de cycles de **manœuvre** exigé puisse être accompli.

19.14 Evaluation de la conformité

19.14.1 Après l'exécution de tous les essais applicables de 19.6 à 19.13 inclus, modifiés selon la Partie 2 correspondante, le **dispositif de commande** doit être considéré comme conforme:

– *si toutes les actions automatiques et manuelles fonctionnent de la manière prévue selon les termes du présent document;*

– *si les exigences de l'Article 16 concernant les points désignés à la Note a du Tableau 17, c'est-à-dire les bornes, les parties transportant le courant et les surfaces de support, sont encore satisfaites;*

– *si les exigences de l'Article 6, l'Article 11 et de 19.5 sont encore satisfaites. Pour les essais de 19.5 et de l'Article 11, les **dispositifs de commande** pour lesquels des échantillons spéciaux ont été soumis à l'Article 15 sont soumis à essai dans une condition adéquate pour s'assurer que les contacts sont ouverts;*

– *si, pour les **actions de type 2**, lors de la répétition de l'essai applicable de l'Article H.17, la **valeur de fonctionnement**, le **temps de fonctionnement** ou la **séquence de fonctionnement** se trouve, selon le cas déclaré, soit à l'intérieur de la plage des valeurs de la **dérive**, soit à l'intérieur de la plage des valeurs d'une combinaison de la **dérive** et des **tolérances de fabrication**;*

– *si les coupures de circuit déclarées pour chaque **action manuelle** peuvent encore être obtenues;*

– *s'il n'y a aucune trace (le fusible de 19.2.5 doit au moins ne pas avoir sauté) de **pannes** électriques transitoires entre les **parties actives** et les parties métalliques mises à la terre, les parties métalliques accessibles ou les **organes de manœuvre**.*

19.14.2 Pour les **dispositifs de commande électronique**, après l'exécution de tous les essais applicables de 19.6 à 19.13 inclus et de 19.1.4, modifiés selon la Partie 2 correspondante, le **dispositif de commande** doit être considéré comme conforme:

– si les critères de 19.14.1 sont satisfaits;

– si, pour des **dispositifs de commande** assurant une **coupure électronique** (type 1.Y ou 2.Y), les exigences de 9.4.16 sont toujours satisfaites.

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19.15 Essai pour les dispositifs de commande à usages particuliers

Les essais applicables pour les dispositifs de commande à usages particuliers sont spécifiés dans la Partie 2 correspondante.

19.16 Voir J.19.16.

19.17 Voir J.19.17.

20 Résistance mécanique

20.1 Exigences générales

20.1.1 Les **dispositifs de commande** doivent être construits de manière à pouvoir supporter les contraintes mécaniques susceptibles de se produire en **usage normal**.

20.1.2 Les **organes de manœuvre** des **dispositifs de commande des classes I** et **II** ou des **dispositifs de commande** destinés à du matériel des classes I et II doivent avoir une résistance mécanique suffisante ou être construits de façon qu'une protection adéquate contre les chocs électriques soit maintenue en cas de rupture de l'**organe de manœuvre**.

20.1.3 Les **dispositifs de commande intégrés** et **incorporés** n'ont pas à subir les essais de 20.2 car leur résistance aux chocs est soumise à essai selon la norme particulière du matériel.

20.1.4 *La conformité est vérifiée par les essais applicables des paragraphes 20.2 à 20.6 inclus effectués séquentiellement sur un échantillon.*

20.1.5 Après les essais appropriés, le **dispositif de commande** ne doit présenter aucun dommage qui compromettrait la conformité au présent document et en particulier aux exigences des Articles 6, 15 et 11. Aucun décollement des revêtements, barrières ou autres éléments d'isolation ne doit être constaté.

*Il doit encore être possible d'enlever et de replacer les parties amovibles et autres parties externes, telles que les **couvercles**, sans que ces parties ou leurs revêtements ne se brisent.*

*Après cet essai, le **dispositif de commande** doit pouvoir être manœuvré dans toutes les positions qui correspondent à une **coupure totale** ou à une **microcoupure** de circuit.*

*En cas de doute, l'**isolation supplémentaire** ou l'**isolation renforcée** est soumise à un essai de rigidité diélectrique selon les exigences de l'Article 15.*

*Une détérioration de la peinture, de faibles renfoncements qui ne réduisent pas les **lignes de fuite** ou les **distances dans l'air** au-dessous des valeurs spécifiées à l'Article 11 et de petites ébréchures qui n'affectent pas la protection contre les chocs électriques ou l'humidité ne sont pas retenus. Les fissures non visibles à l'œil nu et les fissures superficielles dans des matériaux moulés en fibre renforcée et matériaux analogues sont ignorées. Si un **couvercle** décoratif est doublé par un **couvercle** intérieur, le bris du **couvercle** décoratif est ignoré, si le **couvercle** intérieur satisfait à l'essai après l'enlèvement du **couvercle** décoratif.*

20.2 Résistance aux chocs

20.2.1 Les **dispositifs de commande intercalés dans un câble souple**, **séparés** et **à montage indépendant**, à l'exception des dispositions de 20.3, sont vérifiés en appliquant des coups à l'échantillon au moyen de l'appareil prévu dans l'IEC 60068-2-75.

20.2.2 Toutes les surfaces qui sont accessibles lorsque le **dispositif de commande** est monté comme en **usage normal** sont soumises à essai avec l'appareil de choc.

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20.2.3 *Les **dispositifs de commande** sont maintenus en contact avec une plaque carrée de 175 mm de côté de contreplaqué de 8 mm d'épaisseur sans aucun renfort métallique, montée verticalement sur un bâti rigide fixé à un mur massif de brique, de béton ou matériau analogue.*

20.2.4 *Des coups sont appliqués à toutes les **surfaces accessibles**, y compris les **organes de manœuvre**, sous des angles quelconques, l'appareil d'essai étant étalonné pour délivrer une énergie de (0,5 ± 0,04) Nm.*

*Les **dispositifs de commande** au pied doivent être soumis au même essai, mais en utilisant un appareil d'essai étalonné pour délivrer une énergie de choc de (1,0 ± 0,05) Nm.*

20.2.5 *Pour toutes ces surfaces, trois coups sont appliqués en chaque point qui est susceptible de présenter une faiblesse.*

20.2.5.1 *Une attention particulière doit être accordée aux conséquences de chaque série de trois coups de sorte qu'elles n'aient pas d'influence sur la série suivante.*

20.2.5.2 *Si l'on se doute qu'un défaut a été favorisé par l'application des coups précédents, ce défaut est ignoré et le groupe de trois coups qui a entraîné le défaut est appliqué au même endroit sur un nouvel échantillon, qui doit alors satisfaire à l'essai.*

20.2.6 *Les lampes de signalisation et leurs **couvercles** ne sont soumis à cet essai que s'ils font saillie par rapport à l'enveloppe de plus de 10 mm ou si leur surface dépasse 4 cm², à moins qu'ils ne fassent partie d'un **organe de manœuvre**, auquel cas ils doivent être soumis à essai de la même manière qu'un **organe de manœuvre**.*

20.3 Dispositifs de commande séparés

20.3.1 Les **dispositifs de commande séparés** doivent en plus être vérifiés par l'essai de 20.3.2 et 20.3.3 à l'aide de l'appareil représenté à la Figure 7.

20.3.2 *Deux mètres de câble souple du type le plus léger spécifié en 8.1.5 doivent être raccordés aux bornes d'entrée et fixés de la manière prévue. Les **dispositifs de commande** destinés à être utilisés avec un câble souple raccordé aux bornes de sortie doivent de même être équipés de 2 m du type de câble le plus léger prévu, raccordés et disposés de la manière représentée à la Figure 7.*

L'échantillon doit être posé ou placé sur une surface de verre, comme représenté, et le câble souple doit être soumis à une traction progressive ne dépassant pas la valeur indiquée dans le Tableau 22. Si l'échantillon bouge, il est tiré aussi lentement que possible sur la surface de verre jusqu'à ce qu'il tombe sur le bois dur recouvert de béton.

*La hauteur de la surface de verre au-dessus de la surface de bois est de 0,5 m. Les dimensions du bois dur recouvert de béton doivent être suffisantes pour que le **dispositif de commande** y reste après sa chute.*

Cet essai est répété trois fois.

20.3.3 *Après les essais, l'échantillon doit être évalué comme indiqué en 20.1.5.*

20.4 Dispositifs de commande intercalés dans un câble souple

20.4.1 Les **dispositifs de commande intercalés dans un câble souple** autres que les **dispositifs de commande séparés** doivent en plus être soumis à un essai de chutes répétées dans le tambour rotatif de la Figure 8. La largeur du tambour ne doit pas être inférieure à 200 mm et doit être suffisante pour permettre la chute libre du **dispositif de commande** équipé des câbles comme exigé en 20.4.2.

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20.4.2 Les ***dispositifs de commande*** *à* ***câbles souples fixés à demeure*** *ayant des* ***fixations de type X*** *doivent être équipés du ou des câbles souples de la plus petite section spécifiée en 8.1.5, avec une longueur libre d'environ 50 mm. Les vis de bornes sont serrées avec un couple égal aux deux tiers du couple spécifié en 10.1. Les* ***dispositifs de commande*** *à* ***câbles souples fixés à demeure*** *ayant des* ***fixations du type M****,* ***du type Y*** *et* ***du type Z*** *doivent être soumis à essai avec le ou les câbles souples déclarés ou fournis avec les échantillons, ce ou ces câbles étant coupés de manière à dépasser d'environ 50 mm du* ***dispositif de commande****.*

20.4.3 *L'échantillon tombe d'une hauteur de 50 cm sur une plaque d'acier de 3 mm d'épaisseur, le nombre de chutes étant:*

– *de 1 000 si la masse de l'échantillon sans câble ne dépasse pas 100 g;*

– *de 500 si la masse de l'échantillon sans câble est comprise entre 100 g et 200 g.*

20.4.4 *Les* ***dispositifs de commande intercalés dans un câble souple*** *dont la masse dépasse 200 g ne sont pas soumis à l'essai de chutes répétées dans le tambour rotatif mais doivent être soumis à l'essai de 20.3.*

20.4.5 *La vitesse de rotation du tambour est cinq tours par min, ce qui correspond à 10 chutes par minute.*

20.4.6 *Après cet essai, le* ***dispositif de commande*** *doit être évalué comme indiqué en 20.1.5. Une attention spéciale est portée aux connexions du ou des câbles souples.*

20.5 Dispositifs de commande à traction

20.5.1 Les **dispositifs de commande à traction** doivent être en plus soumis à essai de la manière décrite en 20.5.2 et 20.5.3.

20.5.2 *Le* ***dispositif de commande*** *doit être monté conformément aux déclarations du fabricant et le* ***cordon de traction*** *doit être soumis à une traction constante, sans secousses, pendant 1 min dans la direction normale de manœuvre, puis pendant 1 min dans la direction la plus défavorable, mais ne dépassant pas 45° de la direction normale.*

20.5.3 *Les forces de traction applicables sont indiquées dans le Tableau 21.*

Tableau 21 – Valeurs d'essai des forces de cordon de traction

Courant assigné A	**Force** N	
	Direction normale	**Direction la plus défavorable**
Jusqu'à 4 inclus	50	25
Plus de 4	100	50

20.5.4 *Après cet essai, le* ***dispositif de commande*** *doit être évalué comme indiqué en 20.1.5.*

20.6 Dispositifs de commande au pied

20.6.1 Les **dispositifs de commande** au pied doivent en plus être soumis à essai comme indiqué de 20.6.2 à 20.6.4:

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20.6.2 *Le **dispositif de commande** est soumis à une force appliquée au moyen d'une plaque de pression circulaire en acier d'un diamètre de 50 mm. La force est augmentée progressivement d'une valeur initiale d'environ 250 N à une valeur finale de 750 N en 1 min, après quoi elle est maintenue à cette valeur pendant 1 min.*

20.6.3 *Le **dispositif de commande** équipé d'un câble souple approprié est placé sur un support horizontal plat en acier. La force est appliquée trois fois sur l'échantillon occupant des positions différentes parmi les positions plus défavorables.*

20.6.4 *Après l'essai, le **dispositif de commande** doit être évalué comme indiqué en 20.1.5.*

20.7 Organe de manœuvre et liaisons de manœuvre

20.7.1 Les **dispositifs de commande** équipés ou destinés à être équipés d'**organes de manœuvre** doivent être soumis à essai de la manière suivante.

- *Tout d'abord, une traction axiale doit être appliquée pendant 1 min pour essayer d'arracher l'**organe de manœuvre** du dispositif de commande.*
- *Si la forme est telle que l'application d'une traction axiale n'est pas possible en **usage normal**, le premier essai n'est pas applicable.*
- *Si l'**organe de manœuvre** a une forme telle que l'application d'une traction axiale est improbable en **usage normal**, la force d'essai est de 15 N.*
- *Si la forme est telle que l'application d'une traction axiale est probable, la force d'essai est de 30 N.*
- *Ensuite, une pression axiale de 30 N est appliquée pendant 1 min à chaque **organe de manœuvre**.*

20.7.2 Pour un **dispositif de commande** destiné à fonctionner avec un **organe de manœuvre**, mais soumis aux essais sans cet organe, ou pour un dispositif de commande destiné à comporter un **organe de manœuvre** facilement amovible, une traction et une pression de 30 N sont appliquées à la **liaison de manœuvre**.

NOTE Les matériaux de remplissage et les matériaux analogues, autres que les résines durcissant à l'air, ne sont pas considérés comme satisfaisants pour éviter le desserrage.

20.7.3 Pendant et après chacun de ces essais, le **dispositif de commande** ne doit présenter aucun dommage et un **organe de manœuvre** ne doit pas se déplacer de manière à compromettre la conformité au présent document.

20.8 Essai de flexion

20.8.1 L'essai de flexion est appliqué aux dispositifs de commande intercalés dans un câble souple et aux dispositifs de commande séparés. Le **dispositif de commande** est monté dans l'appareil d'essai de flexion représenté à la Figure 10. L'axe d'oscillation est choisi de façon que le poids qui est fixé au câble et le câble à proprement parler aient un mouvement latéral d'amplitude minimale au cours de l'essai.

*Les échantillons équipés de câbles méplats sont montés de façon que le plus grand axe de la section soit parallèle à l'axe d'oscillation. Chaque câble souple passant par l'ouverture d'entrée est lesté avec un poids de 1 kg. Il est fait circuler dans chaque âme conductrice soumise à l'essai un courant égal à celui qu'elle conduit lorsque le **dispositif de commande** fonctionne à la tension assignée, la tension appliquée entre les âmes étant la tension assignée maximale. La tête oscillante est animée d'un mouvement de va-et-vient sur 90° (45° de part et d'autre de la verticale), et le nombre total de flexions (mouvements de 90°) est de 5 000, à raison de 60 à la minute.*

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20.8.2 Après cet essai, l'échantillon ne doit présenter aucune détérioration au sens du présent document. Pendant l'essai, il ne doit se produire ni interruption du courant ni court-circuit entre les conducteurs individuels, et les brins câblés cassés ne doivent pas percer l'isolation jusqu'à la surface extérieure de l'accessoire. Un court-circuit entre les conducteurs individuels est considéré comme s'étant produit si le courant atteint le double de la valeur du courant d'essai.

20.8.3 Il est admis qu'un maximum de 10 % du nombre total des conducteurs de câble souple doit s'être rompu.

20.9 Essai des dispositifs d'arrêt de traction et de torsion

20.9.1 Le **dispositif de commande** est équipé d'un câble souple et les conducteurs sont introduits dans les bornes, les vis éventuelles des bornes étant serrées juste assez pour que les conducteurs ne puissent pas aisément changer de position. Le dispositif d'arrêt de traction et de torsion est utilisé de la manière prévue, les vis étant serrées avec un couple égal aux deux tiers de celui spécifié en 10.1.

20.9.2 Après cette préparation, il ne doit pas être possible de repousser le câble à l'intérieur du **dispositif de commande** au point que le câble ou les parties internes puissent être endommagés, ou que les parties internes du **dispositif de commande** soient gênées de façon que la conformité au présent document soit affectée.

20.9.3 Le câble est ensuite soumis à des tractions dont la valeur et le nombre sont indiqués dans le Tableau 22. Les tractions sont appliquées dans la direction la plus défavorable, sans secousse, chaque fois pendant 1 s.

20.9.4 Immédiatement après, le câble est soumis pendant 1 min à un couple de torsion dont la valeur est indiquée dans le Tableau 22.

Tableau 22 – Valeurs de traction et de couple

Dispositif de commande	**Traction**[a] N	**Couple**[a] Nm	**Nombre de tractions** [a]
Dispositifs de commande séparés et **dispositifs de commande à montage indépendant**:			
Jusqu'à 1 kg inclus	30	0,1	25
Au-dessus de 1 kg, jusqu'à 4 kg inclus	60	0,25	25
Plus de 4 kg	100	0,35	25
Dispositifs de commande intercalés dans un câble souple (à l'exclusion des **dispositifs de commande séparés**)	90	0,25	100

[a] Certaines normes particulières du matériel peuvent exiger des valeurs différentes.

20.9.5 Pour la **fixation du type X**, les essais sont d'abord effectués avec le câble le plus léger admissible de la plus petite section mentionnée en 8.1.5, puis avec le câble le plus proche de la plus forte section mentionnée. Pour les **fixations du type M**, **du type Y** ou **du type Z**, seul le câble déclaré ou monté est utilisé.

20.9.6 Pendant les essais, le câble ne doit pas être endommagé. Après les essais, aucun déplacement longitudinal du câble de plus de 2 mm ne doit être constaté, les conducteurs ne doivent pas s'être déplacés dans les bornes sur une distance de plus de 1 mm et il ne doit pas y avoir de contrainte notable à la connexion. Les **lignes de fuite** et **distances dans l'air** ne doivent pas être réduites au-dessous des valeurs spécifiées à l'Article 11.

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20.9.7 Pour mesurer le déplacement longitudinal, une marque est réalisée avant les essais sur le câble soumis à la traction à une distance d'environ 20 mm du dispositif d'arrêt de traction et de torsion. Après les essais, le déplacement de la marque sur le câble par rapport au dispositif d'arrêt de traction et de torsion est mesuré, le câble étant maintenu tendu.

21 Résistance à la chaleur, au feu et aux courants de cheminement

21.1 Exigences générales

Toute partie non métallique d'un **dispositif de commande** doit résister à la chaleur, au feu et aux courants de cheminement.

La conformité est vérifiée par les essais de 21.2, sauf pour les ***dispositifs de commande à montage indépendant*** *et les* ***dispositifs de commande séparés*** *qui sont vérifiés par les essais de 21.3.*

21.2 Dispositifs de commande intégrés, incorporés et intercalés dans un câble souple

21.2.1 Les séquences d'essais doivent être exécutées suivant la position ou fonction de la partie non métallique et d'après les températures déclarées de l'essai à la bille et de l'essai au fil incandescent.

21.2.2 *Il n'existe pas d'exigence relative à la chaleur et à la résistance au feu pour les petites parties spécifiées dans l'IEC 60695-2-11:2021, 4.4.*

21.2.3 *Il n'existe pas d'exigence relative à la chaleur et à la résistance au feu pour la masse négligeable d'un matériau combustible telle que définie dans l'IEC 60695-2-11:2021, 4.1; la valeur par défaut de la masse négligeable est de 2 g.*

21.2.4 Les **dispositifs de commande** déclarés dans le Tableau 1, exigence 74, doivent être soumis à essai conformément à l'IEC 60335-1:2020, Article 30.

NOTE Les **dispositifs de commande** peuvent être utilisés dans des applications finales largement différentes. Le choix des niveaux d'essai à partir des exigences ci-après peut être influencé par la prise en considération des exigences de la norme d'application finale.

21.2.5 Pour les parties qui sont accessibles lorsque le **dispositif de commande** est monté dans les conditions d'utilisation prévues, et dont la détérioration peut rendre le **dispositif de commande** dangereux, les essais suivants sont exigés. Voir Annexe G:

– *l'essai à la bille 1 de G.3.2;*

– *l'essai au fil incandescent de l'Article G.1 réalisé à 550 °C.*

21.2.6 Pour les parties qui maintiennent en position les parties transportant le courant, autres que les connexions électriques, les essais suivants sont exigés. Voir Annexe G:

– *l'essai à la bille 2 de G.3.3;*

– *l'essai au fil incandescent de l'Article G.1 réalisé à 550 °C.*

Les essais ne sont pas applicables aux parties qui maintiennent en position les parties transportant le courant dans les circuits à basse puissance tels que définis en 13.1.2.

21.2.7 Pour les parties qui maintiennent ou retiennent en position les connexions électriques, les essais suivants sont exigés. Voir Annexe G:

– *l'essai à la bille 2 de G.3.3;*

suivi de l'essai au fil incandescent à la température appropriée à l'application et telle que déclarée pour le ***dispositif de commande****:*

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Essai au fil incandescent à 650 °C

– *l'essai au fil incandescent de l'Article G.1 réalisé à 650 °C*

Essai au fil incandescent à 750 °C

– *l'essai au fil incandescent de l'Article G.1 réalisé à 750 °C*

Essai au fil incandescent à 850 °C

– *l'essai au fil incandescent de l'Article G.1 réalisé à 850 °C*

Les essais ne sont pas applicables aux parties qui maintiennent en position les parties transportant le courant dans les circuits à basse puissance tels que définis en 13.1.2.

21.2.8 Pour toutes les autres parties (à l'exception des garnitures décoratives, boutons, etc.), l'essai suivant est exigé. Voir Annexe G:

– *l'essai au fil incandescent de l'Article G.1 réalisé à 550 °C.*

Sauf indication contraire dans la Partie 2, les diaphragmes, joints et pâtes d'étanchéité des presse-étoupes ne sont pas soumis aux essais de 21.2.8.

21.2.9 La résistance aux courants de cheminement pour toutes les parties non métalliques pour lesquelles une **ligne de fuite** est spécifiée en 11.3 doit être telle que déclarée dans le Tableau 1, exigence 23.

NOTE 1 Les valeurs exigées pour la résistance aux courants de cheminement sont données soit dans les Parties 2 de l'IEC 60730 soit dans la norme correspondante du matériel concerné.

NOTE 2 A l'intérieur d'un **dispositif de commande**, différentes parties peuvent avoir des valeurs différentes d'IRC (indice de résistance au cheminement) selon le **microenvironnement** de la partie.

*La conformité est vérifiée par les essais de l'Article G.2, exécutés à la valeur déclarée dans le Tableau 1, exigence*23*:*

– *100 V;*
– *175 V;*
– *250 V;*
– *400 V;*
– *600 V.*

NOTE 3 Pour les besoins de 0, la proximité des contacts d'arc n'est pas considérée comme augmentant le dépôt de matériau conducteur externe, étant donné que les essais d'endurance de l'Article 19, suivis par les essais de rigidité diélectrique de l'Article 15, sont considérés comme suffisants pour déterminer l'effet de la **pollution** provenant de l'intérieur du **dispositif de commande**.

21.3 Dispositifs de commande à montage indépendant et séparés

21.3.1 La séquence d'essais de 21.2.5 à 0 s'applique, précédée du préconditionnement de 21.3.2.

21.3.2 *Le préconditionnement doit être effectué dans une étuve comme suit:*

– *sans indication de T: 1 × 24 h à (80 ± 2) °C, le circuit de la partie interrupteur et le mécanisme d'entraînement n'étant pas reliés, les* ***couvercles*** *amovibles étant retirés;*
– *avec indication de T pour des températures ne dépassant pas 85 °C: 1 × 24 h à (80 ± 2) °C, la partie interrupteur du* ***dispositif de commande*** *et le mécanisme d'entraînement n'étant pas reliés et sans* ***couvercles*** *et ensuite 6 × 24 h à* T_{max} *± 2 K avec* ***couvercles****, les circuits de la partie commutation et le mécanisme d'entraînement étant reliés;*

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– *avec indication de T pour des températures dépassant 85 °C: 6 × 24 h à* T_{max} *± 2 K avec* ***couvercles****, le circuit de commutation et le mécanisme d'entraînement étant reliés.*

22 Résistance à la corrosion

22.1 Résistance à la rouille

22.1.1 Les parties en métaux ferreux, y compris les **couvercles** et les enveloppes, doivent être protégées contre la corrosion si celle-ci peut affecter la conformité au présent document.

22.1.2 Cette exigence n'est pas applicable aux **éléments thermosensibles** ni aux autres composants dont les caractéristiques de fonctionnement seraient affectées par un traitement de protection.

22.1.3 *La conformité est vérifiée par 22.1.4 à 22.1.6:*

22.1.4 *Les parties à soumettre à essai sont maintenues pendant 14 jours à une humidité relative de 93 % à 97 % et à une température de (40 ± 2) °C.*

22.1.5 *Après un séchage de 10 min dans une étuve à une température de (100 ± 5) °C, les surfaces des parties ne doivent présenter aucune trace de corrosion susceptible d'affecter la conformité aux exigences des Articles 6, 15 et 11.*

22.1.6 *Les traces de rouille sur les arêtes et le voile jaunâtre disparaissant par simple frottement sont ignorés.*

NOTE 1 Les parties émaillées, galvanisées, shérardisées, plaquées ou traitées d'une manière de protection reconnue équivalente sont considérées comme étant conformes à cette exigence.

NOTE 2 Pour de petits ressorts hélicoïdaux et organes analogues, et pour les parties exposées à l'abrasion, lorsqu'une couche de graisse est utilisée pour constituer une protection contre la rouille, ces parties sont soumises à essai uniquement si l'efficacité de la couche de graisse est inconnue. L'essai est alors effectué sans dégraissage préalable.

23 Exigences de compatibilité électromagnétique (CEM) – Emission

23.1 Exigence générale

Les dispositifs de commande électrique doivent être construits de façon à ne pas émettre de perturbations électriques ou électromagnétiques excessives dans leur environnement conformément aux essais en 23.2 et 23.3.

Les **dispositifs de commande intégrés** et les **dispositifs de commande incorporés** ne sont pas soumis aux essais de 23.2 et 23.3, car le résultat de ces essais peut être affecté par l'incorporation du **dispositif de commande** dans le matériel et l'utilisation de mesures pour en contrôler les émissions qui y sont utilisées. Ils peuvent, cependant, être effectués selon les conditions déclarées sur demande du fabricant ou définies dans les normes dédiées données dans le Tableau 23 ou le Tableau 24.

Un plan et un rapport d'essai CEM (voir 0) doivent être établis avant les essais. Ils doivent contenir, au minimum, les éléments donnés dans la configuration de l'EUT lors des essais 23.2 à 23.3. Il peut être déterminé en fonction des caractéristiques électriques et de l'utilisation d'un appareil particulier que certains essais sont inappropriés et donc inutiles. Dans de tels cas, la décision de ne pas soumettre à essai doit être consignée dans le plan d'essai CEM et le rapport d'essai CEM.

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23.2 Émission haute fréquence

23.2.1 Exigences

Les dispositifs de commande électrique utilisant des accès de réseau câblé, des logiciels, des circuits oscillants ou des alimentations à découpage doivent satisfaire aux exigences suivantes:

– pour les **environnements électromagnétiques résidentiels** ou **industriels**, comme indiqué dans le Tableau 23,

NOTE 1 Voir également Tableau 1, exigence 75.

– pour l'**environnement électromagnétique industriel**, comme indiqué dans le Tableau 24;

NOTE 2 Voir également Tableau 1, exigence 75.

– pour les perturbations discontinues indiquées dans la CISPR 14-1:2020, paragraphe 4.4, si l'essai détaillé en 23.2.2 et 23.2.3 entraîne une durée maximale d'émission RF de 20 ms et lorsque de tels dispositifs de commande ont une cadence de répétition supérieure à 5, à moins qu'un examen et/ou des essais ne montrent que la durée minimale entre le fonctionnement des contacts en fonctionnement normal ne peut être inférieure à 10 min;

– pour les matériels ISM (industriel, scientifique et médical) et les dispositifs de commande séparés, à montage indépendant et intercalés dans un câble souple destinés à être utilisés avec des matériels ISM, les dispositifs de commande doivent satisfaire aux exigences de la CISPR 11.

NOTE 3 Voir également Tableau 1, exigence 65.

NOTE 4 L'accès de réseau câblé est défini dans la CISPR 32:2015, 3.1.32.

NOTE 5 La Partie 2 appropriée indique si les exigences du présent article s'appliquent aux **dispositifs de commande électrique** incorporés et intégrés.

23.2.2 Conditions d'essai

Un échantillon précédemment non soumis à l'essai est soumis à l'essai.

Les conditions électriques et thermiques sont comme spécifié en 19.2 et 19.3, excepté ce qui suit:

– *pour les **dispositifs de commande sensibles**, le taux de variation des grandeurs de manœuvre est α_1 et β_1;*

– *pour les **dispositifs de commande non sensibles**, le fonctionnement des **dispositifs de commande** est provoqué à la plus faible vitesse de manœuvre possible des contacts en fonctionnement normal;*

– *pour les **dispositifs de commande** déclarés pour utilisation avec des charges inductives, le facteur de puissance est 0,6, sauf déclaration contraire à l'exigence 8 du Tableau 1.Pour les **dispositifs de commande** déclarés pour utilisation avec des charges purement résistives, le facteur de puissance est 1,0.*

23.2.3 Procédure d'essai

*Le **dispositif de commande** est mis en fonction en continu, mais pendant au moins cinq **cycles de fonctionnement par contact** pendant le cycle de mesure, le cas échéant.*

*La durée d'interférence radio est mesurée par un oscilloscope relié au **dispositif de commande** de façon à mesurer la chute de tension dans les contacts. L'instrumentation de mesure doit être conforme à la CISPR 14-1:2020, 5.1.7.*

NOTE Pour cet essai, une interférence radio est toute fluctuation de tension observée dans les contacts se superposant sur l'onde de l'alimentation comme résultat du **fonctionnement** des contacts.

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Tableau 23 – Limite d'émission pour l'environnement électromagnétique résidentiel

Accès	Plage de fréquences	Limites	Limites pour référence/exemple	Procédure	Note d'applicabilité	Remarques
Enveloppe	30 MHz à 230 MHz 230 MHz à 1 GHz	CISPR 32[a], Tableau A.4.2	40 dB(μV/m) quasi-crête à 3 m 47 dB(μV/m) quasi-crête à 3 m	CISPR 32[a], Tableau A.1	Voir Note 1 et Note 2	Distances de mesure autorisées: 3 m ou 10 m
	30 MHz à 230 MHz 230 MHz à 1 GHz	CISPR 32[a], Tableau A.4.1	30 dB(μV/m) quasi-crête à 10 m 37 dB(μV/m) quasi-crête à 10 m	CISPR 32[a], Tableau A.1		
	Entre 1 GHz et 6 GHz	CISPR 32[a], Tableau A.5	74 (μV/m) crête à 3 m 54 dB(μV/m) moyenne à 3 m	CISPR 32[a], Tableau A.1		
Alimentation alternative	0,15 MHz à 0,5 MHz Les limites décroissent linéairement avec le logarithme de la fréquence	CISPR 32[a], Tableau A.10	66 dB(μV) à 56 dB(μV) quasi-crête 56 dB(μV) à 46 dB(μV) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.1		
	0,5 MHz à 5 MHz		56 dB(μV) quasi-crête 46 dB(μV) moyenne			
	5 MHz à 30 MHz		60 dB(μV) quasi-crête 50 dB(μV) moyenne			
	0,15 MHz à 30 MHz	CISPR 14-1:2020, alinéa 4.4.2	Perturbations discontinues	CISPR 14-1: 2020, paragraphe 4.4		L'évaluation statistique de la norme fondamentale ne s'applique pas
Accès d'aliment-ation en courant continu	0,15 MHz à 0,5 MHz	IEC 61000-6-3, Tableau 5, paragraphe 5.1	79 dB(μV) quasi-crête 66 dB(μV) moyenne	IEC 61000-6-3: 2020, Annexe B	Voir Note 3 et Note 4	Réseau de mesure V-AN
	0,5 MHz à 30 MHz		73 dB(μV) quasi-crête 60 dB(μV) moyenne			
	0,15 MHz à 0,5 MHz	IEC 61000-6-3, Tableau 5, paragraphe 5.2	84 dB(μV) à 74 dB(μV) quasi-crête 74 dB(μV) à 64 dB(μV) moyenne	IEC 61000-6-3: 2020, Annexe B	Voir Note 3 et Note 4	Réseau de mesure Δ-AN
	0,5 MHz à 30 MHz		74 dB(μV) quasi-crête 64 dB(μV) moyenne			
Accès par le réseau HBES/SGTB	0,15 MHz à 0,5 MHz Les limites décroissent linéairement avec le logarithme de la fréquence	CISPR 32[a], Tableau A.12 paragraphe A12.1	84 dB(μV) à 74 dB(μV) quasi-crête 74 dB(μV) à 64 dB(μV) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.2	Voir Note 5	Dispositif d'accouplement AAN
		CISPR 32[a], Tableau A.12 paragraphe A12.3	40 dB(μA) à 30 dB(μA) quasi-crête 30 dB(μA) à 20 dB(μA) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.3	Voir Note 5	Dispositif d'accouplem-ent Sonde de courant
	Entre 0,5 MHz et 30 MHz	CISPR 32[a], Tableau A.12 paragraphe A12.1	74 dB(μV) quasi-crête 64 dB(μV) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.2	Voir Note 5	Dispositif d'accouplem-ent AAN
		CISPR 32[a], Tableau A.12 paragraphe A12.3	30 dB(μA) quasi-crête 20 dB(μA) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.3	Voir Note 5	Dispositif d'accouplem-ent Sonde de courant

NOTE 1 Applicable seulement aux **dispositifs de commande** contenant des dispositifs de traitement, par exemple des microprocesseurs fonctionnant à des fréquences supérieures à 9 kHz.

NOTE 2 Appliquer une distance de mesure de 3 m ou 10 m.

NOTE 3 Conformément à l'IEC 61000-6-3, , appliquer soit le Tableau 5, paragraphe 5.1 (V-AM/V-AMN), soit le paragraphe 5.2 (Δ-AN) dans la plage de fréquences exigée.

NOTE 4 Pour l'applicabilité de l'essai par rapport à la connexion de la source d'alimentation en courant continu, voir les informations de l'IEC 61000-6-3:2020, Annexe B, Tableau B.1.

NOTE 5 Conformément à la CISPR 32, appliquer le dispositif d'accouplement A12.1 (AAN) ou A12.3 (sonde de courant).

[a] CISPR 32:2015 et CISPR 32:2015/A1:2019.

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Tableau 24 – Limite d'émission pour l'environnement électromagnétique industriel

Accès	Plage de fréquences	Limites	Limites pour référence/exemple	Procédure	Note d'applicabilité	Remarques
Enveloppe	30 MHz à 230 MHz 230 MHz à 1 GHz	CISPR 32[a], Tableau A.2.2	50 dB(µV/m) quasi-crête à 3 m 57 dB(µV/m) quasi-crête à 3 m	CISPR 32[a], Tableau A.1	Voir Note 1 et Note 2	Distances de mesure autorisées: 3 m ou 10 m
	30 MHz à 230 MHz 230 MHz à 1 GHz	CISPR 32[a], Tableau A.2.1	40 dB(µV/m) quasi-crête à 10 m 47 dB(µV/m) quasi-crête à 10 m	CISPR 32[a], Tableau A.1		
	Entre 1 GHz et 6 GHz	CISPR 32[a], Tableau A.3	80 (µV/m) crête à 3 m 60 dB(µV/m) moyenne à 3 m	CISPR 32[a], Tableau A.1		
Alimentation alternative	0,15 MHz à 0,5 MHz	CISPR 32[a], Tableau A.9	79 dB(µV) quasi-crête 66 dB(µV) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.1		
	0,5 MHz à 30 MHz		73 dB(µV) quasi-crête 60 dB(µV) moyenne			
	0,15 MHz à 30 MHz	CISPR 14-1: 2020, alinéa 4.4.2	Perturbations discontinues	CISPR 14-1:2020, paragraphe 4.4		L'évaluation statistique de la norme fondamentale ne s'applique pas
Accès d'alimentat-ion en courant continu	0,15 MHz à 0,5 MHz	IEC 61000-6-4 Tableau A.1, paragraphe A.1.1 (informatif)	89 dB(µV) quasi-crête 76 dB(µV) moyenne	IEC 61000-6-4: 2018, Annexe A	Voir Note 3 et Note 4	Réseau de mesure AMN
	0,5 MHz à 30 MHz		83 dB(µV) quasi-crête 70 dB(µV) moyenne			
Accès par le réseau HBES/SGTB	0,15 MHz à 0,5 MHz	CISPR 32[a], Tableau A.11, paragraphe A11.1	97 dB(µV) à 87 dB(µV) quasi-crête 84 dB(µV) à 74 dB(µV) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.2	Voir Note 5	Dispositif d'accouplem-ent AAN
	Les limites décroissent linéairement avec le logarithme de la fréquence	CISPR 32[a], Tableau A.11 paragraphe A11.3	53 dB(µA) à 43 dB(µA) quasi-crête 40 dB(µA) à 30 dB(µA) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.3	Voir Note 5	Dispositif d'accouplem-ent Sonde de courant
	Entre 0,5 MHz et 30 MHz	CISPR 32[a], Tableau A.11 Article A11.1	87 dB(µV) quasi-crête 74 dB(µV) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.2	Voir Note 5	Dispositif d'accouplem-ent AAN
		CISPR 32[a], Tableau A.11 paragraphe A11.3	43 dB(µA) quasi-crête 30 dB(µA) moyenne	CISPR 32[a], Tableau A.8, paragraphe A8.3	Voir Note 5	Dispositif d'accouplem-ent Sonde de courant

NOTE 1 Applicable seulement aux **dispositifs de commande** contenant des dispositifs de traitement, par exemple des microprocesseurs fonctionnant à des fréquences supérieures à 9 kHz.

NOTE 2 Appliquer une distance de mesure de 3 m ou 10 m.

NOTE 3 Conformément à l'IEC 61000-6-4:2018, si cela est déclaré dans le Tableau 1, exigence 75 du présent document. Remarques: L'IEC 61000-6-4:2018, Annexe A, est informative.

NOTE 4 Pour l'essai applicable par rapport à la connexion de la source d'alimentation en courant continu, voir les informations de l'IEC 61000-6-4:2018, Annexe A, Tableau A.2.

NOTE 5 Conformément à la CISPR 32, appliquer le dispositif d'accouplement A11.1 (AAN) ou A11.3 (sonde de courant).

[a] CISPR 32:2015 et CISPR 32:2015/A1:2019.

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23.3 Emission basse fréquence

23.3.1 Exigences

Les **dispositifs de commande** dans lesquels un **dispositif électronique** commande directement une charge externe reliée au réseau d'alimentation (l'accès de **commande**) doivent être conformes aux exigences de l'IEC 61000-3-2 et l'IEC 61000-3-3 pour le courant de charge externe ≤ 16 A par phase, et l'IEC 61000-3-11 et l'IEC 61000-3-12 pour le courant de charge externe > 16 A et ≤ 75 A par phase.

23.3.2 Procédure d'essai

Pour ces essais, une charge et des mesures pour commander les émissions éventuelles doivent être utilisées comme déclaré par le fabricant dans le Tableau 1, exigence 54. Cette exigence ne s'applique pas aux **dispositifs de commande** déclarés et conçus pour charge par **mode pilote** seulement.

24 Fonctionnement normal

24.1 Forme d'onde de sortie des dispositifs de commande électronique

La forme d'onde de sortie des **dispositifs de commande électronique** doit être conforme à celle déclarée.

*La forme d'onde de sortie du **dispositif de commande** doit être examinée dans toutes les conditions normales de fonctionnement et doit être sinusoïdale ou conforme à celle déclarée à l'exigence 48 du Tableau 1.*

NOTE L'attention est attirée sur l'IEC 61000-3-2 et l'IEC 61000-3-3 qui imposent des restrictions aux perturbations produites dans le réseau.

24.2 Fonctionnement dans la plage de tensions

Un **dispositif de commande** à électro-aimant incorporé doit fonctionner comme prévu à toute tension dans la plage comprise entre 85 % de la tension assignée minimale et 110 % de la tension assignée maximale.

*La conformité est vérifiée en soumettant le **dispositif de commande** aux essais suivants dans les conditions de fonctionnement maximales et minimales annoncées, à l'exception du fait que seul un **dispositif de commande** ayant une valeur T_{min} inférieure à 0 °C est vérifié à T_{min}:*

*Le **dispositif de commande** est soumis à 1,1 $V_{R\ max}$ jusqu'à ce que la température d'équilibre soit atteinte et son **fonctionnement** est alors immédiatement vérifié à 1,1 $V_{R\ max}$ et à la tension assignée.*

*Le **dispositif de commande** est aussi soumis à 0,85 $V_{R\ min}$ jusqu'à ce que la température d'équilibre soit atteinte et son **fonctionnement** est alors immédiatement vérifié à 0,85 $V_{R\ min}$.*

Les dispositifs de commande alimentés par batterie doivent être soumis à essai à une tension maximale et à une tension minimale telles que déclarées par le fabricant dans l'exigence 85 du Tableau 1.

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25 Exigences de compatibilité électromagnétique (CEM) – Immunité

25.1 Généralités

Les **dispositifs de commande électronique** doivent être évalués conformément au Tableau 25:

Tableau 25 – Essai CEM applicable en fonction de la classe de la fonction de commande et du type d'action

Construction du dispositif de commande/de l'application	Classe de la fonction de commande			
	Classe A		Classe B	Classe C
	Action de type 1	Action de type 2		
Dispositifs de commande intégrés	25.7 à 25.10 (si cela est déclaré)[a] 25.5 à 25.10 (si cela est demandé)[b]	25.7 à 25.10 25.5 à 25.10 (si cela est demandé)[b]	25.5, 25.6 et Article H.25	Article H.25
Dispositifs de commande incorporés	25.7 à 25.10 (si cela est déclaré)[a] 25.5 à 25.10 (si cela est demandé)[b]	25.7 à 25.10 25.5 à 25.10 (si cela est demandé)[b]	Article H.25	Article H.25
Dispositifs de commande intercalés dans un câble souple, dispositifs de commande séparés et **dispositifs de commande à montage indépendant** pour l'application HBES/SGTB et le matériel qui utilise des dispositifs de commande incorporés/intégrés pour l'application HBES/SGTB	25.5, 25.6 et 25.7 à 25.10 (si cela est déclaré)[a]	25.5 à 25.10	25.5, 25.6 et Article H.25	25.5, 25.6 et Article H.25

[a] Si cela est déclaré dans le Tableau 1, exigence 86.

[b] Si cela est demandé par le fabricant du dispositif de commande dans le Tableau 1, exigence 84.

25.2 Plan et rapport d'essai CEM

25.2.1 Généralités

Un plan d'essai CEM doit être établi avant les essais. Il doit contenir, au minimum, les éléments donnés dans la configuration de l'EUT lors des essais d'émission en 23.1 et d'immunité de 25.5 à 25.10. Il peut être déterminé en fonction des caractéristiques électriques et de l'utilisation d'un appareil particulier que certains essais sont inappropriés et donc inutiles. Dans de tels cas, la décision de ne pas soumettre à essai doit être consignée dans le plan d'essai CEM et le rapport d'essai CEM.

25.2.2 Configuration de l'EUT pendant les essais

25.2.2.1 Généralités

Les dispositifs de commande et le matériel de commande se composent souvent de **systèmes** sans configuration fixe. Le type, le nombre et l'installation de différents sous-ensembles dans le matériel de commande peuvent varier d'un **système** à l'autre. Il est donc raisonnable, et recommandé, de ne pas soumettre à essai tous les montages possibles.

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Pour simuler les conditions CEM (liées à la fois à l'émission et à l'immunité), l'assemblage du matériel de commande doit représenter une installation type telle que spécifiée par le fabricant. Ces essais doivent être menés comme des essais de type dans les conditions normales spécifiées par le fabricant.

25.2.2.2 Composition de l'EUT

Tous les dispositifs, racks, modules, cartes, etc. importants pour la CEM et appartenant à l'EUT doivent être documentés dans le plan d'essai CEM et le rapport d'essai CEM. Le cas échéant, la version du logiciel doit être documentée dans le plan d'essai CEM et le rapport d'essai CEM.

25.2.2.3 Assemblage de l'EUT

Si un EUT possède différentes configurations internes et externes, les essais de type doivent être effectués avec une ou plusieurs configurations types qui représentent l'usage normal. La raison du choix des configurations doit être documentée dans le plan d'essai CEM et le rapport d'essai CEM.

25.2.2.4 Accès E/S

En présence de plusieurs accès E/S qui sont tous du même type, le raccordement d'un câble à un seul de ces accès est suffisant, à condition qu'il puisse être démontré que les câbles supplémentaires n'affecteront pas les résultats de manière significative.

25.2.2.5 Matériel auxiliaire

Lorsque plusieurs dispositifs sont fournis pour être utilisés avec l'EUT, au moins un de chaque type de dispositif doit être choisi pour simuler les conditions de fonctionnement réelles. Les dispositifs auxiliaires peuvent être simulés.

25.2.2.6 Câblage et mise à la terre

Les câbles et la terre doivent être raccordés à l'EUT conformément aux spécifications du fabricant. Il ne doit pas y avoir de connexions de terre supplémentaires.

25.2.3 Conditions de fonctionnement de l'EUT pendant les essais

25.2.3.1 Modes de fonctionnement

Des modes de fonctionnement représentatifs doivent être sélectionnés, en tenant compte du fait que seules les fonctions les plus typiques du dispositif de commande électronique peuvent être soumises à essai. Les modes de fonctionnement estimés comme les plus défavorables pour une application normale doivent être sélectionnés.

NOTE La condition de veille du dispositif de commande est considérée comme un mode de fonctionnement.

25.2.3.2 Conditions environnementales

Les essais doivent être effectués dans la plage de fonctionnement environnemental spécifiée par le fabricant (par exemple, température ambiante, humidité, pression atmosphérique) et dans les plages assignées de tension et de fréquence d'alimentation.

25.2.3.3 Logiciel de l'EUT pendant l'essai

Le logiciel utilisé pour simuler les différents modes de fonctionnement doit être documenté. Ce logiciel doit représenter le mode de fonctionnement estimé comme le plus défavorable pour une application normale.

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25.2.3.4 Spécification des critères de performance

Pour les essais d'immunité, les critères de performance pour chaque mode de fonctionnement et essai doivent être spécifiés, dans la mesure du possible, sous forme de valeurs quantitatives.

25.2.3.5 Description de l'essai

Chaque essai à appliquer doit être spécifié dans le plan d'essai CEM. La description des essais, les méthodes d'essai, les caractéristiques de l'essai et les montages d'essai sont donnés dans les normes fondamentales, auxquelles il est fait référence, pour les émissions, dans le Tableau 23 ou le Tableau 24 et, pour l'immunité, dans le Tableau 26 ou le Tableau 27. Des informations supplémentaires nécessaires à la mise en œuvre pratique des essais sont données dans le présent document. Le contenu des normes peut ne pas être reproduit dans le plan d'essai. Dans certains cas, le plan d'essai CEM doit spécifier l'application en détail.

25.3 Exigences d'immunité

25.3.1 Conditions pendant l'essai

La configuration et les modes de fonctionnement au cours des essais doivent être notés avec précision dans le rapport d'essai.

Les essais doivent être appliqués aux accès correspondants conformément au Tableau 26 ou au Tableau 27, suivant le cas.

Les essais doivent être réalisés conformément aux normes fondamentales. Ils doivent être réalisés l'un après l'autre. Si des méthodes supplémentaires sont exigées, la méthode et la raison associée doivent être documentées dans le rapport d'essai.

25.3.2 Exigences des essais d'immunité

Les exigences des essais d'immunité pour les "**environnements électromagnétiques résidentiels**" sont données dans le Tableau 26, comme déclaré dans le Tableau 1, exigence 77.

Les exigences des essais d'immunité pour l'"**environnement électromagnétique industriel**" sont données dans le Tableau 27, comme déclaré dans le Tableau 1, exigence 78.

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Tableau 26 – Exigences des essais d'immunité pour les environnements électromagnétiques résidentiels

Accès	Phénomène	Norme fondamentale	Valeur d'essai	Critères de performance	
				m	n
Enveloppe	Décharge électrostatique DES	IEC 61000-4-2	±8 kV dans l'air / ±4 kV de contact	B	
	Champ électromagnétique	IEC 61000-4-3[g, h, i]	3 V/m (80 MHz à 1 GHz)	A	
			3 V/m (1,4 GHz à 6 GHz)	A	
			10 V/m (80 MHz à 1GHz)		B
	Champ magnétique à la fréquence industrielle [e]	IEC 61000-4-8	3 A/m (50 Hz, 60 Hz)	A	
Alimentation CA (y compris terre de protection)	Creux de tension[k]	IEC 61000-4-11	0 % pendant 0,5 cycle	B	A
			0 % pendant 1 cycle	B	A
			70 % pendant 25/30 cycles[l]	C	
			40 % pendant 10/12 cycles[l]		B
	Coupures de tension [k]	IEC 61000-4-11	0 % pendant 250/300 cycles[l]	C	
	Salves	IEC 61000-4-4	±1 kV (5/50 ns, 5 kHz) [o]	B	A
			±2 kV (5/50 ns, 5 kHz) [o]		B
	Ondes de choc[p]	IEC 61000-4-5	±1 kV a, n / ±2 kV [b, o]	B	
	Perturbations conduites, induites par les champs radioélectriques	IEC 61000-4-6	3 V (150 kHz à 80 MHz) [q]	A	
			10 V (150 kHz à 80 MHz) [q]		B
Accès d'alimentation en courant continu [f] (y compris terre de protection)	Salves[j, r]	IEC 61000-4-4	±0,5 kV (5/50 ns, 5 kHz) [o]	B	A
			±1 kV (5/50 ns, 5 kHz) [o]		B
	Ondes de choc[c, j, r]	IEC 61000-4-5	±0,5 kV a, n /±1 kV [b, o]	B	
			±2 kV [b, o]		B
	Perturbations conduites, induites par les champs radioélectriques[d]	IEC 61000-4-6	3 V (150 kHz à 80 MHz) [q]	A	
			10 V (150 kHz à 80 MHz) [q]		B
Accès de commande/ signal E/S (y compris lignes connectées à l'accès par la borne de terre fonctionnelle)	Salves[d]	IEC 61000-4-4	±0,5 kV (5/50 ns, 5 kHz) [o]	B	A
			±1 kV (5/50 ns, 5 kHz) [o]		B
	Ondes de choc[c]	IEC 61000-4-5	±1kV [b, o]	B	
			±0,5 kV [a, o] / ±2 kV [b, o]		B
	Perturbations conduites, induites par les champs radioélectriques[d]	IEC 61000-4-6	3 V (150 kHz à 80 MHz) [q]	A	
			10 V (150 kHz à 80 MHz) [q]		B
Lignes de réseau HBES/SGTB	Salves[d]	IEC 61000-4-4	±0,5 kV (5/50 ns, 5 kHz) [o]		A
			±1 kV (5/50 ns, 5 kHz) [o]		B
	Ondes de choc[c]	IEC 61000-4-5	±0,5 kV [a, o] / ±2 kV [b, o]		B
	Perturbations conduites, induites par les champs radioélectriques[d]	IEC 61000-4-6	3 V (150 kHz à 80 MHz) [q]		A
			10 V (150 kHz à 80 MHz) [q]		B

[a] Entre phases.

[b] Phase-terre (masse).

[c] Uniquement dans le cas de lignes de grande longueur, voir 3.24.9 (comme cela est déclaré dans le Tableau 1, exigence 79).

[d] Uniquement dans le cas de lignes > 3 m (comme cela est déclaré dans le Tableau 1, exigence 80).

[e] Applicable uniquement aux appareils comportant des dispositifs sensibles aux champs magnétiques (comme cela est déclaré dans le Tableau 1, exigence 83).

[f] Les accès et connexions en courant continu entre les parties d'un matériel/**système** qui ne sont pas connectées à un réseau de distribution en courant continu sont traités comme des accès de signal/commande E/S.

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[g] L'IEC 61000-4-20 peut être utilisée pour les EUT de petite taille, tels que définis dans l'IEC 61000-4-20.

[h] Une enceinte complètement anéchoïque (FAR) telle que décrite dans l'IEC 61000-4-22 peut également être utilisée comme site d'essai pour l'essai d'immunité aux fréquences radioélectriques.

[i] Une chambre réverbérante (RVC) telle que décrite dans l'IEC 61000-4-21 peut également être utilisée (pour plus de détails, voir IEC 61000-6-1 et IEC 61000-4-21).

[j] Non applicable aux accès d'entrée destinés à être raccordés à des piles ou des piles rechargeables qui doivent être retirées ou débranchées de l'appareil pour pouvoir être rechargées.

[k] Applicable uniquement aux accès d'entrée.

[l] Par exemple, "25/30 cycles" signifie "25 cycles pour l'essai à 50 Hz" et "30 cycles pour l'essai à 60 Hz" (comme cela est déclaré dans le Tableau 1, exigence 81).

[m] Critères de performance par défaut de tous les dispositifs de commande.

[n] Exigence supplémentaire par rapport à la Note [m] pour les dispositifs de commande destinés à être utilisés conformément aux réseaux HBES/SGTB de l'IEC 63044-5-2 (comme cela est déclaré dans le Tableau 1, exigence 82).

[o] Tension d'essai en circuit ouvert.

[p] Tout appareil avec un accès d'entrée d'alimentation en courant alternatif destiné à une utilisation avec un transformateur doit être soumis à essai au niveau de l'entrée du transformateur spécifié par le fabricant ou, lorsqu'aucun transformateur n'est spécifié, en utilisant un transformateur type de 300 VA min.

[q] Le niveau d'essai spécifié est la valeur efficace de la porteuse non modulée.

[r] Le matériel avec un accès d'entrée d'alimentation en courant continu destiné à une utilisation avec un adaptateur de courant alternatif/continu doit être soumis à l'essai sur l'entrée de courant alternatif de l'adaptateur de courant alternatif/continu spécifié par le fabricant ou, lorsqu'aucun adaptateur n'est spécifié, l'essai doit être effectué sur l'accès d'alimentation en courant continu en utilisant les niveaux d'essai du présent tableau.

Tableau 27 – Exigences des essais d'immunité pour l'environnement électromagnétique industriel

Accès	Phénomène	Norme fondamentale	Valeur d'essai	Critères de performance
Enveloppe	Décharge électrostatique (DES)	IEC 61000-4-2	±8 kV dans l'air / ±4 kV de contact	B
	Champ électromagnétique	IEC 61000-4-3[g, h, i]	10 V/m (80 MHz à 1 GHz)	A
			3 V/m (1,4 GHz à 6 GHz)	A
	Champ magnétique à la fréquence du réseau assignée[e]	IEC 61000-4-8	30 A/m	A
Alimentation en courant alternatif	Creux de tension[k]	IEC 61000-4-11	0 % pendant 0,5 cycle	B
			0 % pendant 1 cycle	B
			70 % pendant 25/30 cycles[l]	C
	Coupures brèves[k]	IEC 61000-4-11	0 % pendant 250/300 cycles[l]	C
	Salves	IEC 61000-4-4	±2 kV (5/50 ns, 5 kHz) [n]	B
	Ondes de choc[o]	IEC 61000-4-5	±1 kV [a, n] / ±2 kV [b, n]	B
	Perturbations conduites, induites par les champs radioélectriques	IEC 61000-4-6	10 V (150 kHz à 80 MHz)[o]	A
Accès d'alimentation en courant continu [f] (y compris terre de protection)	Salves[j, q]	IEC 61000-4-4	±1 kV (5/50 ns, 5 kHz) [n]	B
	Ondes de choc[c, j, q]	IEC 61000-4-5	±1 kV [a, n] / ±2 kV [b, n]	B
	Perturbations conduites, induites par les champs radioélectriques[d]	IEC 61000-4-6	10 V (150 kHz à 80 MHz)[p]	A

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Accès	Phénomène	Norme fondamentale	Valeur d'essai	Critères de performance
Accès de commande/ signal E/S (y compris lignes connectées à l'accès par la borne de terre fonctionnelle)	Salves[d]	IEC 61000-4-4	±1 kV (5/50 ns, 5 kHz) [n]	B
	Ondes de choc[c]	IEC 61000-4-5	±1 kV [b, n]	B
	Perturbations conduites, induites par les champs radioélectriques[d]	IEC 61000-4-6	10 V (150 kHz à 80 MHz)[p]	A
Lignes de réseau HBES/SGTB[m]	Salves[d]	IEC 61000-4-4	±0,5 kV (5/50 ns, 5 kHz) [n]	A
	Ondes de choc[c]	IEC 61000-4-5	±1kV [a, n] / ±2kV [b, n]	B
	Perturbations conduites, induites par les champs radioélectriques[d]	IEC 61000-4-6	10 V (150 kHz à 80 MHz)[p]	A

[a] Entre phases.

[b] Phase-terre (masse).

[c] Uniquement dans le cas de lignes de grande longueur, voir 3.24.9 (comme cela est déclaré dans le Tableau 1, exigence 79).

[d] Uniquement dans le cas de lignes > 3 m (comme cela est déclaré dans le Tableau 1, exigence 80).

[e] Applicable uniquement aux appareils comportant des dispositifs sensibles aux champs magnétiques (comme cela est déclaré dans le Tableau 1, exigence 83).

[f] Les accès et connexions en courant continu entre les parties d'un matériel/**système** qui ne sont pas connectées à un réseau de distribution en courant continu sont traités comme des accès de signal/commande E/S.

[g] L'IEC 61000-4-20 peut être utilisée pour les EUT de petite taille, tels que définis dans l'IEC 61000-4-20.

[h] Une enceinte complètement anéchoïque (FAR) telle que décrite dans l'IEC 61000-4-22 peut également être utilisée comme site d'essai pour l'essai d'immunité aux fréquences radioélectriques.

[i] Une chambre réverbérante (RVC) telle que décrite dans l'IEC 61000-4-21 peut également être utilisée (pour plus de détails, voir IEC 61000-6-1 et IEC 61000-4-21).

[j] Non applicable aux accès d'entrée destinés à être raccordés à des piles ou des piles rechargeables qui doivent être retirées ou débranchées de l'appareil pour pouvoir être rechargées.

[k] Applicable uniquement aux accès d'entrée.

[l] Par exemple, "25/30 cycles" signifie "25 cycles pour l'essai à 50 Hz" et "30 cycles pour l'essai à 60 Hz" (comme cela est déclaré dans le Tableau 1, exigence 81).

[m] Exigence supplémentaire pour les dispositifs de commande destinés à être utilisés conformément aux réseaux HBES/SGTB de l'IEC 63044-5-3 (comme cela est déclaré dans le Tableau 1, exigence 82).

[n] Tension d'essai en circuit ouvert.

[o] Tout appareil avec un accès d'entrée d'alimentation en courant alternatif destiné à une utilisation avec un transformateur doit être soumis à essai au niveau de l'entrée du transformateur spécifié par le fabricant ou, lorsqu'aucun transformateur n'est spécifié, en utilisant un transformateur type de 300 VA min.

[p] Le niveau d'essai spécifié est la valeur efficace de la porteuse non modulée.

[q] Le matériel avec un accès d'entrée d'alimentation en courant continu destiné à une utilisation avec un adaptateur de courant alternatif/continu doit être soumis à l'essai sur l'entrée de courant alternatif de l'adaptateur de courant alternatif/continu spécifié par le fabricant ou, lorsqu'aucun adaptateur n'est spécifié, l'essai doit être effectué sur l'accès d'alimentation en courant continu en utilisant les niveaux d'essai du présent tableau.

25.4 Critères de performance

Les critères de performance sont donnés dans le Tableau 28 et sont basés sur les conditions de fonctionnement et les spécifications fonctionnelles du dispositif de commande pendant et après l'essai.

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Après l'essai, le dispositif de commande doit satisfaire aux exigences de l'Article 6, de 15.2 et de l'Article 11.

Tableau 28 – Critères de performance

Conditions de fonctionnement	Critères de performance		
	A	B	C
Entrées/sorties numériques	Aucun écart sur les valeurs lues en entrée. Aucun écart sur les réglages de sortie. (aucun changement d'état)	Aucun écart sur les valeurs lues en entrée. Aucun écart sur les réglages de sortie. (aucun changement d'état)	Les erreurs, telles qu'un changement d'état, la destruction de données et les pertes de connexion, sont autorisées, à condition que l'état initial soit restauré automatiquement après l'essai (reprise automatique après l'essai[b])
Entrées/sorties analogiques	L'écart déclaré dans la spécification de produit final est autorisé.[a]	Les écarts sont autorisés pendant l'essai.	
Ecran, moniteur	Le fonctionnement doit être possible dans des conditions de confort raisonnables.	Les écarts sont autorisés. (Par exemple, une **panne** d'affichage de type scintillement.)	
Inhibition/basculement par l'opérateur local	Aucun écart.	Les écarts sont autorisés pour les valeurs analogiques. Aucun changement d'état pour les valeurs numériques.	
Accès par le réseau HBES/SGTB Accès de communication	Aucun écart détectable par l'utilisateur. Le taux de transfert de données réduit doit être raisonnable pour l'opération de commande.	La dégradation de fonctionnement est autorisée, mais pas la perte de communication pendant plus d'1 min.	

[a] L'écart admissible est évalué par rapport à la valeur sans interférence électromagnétique. Cela signifie que tout écart de base est ignoré.

[b] Ce critère de performance repose sur le fait que l'opération de commande dans l'application d'usager n'est pas supervisée.

25.5 Essai d'immunité aux ondes de choc

Le dispositif de commande est monté comme spécifié en 4.3.2.1, alimenté à la tension assignée et fonctionne dans des conditions de fonctionnement représentatives. Il est soumis à essai conformément à l'IEC 61000-4-5.

Les valeurs d'essai pour le niveau CEM déclaré sont spécifiées dans le Tableau 26 ou le Tableau 27.

Fréquence de répétition: 1/min au maximum

Polarité: positive (+) et négative (−)

Nombre d'impulsions: cinq impulsions sont appliquées pour chaque polarité

Angle de phase: 0°, 90°, 180° et 270° par rapport à l'angle de phase de la tension de ligne en courant alternatif du matériel soumis à essai.

NOTE La plupart des protecteurs couramment utilisés ont des capacités de puissance moyenne faibles, même si leur puissance de crête ou leur gestion d'énergie de crête peuvent supporter des courants élevés. Par conséquent, la fréquence de répétition maximale (le temps entre deux ondes de choc et le temps de reprise) dépend des dispositifs de protection intégrés de l'EUT.

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25.6 Essai d'immunité aux transitoires électriques rapides

Le dispositif de commande est monté comme spécifié en 4.3.2.1, alimenté à la tension assignée et fonctionne dans des conditions de fonctionnement représentatives. Il est soumis à essai conformément à l'IEC 61000-4-4.

Les valeurs d'essai pour le niveau CEM déclaré sont spécifiées dans le Tableau 26 ou le Tableau 27.

Polarité: positive (+) et négative (−)

Durée: une minute pour chaque polarité

25.7 Immunité aux champs électromagnétiques de fréquences radio

25.7.1 Immunité aux perturbations conduites

Le dispositif de commande est monté comme spécifié en 4.3.2.1, alimenté à la tension assignée et fonctionne dans des conditions de fonctionnement représentatives. Il est soumis à essai conformément à l'IEC 61000-4-6. La plage de fréquences complète est balayée au moins une fois.

Les niveaux d'essai et les valeurs de tension d'essai pour le niveau CEM déclaré sont spécifiés dans le Tableau 26 ou le Tableau 27.

25.7.2 Immunité aux champs électromagnétiques rayonnés

Le dispositif de commande est monté comme spécifié en 4.3.2.1, alimenté à la tension assignée et fonctionne dans des conditions de fonctionnement représentatives. Il est soumis à essai conformément à l'IEC 61000-4-3. La plage de fréquences complète est balayée au moins une fois.

Les valeurs d'essai pour le niveau CEM déclaré sont spécifiées dans le Tableau 26 ou le Tableau 27.

25.8 Décharge électrostatique

Le dispositif de commande est monté comme spécifié en 4.3.2.1, alimenté à la tension assignée et fonctionne dans des conditions de fonctionnement représentatives. Il est soumis à essai conformément à l'IEC 61000-4-2.

Les valeurs d'essai pour le niveau CEM déclaré sont spécifiées dans le Tableau 26 ou le Tableau 27, où 5 décharges dans chaque polarité (+/−) doivent être appliquées:

- des décharges de contact doivent être appliquées aux points et surfaces de l'EUT qui sont accessibles aux personnes en usage normal et au HCP et au VCP conformément à la norme fondamentale;
- des décharges dans l'air doivent être appliquées aux points et surfaces de l'EUT qui sont accessibles aux personnes en usage normal.

25.9 Immunité aux champs magnétiques à la fréquence du réseau

Cet essai s'applique uniquement aux dispositifs de commande contenant des dispositifs sensibles aux champs magnétiques (par exemple, dispositifs à effet hall) et s'il est déclaré par le fabricant (comme cela est déclaré dans le Tableau 1, exigence 83).

Le dispositif de commande est monté comme spécifié en 4.3.2.1, alimenté à la tension assignée et fonctionne dans des conditions de fonctionnement représentatives. Il est soumis à essai conformément à l'IEC 61000-4-8.

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Les valeurs d'essai pour le niveau CEM déclaré sont spécifiées dans le Tableau 26 ou le Tableau 27.

25.10 Essai de l'influence des creux de tension et coupures de tension dans le réseau d'alimentation

Durant l'essai, le dispositif de commande doit être initialement mis en fonctionnement à sa tension assignée. Le dispositif de commande fonctionne dans des conditions de fonctionnement représentatives.

Il est soumis à essai conformément à l'IEC 61000-4-11. L'essai s'applique uniquement aux accès d'entrée d'alimentation en courant alternatif.

Les valeurs d'essai pour le niveau CEM déclaré sont spécifiées dans le Tableau 26 ou le Tableau 27.

26 Essais en fonctionnement anormal

26.1 Essai de température anormale

26.1.1 Essai de brûlure

26.1.1.1 Les dispositifs de commande avec des électro-aimants incorporés doivent résister aux effets de blocage du mécanisme du dispositif de commande.

La conformité est vérifiée par les essais de 26.1.1.2 et de 26.1.1.3.

NOTE Pour les relais et les contacteurs, la conformité à cette exigence est considérée comme satisfaite par l'accomplissement des essais de l'Article 19.

26.1.1.2 Le mécanisme du dispositif de commande est bloqué dans la position présumée dans laquelle le dispositif de commande n'est pas alimenté. Le dispositif de commande est alors alimenté à la fréquence assignée et à la tension assignée comme indiqué en 19.2.2, 19.2.3 a) et 19.2.3 b).

La durée de l'essai est soit 7 h soit jusqu'à ce que le dispositif de protection interne éventuel se déclenche, ou jusqu'à la brûlure, suivant ce qui a lieu en premier.

26.1.1.3 A l'issue de cet essai, le dispositif de commande doit être considéré comme conforme si:

– *il n'y a pas d'émission de flammes ou de métal fondu et qu'il n'y a pas à l'évidence d'endommagement du* ***dispositif de commande*** *qui pourrait compromettre la conformité au présent document;*
– *les exigences de 15.2 sont encore satisfaites.*

NOTE Le **dispositif de commande** peut ne pas être fonctionnel à la suite de l'essai.

26.1.2 Essai de sortie mécanique bloquée

26.1.2.1 Les **dispositifs de commande** comprenant des moteurs, tels que les actionneurs électriques, doivent résister aux effets d'une sortie bloquée sans dépasser les températures indiquées au Tableau 29. Les températures sont mesurées par la méthode spécifiée en 16.7 a). Cet essai n'est pas réalisé sur les **dispositifs de commande** comprenant des moteurs tels que les actionneurs électriques pour qui, lorsqu'ils sont soumis à essai en condition de sortie bloquée pendant 7 h, tout dispositif de protection, si fourni, ne cycle pas en conditions bloquées et qui ne dépassent pas les limites de température du Tableau 17.

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26.1.2.2 Les **dispositifs de commande** comprenant des moteurs, tels que les actionneurs électriques, sont soumis à essai pendant 24 h avec la sortie bloquée sous la tension assignée et avec une température ambiante dans la plage de 15 °C à 30 °C, la température mesurée résultante étant corrigée par rapport à une valeur de référence de 25 °C.

Pour les **dispositifs de commande** comprenant des moteurs déclarés **fonctionnant** en triphasé, il faut réaliser l'essai avec une quelconque des phases déconnectée.

Tableau 29 – Température maximale des enroulements (pour l'essai en condition de sortie mécanique bloquée)

Condition	Température de l'isolant par classe °C							
	A	**E**	**B**	**F**	**H**	**200**	**220**	**250**
Si impédance protégée:	150	165	175	190	210	230	250	280
Si protégée par des dispositifs de protection:								
Pendant la première heure	200	215	225	240	260	280	300	330
– valeur maximale								
Après la première heure								
– valeur maximale	175	190	200	215	235	255	275	305
– moyenne arithmétique	150	165	175	190	210	230	250	280

26.1.2.3 La température moyenne doit être à l'intérieur des limites à la fois pendant la deuxième heure et pendant la vingt-quatrième heure de l'essai.

NOTE La température moyenne d'un enroulement est la moyenne arithmétique des valeurs minimale et maximale de la température de l'enroulement pendant une durée de 1 h.

26.1.2.4 Pendant l'essai, le moteur doit être constamment sous tension.

26.1.2.5 Immédiatement après l'achèvement de l'essai, le moteur doit être capable de satisfaire à l'essai de rigidité diélectrique spécifié à l'Article 15, sans réalisation préalable de l'épreuve hygroscopique de 14.2.

26.2 Essais de surcharge

26.2.1 Essais de surcharge effectués sur des dispositifs de commande intercalés dans un câble souple tels qu'indiqués en 9.10.2 et équipés d'une fiche et d'une prise de courant

Les essais conformes à 26.2.3 doivent être effectués.

La température ne doit pas dépasser les valeurs indiquées au Tableau 17.

26.2.2 Pour les dispositifs de commande non couverts par 26.2.1

Les essais conformes à 26.2.3 doivent être effectués à une température ambiante de (20 ± 5) °C. Si le Tableau 1, exigence 70 l'indique, l'essai n'est pas effectué pour les ***dispositifs de commande incorporés*** *et les* ***dispositifs de commande intégrés****.*

26.2.3 Essais

Les essais de 26.2.3 ne sont pas applicables aux dispositifs de commande lorsque la charge est intégrée dans le dispositif de commande à proprement parler ou lorsque la charge connectée est déclarée dans le Tableau 1, exigence 8 et contrôlée (par exemple, matériel fixe).

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Les essais sont effectués comme suit.

– *Les **dispositifs de commande** tels que spécifiés sans dispositif de protection et sans fusible incorporé sont chargés pendant 1 h avec le courant conventionnel de déclenchement pour le fusible qui dans l'installation protège le **dispositif de commande**.*
– *Les **dispositifs de commande** protégés par des dispositifs de protection (y compris les fusibles) sont chargés de façon telle que le courant à travers le **dispositif de commande** soit 0,95 fois le courant avec lequel le dispositif de protection se libère au bout de 1 h. L'échauffement est mesuré après qu'un régime établi a été atteint ou au bout de 4 h, suivant le temps le plus court des deux.*
– *Les **dispositifs de commande** protégés par des fusibles incorporés conformes à la série IEC 60127 ou la série IEC 60269 doivent remplacer ces fusibles par des liaisons d'impédance négligeable et doivent être chargés de façon telle que le courant à travers ces liaisons doit être de 2,1 fois le courant assigné du fusible. L'échauffement est mesuré après que le **dispositif de commande** a été chargé pendant 30 min. La valeur 2,1 fois peut être réduite de 0,5 %/K, si l'essai de surcharge est effectué à une température supérieure à la température ambiante normale.*
– *Les **dispositifs de commande** protégés par des fusibles incorporés et par des dispositifs de protection sont chargés soit comme décrit ci-dessus avec les fusibles incorporés, soit avec un autre dispositif de protection, en choisissant l'essai qui exige la charge la plus faible.*
– *Les **dispositifs de commande** protégés par des dispositifs de protection qui court-circuitent seulement en cas de surcharge doivent être soumis à essai à la fois comme des **dispositifs de commande** avec dispositifs de protection et comme **dispositifs de commande** sans dispositif de protection.*

La conformité aux points a) à g) de 13.1.3.8, le cas échéant, est vérifiée.

26.3 Essai de court-circuit de pile

26.3.1 Pour les **dispositifs de commande** équipés de piles pouvant être retirées sans l'aide d'un **outil** et disposant de bornes pouvant être court-circuitées par une barre rectiligne mince, les bornes de la pile sont court-circuitées avec la pile totalement chargée.

La durée de l'essai peut être de 1 h ou jusqu'à l'obtention d'une condition finale, selon ce qui se produit en premier.

26.3.2 A l'issue de cet essai, le **dispositif de commande** doit être considéré comme conforme si:

– *il n'y a pas d'émission de flammes ou de métal fondu et qu'il n'y a pas à l'évidence d'endommagement du **dispositif de commande** qui pourrait compromettre la conformité au présent document;*
– *les exigences de 15.2 sont encore satisfaites.*

NOTE Le **dispositif de commande** peut ne pas être fonctionnel à la suite de l'essai.

Dimensions en millimètres

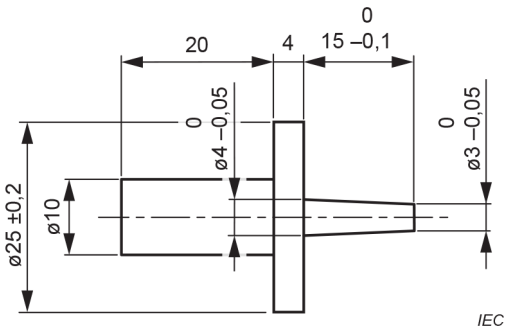
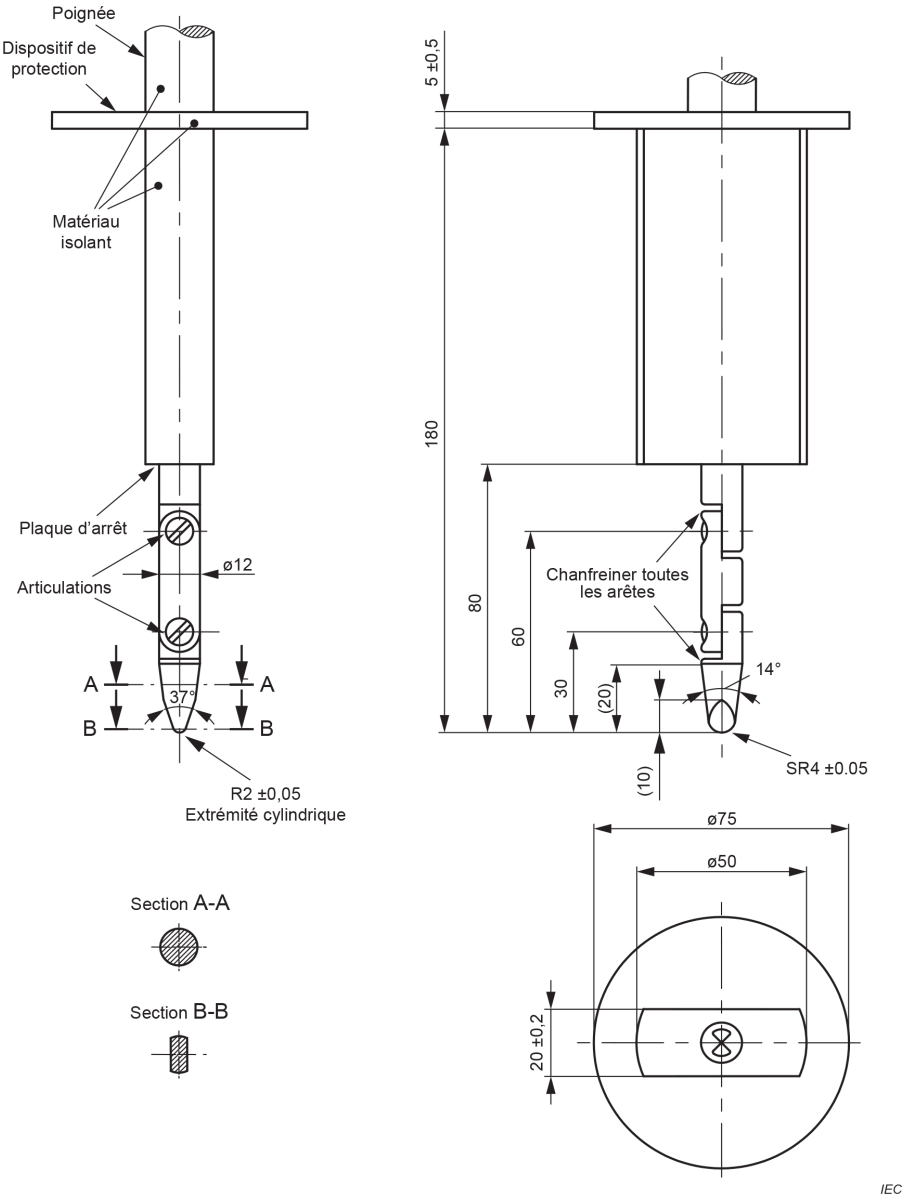


Figure 4 – Broche d'épreuve de calibre 13 de l'IEC 61032:1997

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Dimensions linéaires en millimètres



Tolérances des dimensions sans indication de tolérance:

sur les angles $^{0}_{-10}$ °

sur les dimensions linéaires:

jusqu'à 25 mm: $^{0}_{-0,05}$

au-dessus de 25 mm: ±0,2

Matériau du doigt: par exemple, acier trempé.

Les deux articulations du doigt peuvent être pliées sous un angle de 90° mais dans une seule et même direction.

L'emploi de la solution pointe-encoche n'est qu'une des solutions possibles pour limiter l'angle de pliage à 90°. Pour cette raison, les dimensions et tolérances de ces détails ne sont pas indiquées sur le dessin. La conception réelle doit assurer un angle de pliage de 90°, avec une tolérance de 0° à 10°.

Figure 5 – Doigt d'épreuve de calibre B de l'IEC 61032:1997

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Dimensions en millimètres

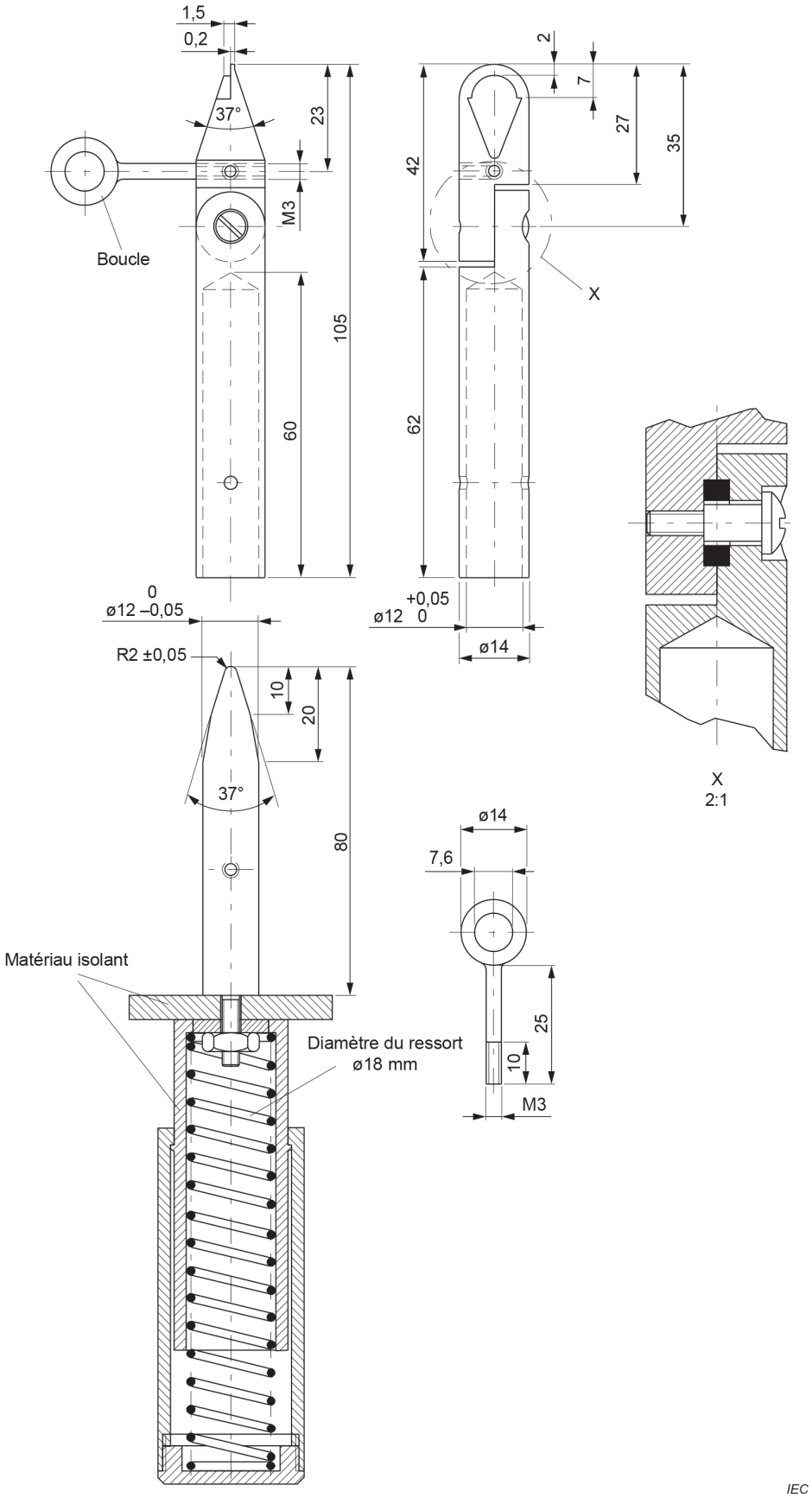


Figure 6 – Ongle d'épreuve

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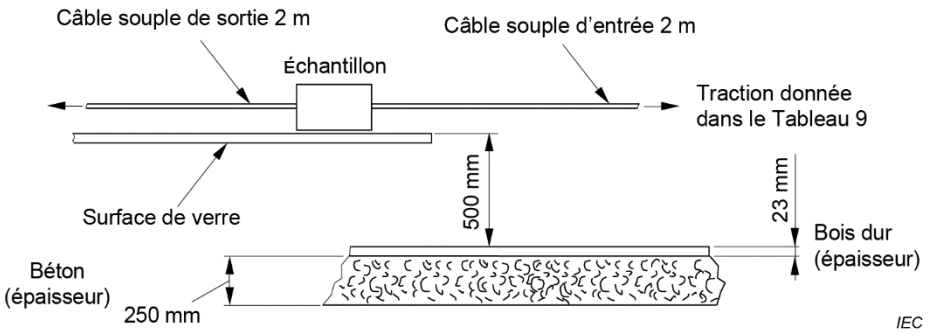


Figure 7 – Essai de chute pour dispositifs de commande séparés

Dimensions en millimètres

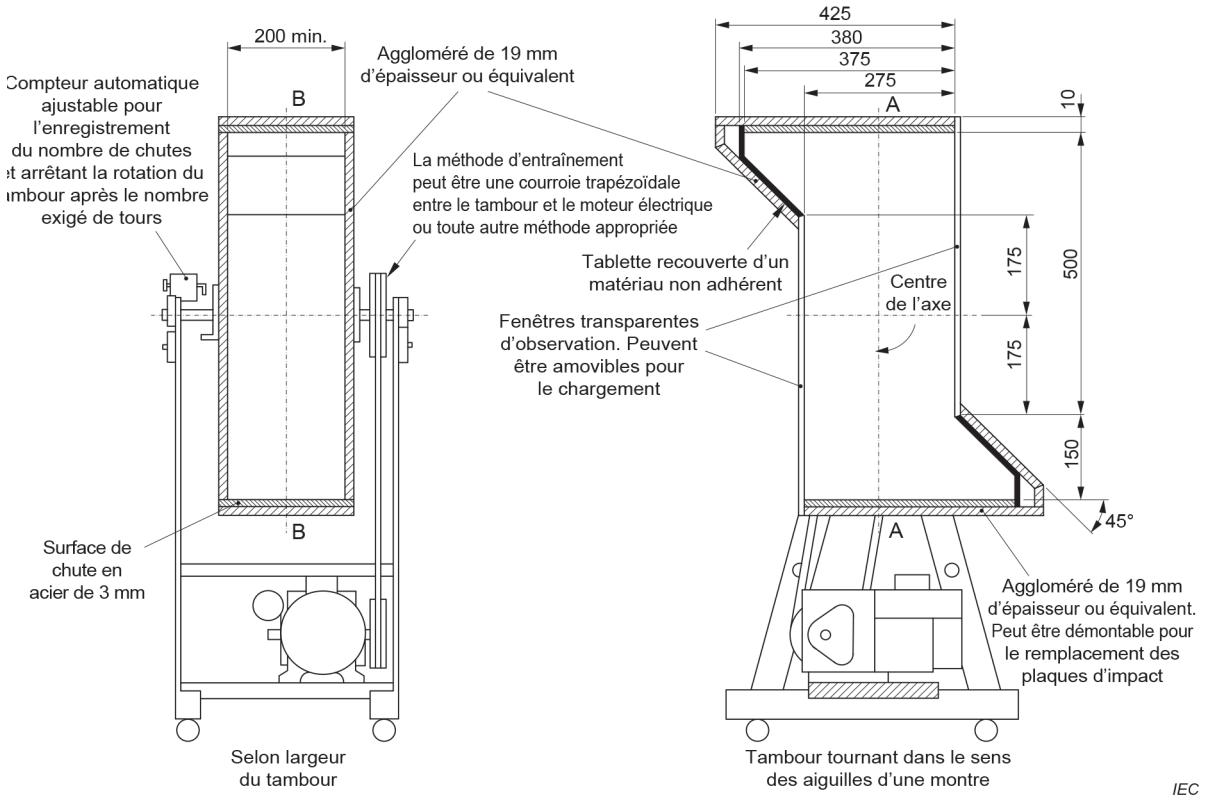


Figure 8 – Appareil pour essai de chutes répétées

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Dimensions en millimètres

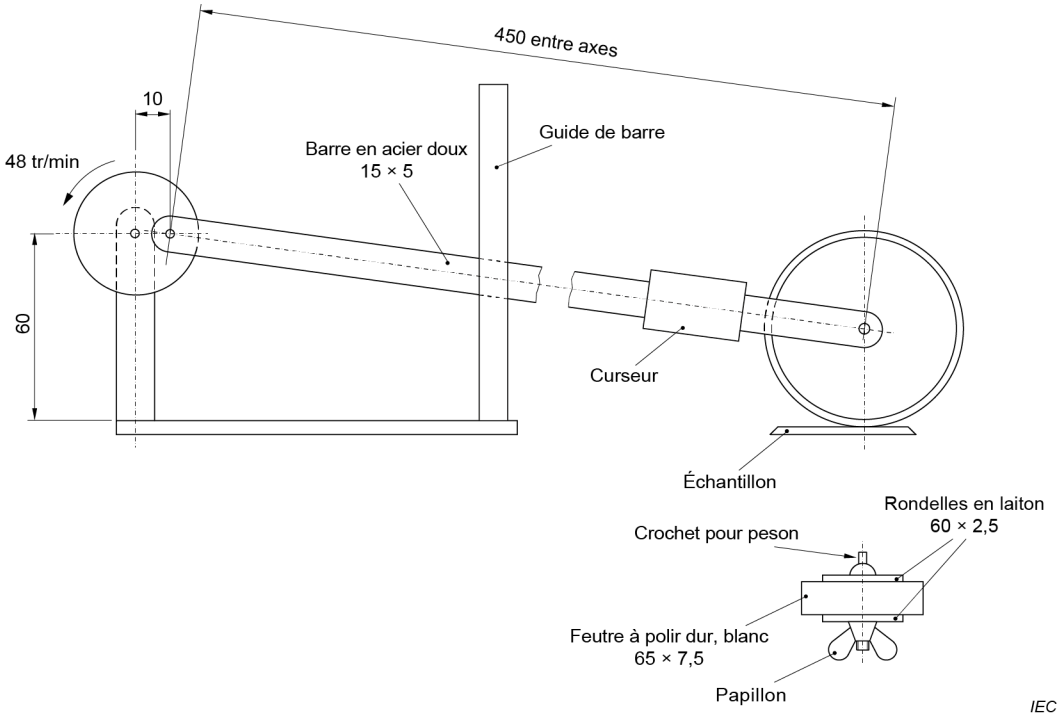


Figure 9 – Appareil pour vérifier l'indélébilité des marquages

Dimensions en millimètres

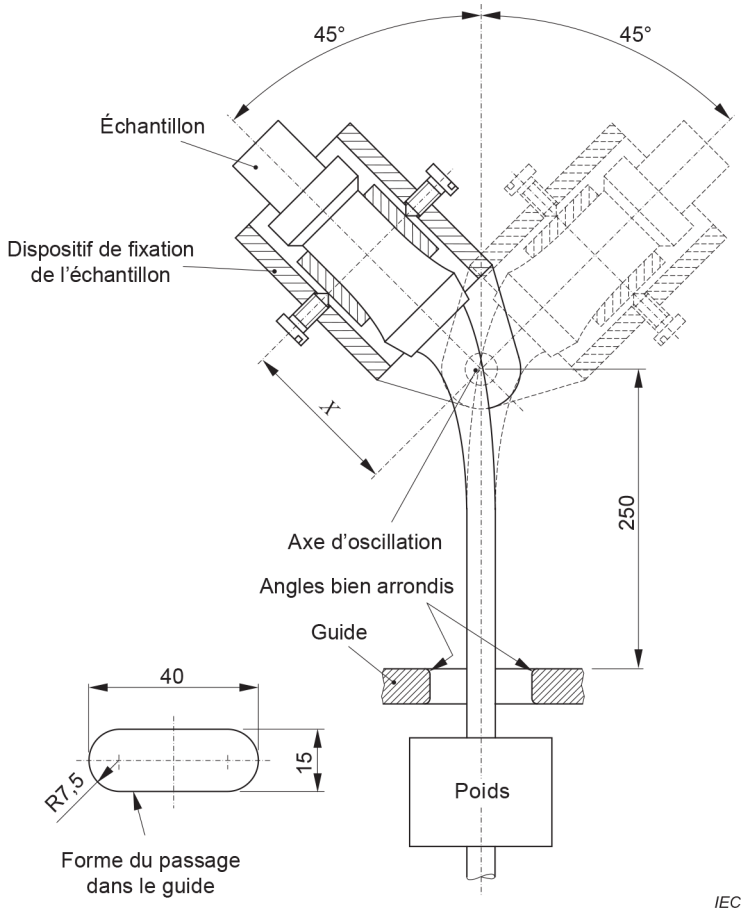
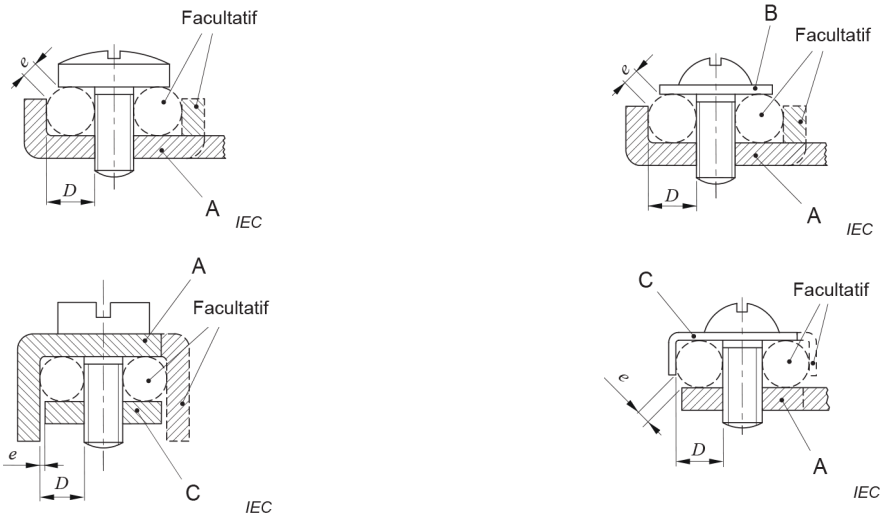


Figure 10 – Appareil d'essai de flexion

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Vis ne nécessitant pas de rondelle, de plaquette ou de dispositif empêchant le conducteur ou ses brins de s'échapper

Vis nécessitant une rondelle, une plaquette ou un dispositif empêchant le conducteur ou ses brins de s'échapper



Bornes à serrage sous tête de vis



Bornes à goujon fileté

A partie fixe

B rondelle ou plaquette

C dispositif empêchant le conducteur ou ses brins de s'échapper

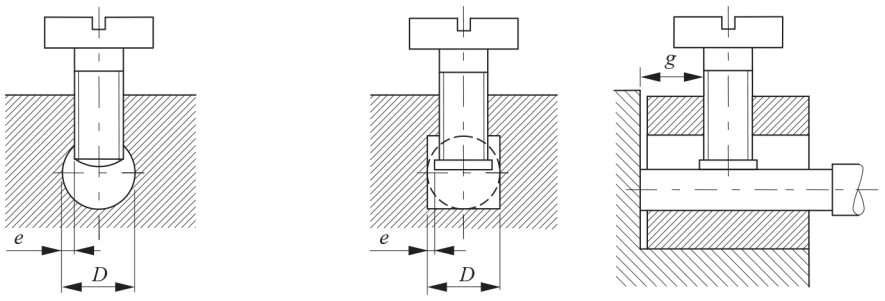
D logement du conducteur

E goujon

Courant circulant dans la borne [a]		**Diamètre minimal du logement du conducteur**	**Ecartement maximal entre pièces de maintien du conducteur**	**Couple minimal** Nm			
				Vis à fente		**Autres vis**	
Pour conducteur souple	**Pour conducteur fixe**			**Une vis**	**Deux vis**	**Une vis**	**Deux vis**
A	*A*	*D*	*e*	*g*	*g*		
0 à 6	0 à 6	1,4	1,0	0,4	–	0,4	–
6 à 10	0 à 6	1,7	1,0	0,5	–	0,5	–
10 à 16	6 à 10	2,0	1,5	0,8	–	0,8	–
16 à 25	10 à 16	2,7	1,5	1,2	0,5	1,2	0,5
25 à 32	16 à 25	3,6	1,5	2,0	1,2	2,0	1,2
–	25 à 32	4,3	2,0	2,0	1,2	2,0	1,2
32 à 40	32 à 40	5,5	2,0	2,0	1,2	2,0	1,2
40 à 63	40 à 63	7,0	2,0	2,0	2,0	3,0	2,0
La pièce qui retient le conducteur en place peut être en matériau isolant à condition de ne pas participer à la transmission de l'effort de serrage. Les dessins ne préjugent pas des détails non cotés.							
[a] Des exigences pour les applications supérieures à 63 A sont à l'étude.							

Figure 11 – Bornes à serrage sous tête de vis et bornes à goujon fileté

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Borne sans plaquette

Borne avec plaquette

IEC

Dimensions en millimètres

Courant circulant dans la borne [a]		Diamètre minimal du logement du conducteur	Ecartement maximal entre pièces de maintien du conducteur	Distance minimale entre la vis de serrage et l'extrémité du conducteur engagé à fond		Couple minimal Nm					
						Vis sans tête		Vis à fente		Autres vis	
Pour conducteur souple	Pour conducteur fixe			Une vis	Deux vis	Une vis	Deux vis	Une vis	Deux vis	Une vis	Deux vis
A	A	*D*	*e*	*g*	*g*						
0 à 10	0 à 6	2,5	0,5	1,5	1,5	0,2	0,2	0,4	0,4	0,4	0,4
10 à 16	6 à 10	3,0	0,5	1,5	1,5	0,25	0,2	0,5	0,4	0,5	0,4
16 à 25	10 à 16	3,6	0,5	1,8	1,5	0,4	0,2	0,8	0,4	0,8	0,4
25 à 32	16 à 25	4,0	0,6	1,8	1,5	0,4	0,25	0,8	0,5	0,8	0,5
-	25 à 32	4,5	1,0	2,0	1,5	0,7	0,25	1,2	0,5	1,2	0,5
32 à 40	32 à 40	5,5	1,3	2,5	2,0	0,8	0,7	2,0	1,2	2,0	1,2
40 à 63	40 à 63	7,0	1,5	3,0	2,0	1,2	0,7	2,5	1,2	3,0	1,2

La partie de la borne qui contient le trou taraudé et la partie contre laquelle le conducteur est serré par la pression de la vis peuvent être des parties distinctes, comme dans le cas d'une borne à étrier.

La forme du logement du conducteur n'est pas nécessairement celle des figures, à condition de pouvoir contenir un cercle inscrit d'un diamètre égal à la valeur minimale de D.

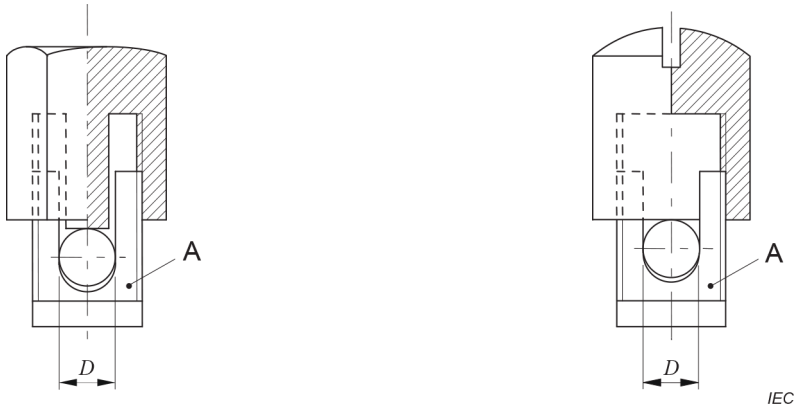
La distance minimale entre la vis et l'extrémité du conducteur engagé à fond ne s'applique que pour les bornes dont le logement de conducteur est borgne.

Les dessins ne préjugent pas des détails non cotés.

[a] Des exigences pour les applications supérieures à 63 A sont à l'étude.

Figure 12 – Bornes à trou

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A partie fixe

D logement du conducteur

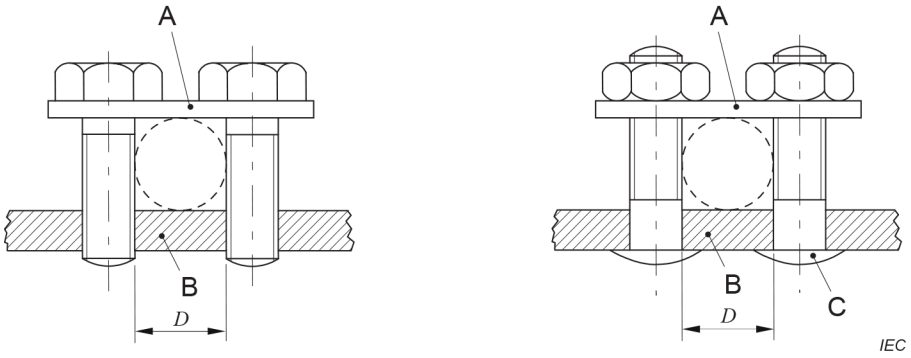
Le fond du logement du conducteur doit être légèrement arrondi, de façon à obtenir une connexion sûre.

Taille de la borne	Diamètre minimal du logement du conducteur[a] mm	Distance minimale entre la partie fixe et l'extrémité du conducteur engagé à fond mm
0	1,4	1,5
1	1,7	1,5
2	2,0	1,5
3	2,7	1,8
4	3,6	1,8
5	4,3	2,0
6	5,0	2,5
7	7,0	3,0
8	8,5	4,0
[a] La valeur du couple de torsion à appliquer est celle spécifiée dans le Tableau 9.		

Figure 13 – Bornes à capot taraudé

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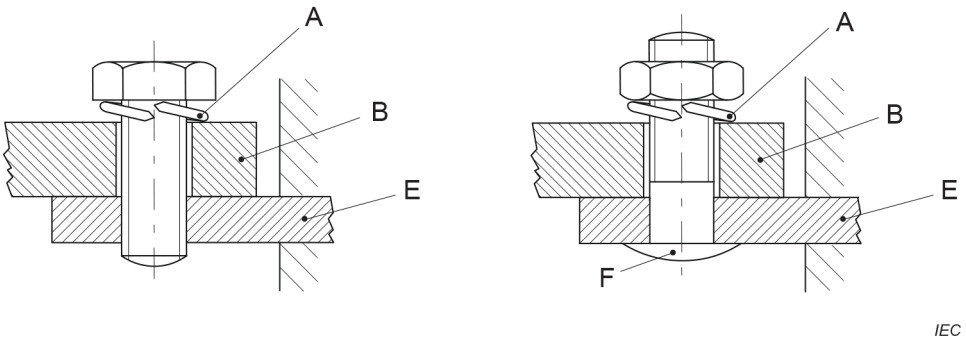
A plaquette

B partie fixe

C goujon

D logement du conducteur

a) Bornes à plaquette



A dispositif de blocage

B cosse ou barrette

E partie fixe

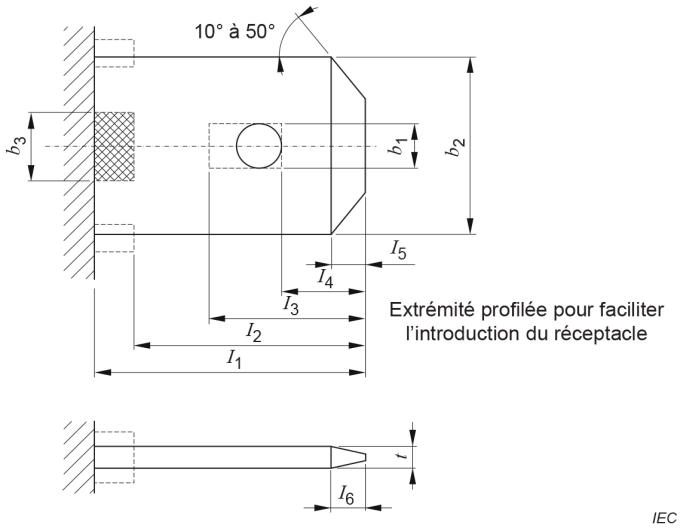
F goujon

b) Bornes pour cosses et barrettes

Figure 14 – Bornes pour plaquette et pour cosses et barrettes

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Dimensions en millimètres

Dimension pour les Figures 14 et 15 [a]	Taille de raccord			
	2,8	**4,8**	**6,3**	**9,5**
l_1 (min.) [b]	7,7	6,9	8,6	14,0
l_2 (min.) [b]	7,0	6,2	7,9	12,0
l_3 (max.) [c]	3,0	5,2	6,7	8,2
l_4	1,0 ± 0,2	2,5 ± 0,25	3,2 ± 0,3	4,2 ± 0,3
l_5 (max.)	0,7	1,2	1,3	1,7
l_6 (max.)	0,7	1,2	1,3	1,7
b_1 (fente) [a]	$1{,}2\,^{+0,1}_{0}$	$1{,}4\,^{+0,2}_{0}$	$1{,}6\,^{+2,0}_{0}$ [d]	$2{,}1\,^{+2,0}_{0}$ [d]
b_1 (fente) [a]	$1{,}2\,^{+0,1}_{0}$	$1{,}4\,^{+0,2}_{0}$	$1{,}6\,^{+0,1}_{0}$	$2{,}1\,^{+2,0}_{0}$
b_2	2,8 ± 0,1	4,75 ± 0,2	$6{,}3\,^{+0,15}_{-0,1}$	$9{,}5\,^{+0,15}_{-0,1}$
b_3 (min.) [e]	2,0	2,0	2,5	2,5
t [f]	0,5 ± 0,025	0,8 ± 0,03	0,8 ± 0,03	1,2 ± 0,03
p (max.) [g]	0,8	1,2	1,2	1,7
k	–	$0{,}7\,^{0}_{-0,1}$	$1{,}0\,^{0}_{-0,1}$	$1{,}5\,^{0}_{-0,1}$
x	–	1,0 ± 0,2	1,0 ± 0,2	1,4 ± 0,2

NOTE Les dessins ne préjugent pas des détails non cotés.

[a] Les **languettes** peuvent avoir en option un encliquetage pour le verrouillage. Les fossettes rondes, rectangulaires et les trous d'encliquetage doivent être situés dans la surface délimitée par les dimensions b_1, l_3 et l_4 sur la ligne médiane de la **languette**.

Les **languettes** peuvent être constituées de plus d'une couche de matériau, sous réserve que la **languette** en résultant soit conforme au présent document.

Les détails pour des **languettes** dotées de bossages ou de cavités sont à l'étude.

[b] Pour ménager une **distance dans l'air** suffisante pour les **réceptacles** destinés à être équipés d'un manchon, il peut être nécessaire d'augmenter cette dimension de 0,5 mm pour être sûr que le dispositif de réglage fonctionne correctement.

[c] La longueur de la fente (l_3-l_4) doit au moins être égale à sa largeur (b_1).

[d] Ces tolérances sont choisies pour permettre aux **languettes** d'être utilisées comme une partie d'une borne à serrage sous tête de vis.

[e] Sur la surface quadrillée, l'épaisseur ne doit pas être supérieure à la limite supérieure de l'épaisseur spécifiée pour le matériau.

[f] A l'exception d'un creux ou d'un trou et de la surface indiquée par la dimension "b", l'épaisseur "t" doit être maintenue sur toute la surface de connexion. La conformité doit être vérifiée par des mesures sur toute section de (3,2 ± 0,2) mm^2 dans une surface circulaire. De plus, la planéité totale doit avoir une tolérance de 0,03 mm.

[g] Cette dimension ne s'applique qu'au côté levé de la **languette**; de l'autre côté, la tolérance de planéité s'applique à toute la largeur de la **languette**.

Figure 15 – Languettes

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Pour les dimensions, voir Figure 14.

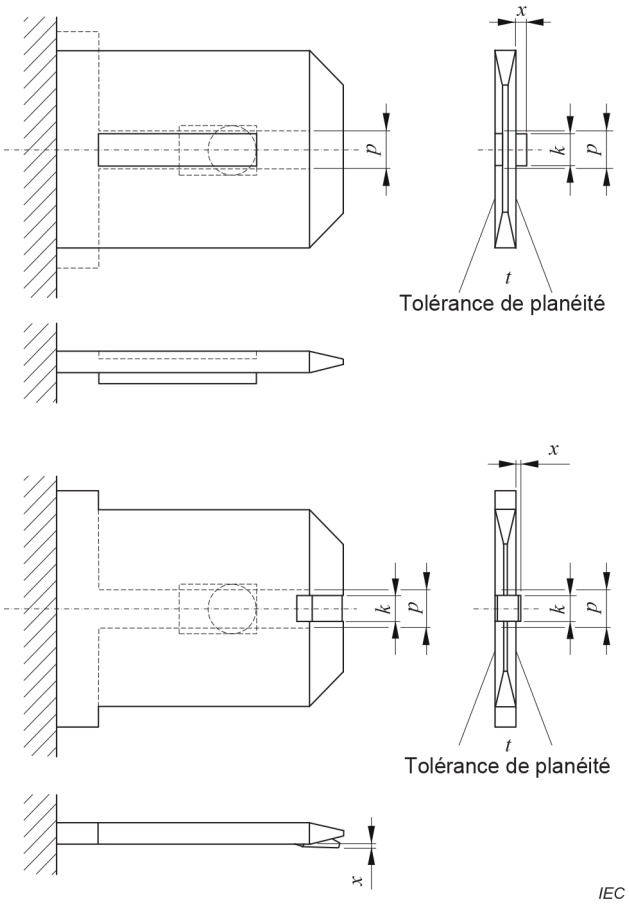
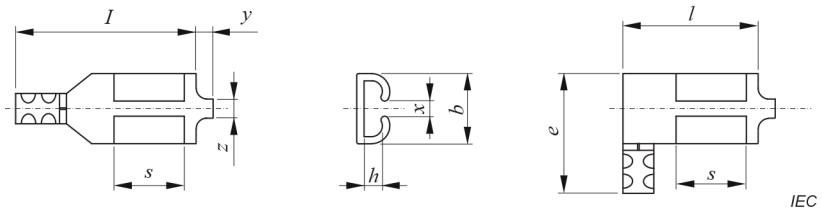


Figure 16 – Languettes pour des raccords non réversibles

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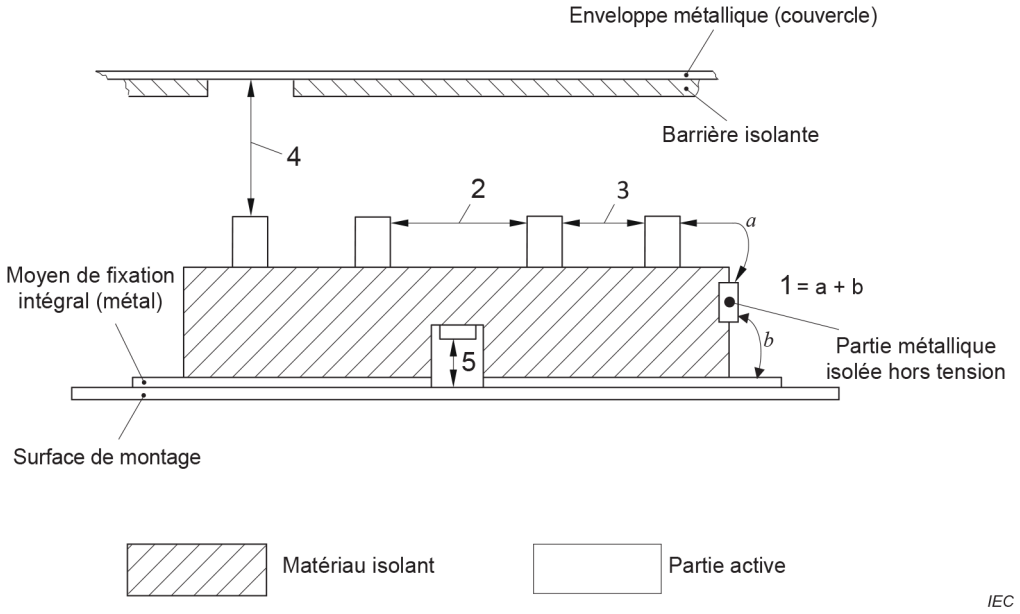


Dimensions en millimètres

Dimension	Taille de raccord			
	2,8	**4,8**	**6,3**	**9,5**
b (max.)	4	6	8	12,5
e (max.)	12	12	15	20
h (max.)[a]	1	2	2,5	3,2
l (max.)	18	18	22	27
s (min.)	4,5	5	6	10
x (min.)[b]	-	0,9	1,2	1,7
y (max.)	0,5	0,5	0,5	1,0
z (max.)	1,5	1,5	2,0	2,0
Les dimensions cotées s'entendent pour les connexions serties. Les dimensions pour les **réceptacles** équipés d'un manchon et pour les **réceptacles** ayant un fourreau préisolé sont à l'étude. Les dessins ne préjugent pas des détails non cotés.				
[a] Ecartement maximal par rapport à la ligne médiane de la lame de la **languette**. [b] Ne s'applique qu'aux **réceptacles** pour raccords non réversibles.				

Figure 17 – Réceptacles

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Légende

1 entre **parties actives** et autres parties métalliques (y compris les parties métalliques nues électriquement isolées)

2 entre **parties actives** devant être isolées les unes des autres (**isolation fonctionnelle**), à l'exception des contacts

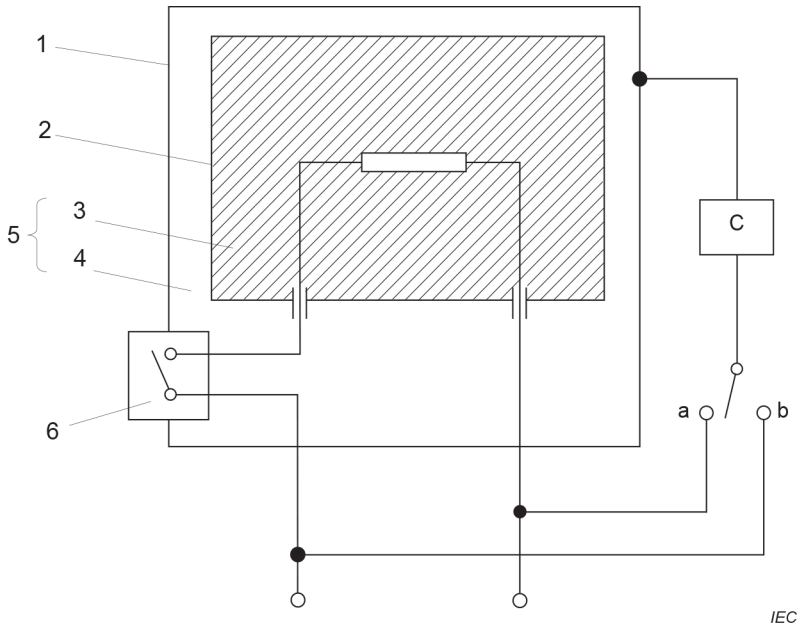
3 entre **parties actives** séparées par l'action du dispositif de commande lorsque l'interconnexion de celles-ci permet à un courant de traverser une charge, le courant étant ainsi limité par la charge:
– **coupure totale de circuit;**
– cette distance ne s'applique pas entre les bornes pour câblages fixes.

4 entre **parties actives** et enveloppe métallique des dispositifs de commande à boîtier fermé (ces distances ne s'appliquent pas au boîtier, au châssis ni aux moyens de fixation intégraux d'un dispositif de commande qui est destiné à être monté à l'intérieur d'une enveloppe du matériel commandé)

5 entre les **parties actives** en retrait des dispositifs de commande à montage indépendant et la surface de montage. Cette distance peut être réduite par l'adjonction de joints ou de cloisons appropriés.

Figure 18 – Mesure des lignes de fuite et des distances dans l'air

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Légende

C circuit de la Figure K.1

1 **partie accessible**

2 partie métallique inaccessible

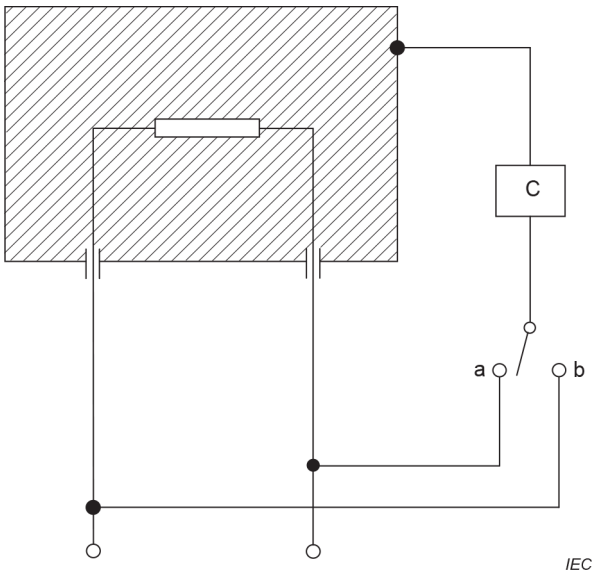
3 **isolation principale**

4 **isolation supplémentaire**

5 **double isolation**

6 **isolation renforcée**

Figure 19 – Schéma pour la mesure du courant de contact à la température de fonctionnement pour connexion monophasée des dispositifs de commande de la classe II

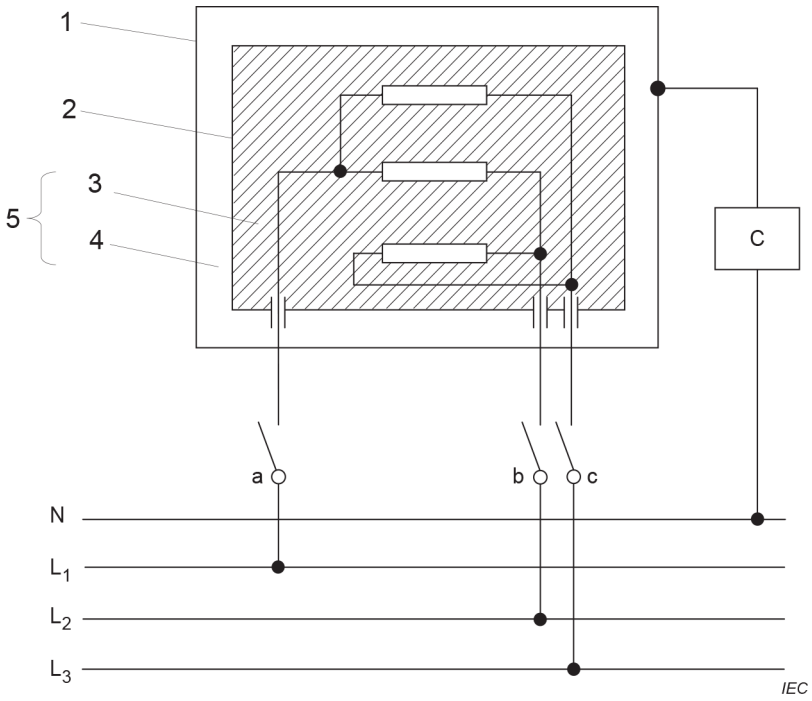


Légende

C circuit de la Figure K.1

Figure 20 – Schéma pour la mesure du courant de contact à la température de fonctionnement pour connexion monophasée des dispositifs de commande autres que ceux de la classe II

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Légende

C circuit de la Figure K.1

1 **partie accessible**

2 partie métallique inaccessible

3 **isolation principale**

4 **isolation supplémentaire**

5 **double isolation**

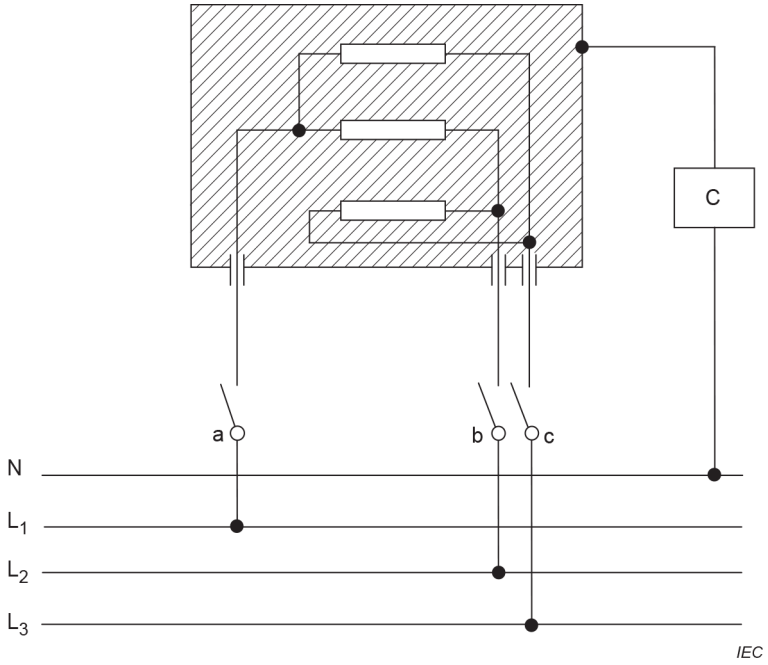
Connexions et alimentations

L_1, L_2, L_3, N tension d'alimentation avec neutre

Figure 21 – Schéma pour la mesure du courant de contact à la température de fonctionnement pour connexion triphasée des dispositifs de commande de la classe II

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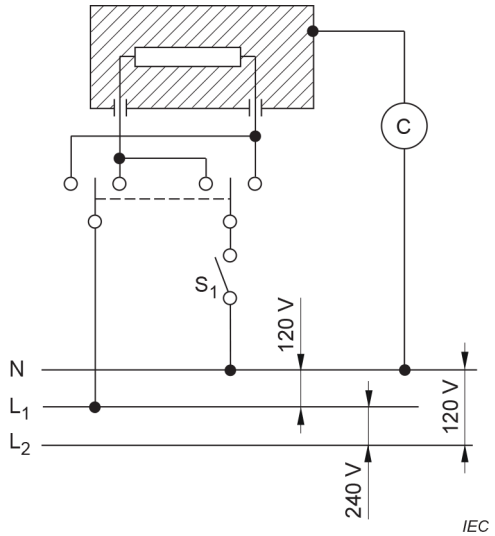
Légende

C circuit de la Figure K.1

Connexions et alimentations

L_1, L_2, L_3, N tension d'alimentation avec neutre

Figure 22 – Schéma pour la mesure du courant de contact à la température de fonctionnement pour connexion triphasée des dispositifs de commande autres que ceux de la classe II



Légende

C circuit de la Figure K.1

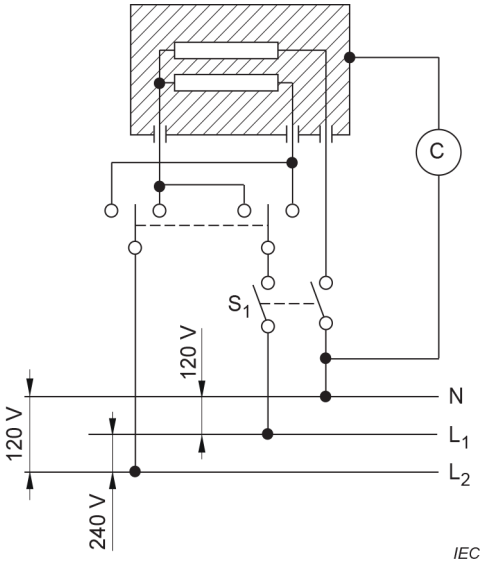
Connexions et alimentations

L_1, L_2, N tension d'alimentation avec neutre

Figure 23 – Schéma pour la mesure du courant de contact à la température de fonctionnement pour connexion monophasée des dispositifs de commande à un réseau à trois conducteurs avec neutre mis à la terre autres que ceux de la classe II

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Légende

C circuit de la Figure K.1

Connexions et alimentations

L_1, L_2, N tension d'alimentation avec neutre

Figure 24 – Schéma pour la mesure du courant de contact à la température de fonctionnement pour connexion diphasée des dispositifs de commande à un réseau à trois conducteurs avec neutre mis à la terre autres que ceux de la classe II

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Annexe A
(normative)

Indélébilité des marquages

A.1 Exigences relatives à l'indélébilité

A.1.1 Les marquages apposés sur les dispositifs de commande doivent être suffisamment indélébiles pour la sécurité et font donc l'objet d'un classement selon les exigences applicables de A.1.2 à A.1.5.

A.1.2 Marquages facultatifs dans le cadre des exigences du présent document.

A.1.3 Marquages obligatoires dans le cadre des exigences du présent document, mais inaccessibles à l'utilisateur final, après le montage ou l'intégration du dispositif de commande dans le matériel.

Il faut que ces marquages soient suffisamment indélébiles pour résister aux manipulations dans les ateliers du **fabricant de dispositifs de commande** après le contrôle final, à l'emballage, au transport vers les ateliers du **fabricant du matériel**, et aux manipulations en cours de montage ou d'intégration. Les marquages doivent en outre rester lisibles au cas où ils seraient exposés à des vapeurs de solvants ou autres produits agressifs.

A.1.4 Marquages obligatoires dans le cadre des exigences du présent document et accessibles à l'utilisateur final après le montage ou l'intégration du dispositif de commande dans le matériel comme en usage normal.

En plus d'une résistance aux manipulations et aux produits mentionnés en A.1.3, ces marquages nécessitent également de pouvoir rester lisibles malgré les manipulations et les frottements qui découlent de l'usage normal du matériel. Les indications portées sur les boutons, poignées et autres commandes doivent être particulièrement résistantes aux **manœuvres** manuelles continuelles de l'utilisateur. Il convient que les autres marquages résistent aux nettoyages, polissages, etc.

A.1.5 La conformité aux exigences d'indélébilité de A.1.3 et A.1.4 est vérifiée par l'application des essais de l'Article A.2 ou de l'Article A.3 à l'aide de l'appareil représenté à la Figure 9.

La partie principale de cet appareil est un disque de feutre à polir de qualité dure et de couleur blanche dont le diamètre est 65 mm et l'épaisseur 7,5 mm. Ce disque est immobilisé en rotation et frotte sur la surface à soumettre à essai avec une force mesurable, sur une course de 20 mm. L'essai normal doit consister en 12 allers et retours (c'est-à-dire 12 tours de l'excentrique) effectués en 15 s environ.

Pendant l'essai, la surface portante du disque de feutre est recouverte d'un tissu absorbant blanc, côté pelucheux à l'extérieur.

Les solvants utilisés sont

– un détergent liquide neutre obtenu par mélange d'un alkyl sulfonate de benzène et de détergents non ioniques ou une solution à 2 % de solvant dans de l'eau désionisée (distillée) où le solvant se compose
  - de 70 % (en volume) de dodécylbenzylsulfonate de sodium (Isomère), formule: C18H29NaO3S, CAS-No. 25155-30-0, et
  - de 30 % (en volume) de glycérine (autres appellations: glycérol, 1,2,3-Propantriol, Propantriol, E 422), formule: C3H8O3, CAS-No. 56-81-5;
– du n-hexane (solvant d'hexane aliphatique ayant une teneur maximale en aromates de 0,1 % en volume, un point d'ébullition initial d'environ 69 °C et une masse volumique spécifique d'environ 0,66 g/cm^3, CAS-No. 110-54-3), et
– de l'eau désionisée (distillée).

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A.2 Mode opératoire d'essai pour les marquages entrant dans la classe de A.1.3

A.2.1 *Les marquages à l'étude doivent résister pendant 4 h à l'action de gouttes de détergent déposées sur la surface marquée. A la fin de cette période, les "auréoles" de détergent doivent être enlevées avec de l'eau chaude à (40 ± 5) °C finement pulvérisée ou en frottant avec un chiffon humide.*

A.2.2 *L'échantillon doit pouvoir sécher complètement à la température ambiante de (25 ± 5) °C.*

A.2.3 *L'échantillon ainsi traité doit ensuite être soumis à un essai de frottement exécuté avec l'appareil de la Figure 9, en utilisant un tissu sec et un poids de 250 g mesuré comme indiqué.*

A.2.4 *L'échantillon doit ensuite être soumis à un essai de frottement avec un tissu imbibé d'eau et un poids de 250 g.*

A.2.5 *Si la forme ou la position du marquage ne permet pas d'employer l'appareil pour blanchir ou frotter (par exemple, s'il se trouve sur une surface en creux), les essais de A.2.3 et A.2.4 ne sont pas effectués.*

A.2.6 *Après ces traitements, le marquage doit rester lisible.*

A.3 Mode opératoire d'essai pour les marquages entrant dans la classe de A.1.4

A.3.1 *Le marquage doit être soumis à un essai de frottement à sec exécuté avec l'appareil de la Figure 9, en utilisant un tissu sec et un poids de 750 g.*

A.3.2 *Le marquage doit ensuite être soumis à un essai de frottement avec un tissu imbibé d'eau et un poids de 750 g.*

A.3.3 *Le marquage doit ensuite résister pendant 4 h à l'action de gouttes de détergent déposées sur la surface marquée. A la fin de cette période, les "auréoles" de détergent doivent être enlevées avec de l'eau chaude à (40 ± 5) °C finement pulvérisée ou en frottant avec un chiffon humide.*

A.3.4 *Après un séchage complet de la surface ainsi traitée, la marque doit être soumise à un essai de frottement avec un tissu imbibé de détergent, l'appareil étant chargé à 750 g.*

A.3.5 *Après élimination du détergent, l'essai de frottement doit être répété avec un tissu imbibé d'essence minérale, l'appareil étant chargé à 750 g.*

A.3.6 *Pour les essais de A.3.1 à A.3.5, l'épaisseur du disque de feutre peut être réduite progressivement pour mieux atteindre le marquage à contrôler. Cependant, l'épaisseur minimale de feutre ne doit pas être inférieure à 2,5 mm. Si l'épaisseur du disque de polissage est réduite, le poids de 750 g doit être réduit proportionnellement.*

A.3.7 *Après ces traitements, le marquage doit rester lisible.*

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Annexe B
(normative)

Mesure des lignes de fuite et des distances dans l'air

*Lors de la détermination et de la mesure des **lignes de fuite** et des **distances dans l'air**, les hypothèses suivantes sont formulées, D étant la **distance dans l'air** pour les dimensions à l'étude (voir de la Figure B.1 à la Figure B.11 pour des exemples de méthode de mesure de la **ligne de fuite** et des **distances dans l'air**):*

- *une encoche peut avoir des flancs parallèles, convergents ou divergents;*
- *une encoche à flancs divergents est considérée comme un intervalle dans l'air si sa largeur minimale est supérieure à $D/12$, si sa profondeur dépasse $D/2$ et si sa largeur au fond est au moins $D/3$ (voir Figure B.8) mais en aucun cas inférieure à la valeur minimale de X comme permis dans le tableau ci-dessous;*
- *tout coin dont l'angle d'ouverture est inférieur à 80° est considéré comme mis en dérivation par un tronçon isolant de la plus faible des deux longueurs suivantes: $D/3$ ou 1 mm, placé dans la position la plus défavorable (voir Figure B.3);*
- *si la distance en haut de l'encoche est supérieure à la plus petite des deux valeurs suivantes: $D/3$ ou 1 mm, la **ligne de fuite** longe le profil de l'encoche, sauf spécification contraire ci-dessus (voir Figure B.2);*
- *pour des parties mobiles l'une par rapport à l'autre, les **lignes de fuite** et les **distances dans l'air** sont mesurées dans la position la plus défavorable;*
- *une **ligne de fuite** évaluée conformément aux présentes règles ne peut être inférieure à la **distance dans l'air** correspondante (mesurée);*
- *une distance inférieure à $D/3$ ou 1 mm suivant la valeur la plus faible n'est pas prise en compte pour l'évaluation de la **distance dans l'air** totale;*
- *lorsque des obstacles isolants sont rapportés, les **lignes de fuite** sont mesurées à travers les joints, sauf si les pièces en présence sont collées ou soudées de façon à assurer l'étanchéité des joints à l'humidité et aux poussières.*

Dans les exemples représentés de la Figure B.1 à la Figure B.11, l'identification suivante est utilisée:

— — — — — — Distance dans l'air Ligne de fuite

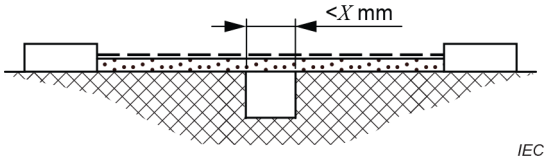
Voir Tableau B.1, pour les valeurs de X.

Tableau B.1 – Valeurs de X

Degré de pollution	Largeur X des encoches: valeurs minimales mm
1	0,25
2	1,0
3	1,5
4	2,5

*Si la **distance dans l'air** associée est inférieure à 3 mm, la largeur minimale de l'encoche peut être réduite au tiers de cette **distance dans l'air**.*

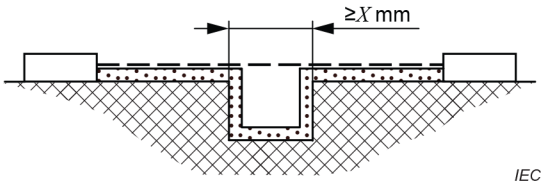
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Le chemin de ligne de fuite à l'étude comporte une encoche de profondeur quelconque et de largeur inférieure à X.

Règle: le chemin de la **distance dans l'air** est le chemin de la distance en ligne droite.

Figure B.1 – Encoche étroite

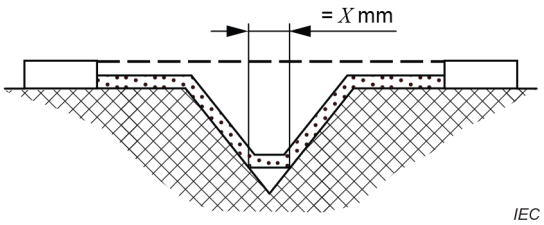


Ce chemin de ligne de fuite comporte une encoche de profondeur quelconque et de largeur supérieure ou égale à X.

Règle: le chemin de la **distance dans l'air** est le chemin de la distance en ligne droite.

Le chemin de la **ligne de fuite** longe le profil de l'encoche.

Figure B.2 – Encoche large

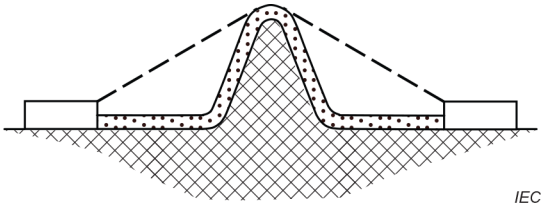


Ce chemin de ligne de fuite comporte une encoche en V dont la largeur est supérieure ou égale à X.

Règle: le chemin de la **distance dans l'air** est le chemin de la distance en ligne droite.

Le chemin de la **ligne de fuite** longe le profil de l'encoche mais "court-circuite" l'encoche au point où sa largeur devient égale à X.

Figure B.3 – Encoche en V



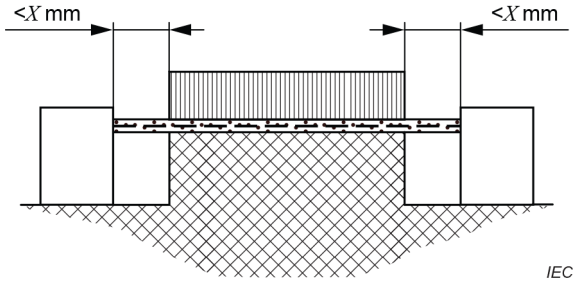
Ce chemin de ligne de fuite comporte une nervure.

Règle: la **distance dans l'air** est le chemin dans l'air le plus court par-dessus le sommet de la nervure.

Le chemin de la **ligne de fuite** longe le profil de la nervure.

Figure B.4 – Nervure

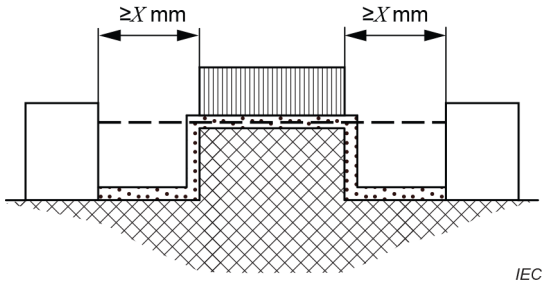
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Ce chemin de ligne de fuite comporte une partie non collée avec des encoches de largeur inférieure à X de chaque côté.

Règle: Le chemin de la **ligne de fuite** et de la **distance dans l'air** est la distance en ligne droite comme représenté.

Figure B.5 – Partie non collée avec encoche étroite

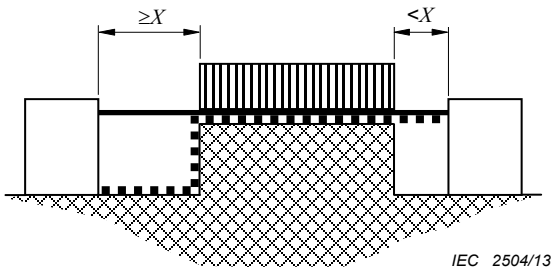


Ce chemin de ligne de fuite comporte une partie non collée avec des encoches de largeur supérieure ou égale à X.

Règle: le chemin de la **distance dans l'air** est la distance en ligne droite comme représenté.

Le chemin de la **ligne de fuite** longe le profil des encoches.

Figure B.6 – Partie non collée avec encoche large

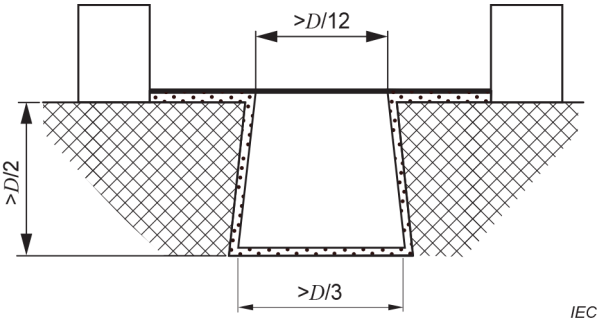


Ce chemin de ligne de fuite comporte une partie non collée avec une encoche de largeur inférieure à X d'un côté et une encoche de largeur supérieure ou égale à X de l'autre côté.

Règle: le chemin de la **distance dans l'air** et de la **ligne de fuite** est comme représenté.

Figure B.7 – Partie non collée avec encoche étroite et encoche large

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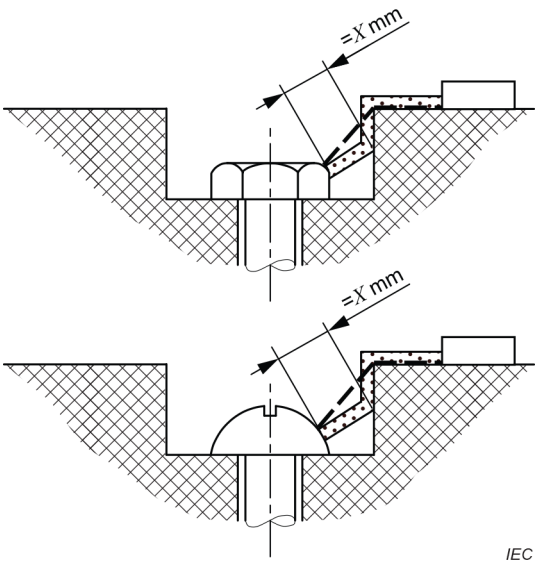
Ce chemin de ligne de fuite comporte une encoche à flancs divergents, dont la profondeur est supérieure ou égale à $D/2$ et dont la largeur est supérieure ou égale à $D/12$ pour la partie la plus étroite, et supérieure ou égale à $D/3$ à la base.

Règle: le chemin de la **distance dans l'air** est la distance en ligne droite.

Le chemin de la **ligne de fuite** longe le profil de l'encoche.

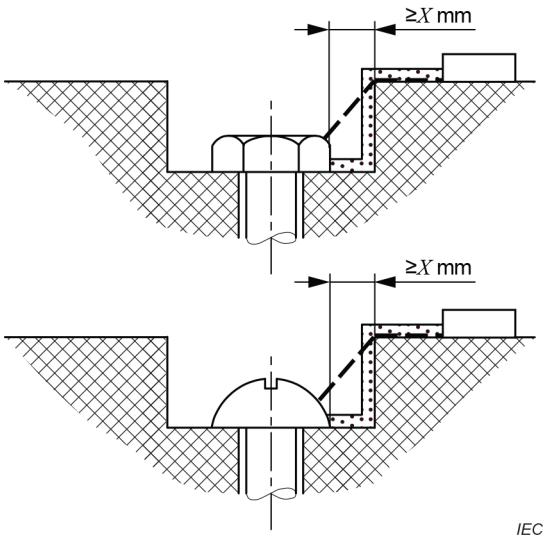
La règle de la Figure B.3 s'applique également aux coins internes si leurs angles sont inférieurs à 80°.

Figure B.8 – Flancs divergents



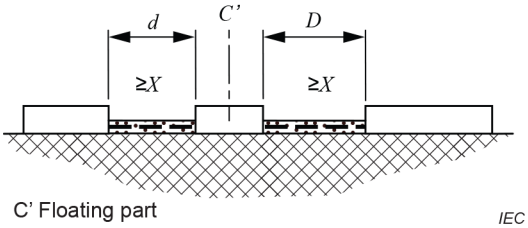
Distance entre tête de vis et paroi de logement trop faible pour être comptée pour le chemin de la ligne de fuite.

Figure B.9 – Logement étroit



Distance entre tête de vis et paroi de logement suffisante pour être comptée pour le chemin de la ligne de fuite.

Figure B.10 – Logement large



La **distance dans l'air** est la distance $d + D$

La **ligne de fuite** est aussi $d + D$

Figure B.11 – Partie flottante conductrice

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Annexe C
(informative)

Tensions nominales des systèmes d'alimentation pour différents modes de dispositifs de commande de surtension

Les tensions nominales des **systèmes** d'alimentation pour différents modes de dispositifs de commande de surtension sont indiquées dans le Tableau C.1 et le Tableau C.2.

La coordination de l'isolement relative aux surtensions transitoires est fondée sur des situations de maîtrise des surtensions. Il y a deux sortes de situations:

– situation naturelle: situation d'un **système** (réseau) électrique où du fait des caractéristiques mêmes du **système** (réseau) il peut être attendu que les surtensions transitoires présumées soient inférieures à un niveau défini;

– situation contrôlée: situation d'un **système** (réseau) électrique où du fait des moyens spécifiques de réduction des surtensions il peut être attendu que les surtensions transitoires présumées soient inférieures à un niveau défini.

NOTE L'alinéa ci-dessus est tiré de l'IEC 60664-1:2007, 4.2.3.

Tableau C.1 – Situation naturelle ou situation contrôlée équivalente

Tension phase-neutre selon les tensions nominales AC ou DC[a]	**Tensions nominales actuellement utilisées dans le monde**				**Tension assignée de choc pour les matériels** [a] V **Catégorie de surtension**			
	Système triphasé à quatre fils avec neutre à la terre	**Système triphasé à trois fils non mis à la terre**	**Système monophasé à deux fils AC ou DC**	**Système monophasé à trois fils AC ou DC**				
V	V	V	V	V	**I**	**II**	**III**	**IV**
50			12,5; 24; 25; 30; 42; 48	30 / 60	330	500	800	1 500
100	66 / 115	66	60		500	800	1 500	2 500
150	120 / 208[b] 127 / 220	115; 120; 127	110; 120	110 / 220 120 / 240 [c]	800	1 500	2 500	4 000
300	220 / 380 230 / 400 240 / 415 260 / 440 277 / 480	220; 230; 240; 260; 277; 347; 380; 400; 415; 440; 480	220	220 / 440	1 500	2 500	4 000	6 000
600	347 / 600 380 / 660 400 / 690 417 / 720 480 / 830	500; 577; 600	480	480 / 960	2 500	4 000	6 000	8 000
1 000		660; 690; 720; 830; 1 000	1 000		4 000	6 000	8 000	12 000

[a] Ces colonnes proviennent de l'IEC 60664-1:2007, Annexe F, Tableau F.1, dans laquelle les valeurs de la **tension assignée de choc** sont spécifiées.

[b] Pratiqué aux Etats-Unis et au Canada.

[c] Pour 120/240 V au Japon, les séries préférentielles de **tensions assignées de choc** de 1 500 V, 2 500 V, 4 000 V et 6 000 V sont utilisées avec les **catégories de surtensions** I, II, III et IV correspondantes.

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Tableau C.2 – Cas où un dispositif de commande de protection est nécessaire et la commande est fournie par des parafoudres ayant un rapport tension de calage-tension assignée non inférieur à celui spécifié par l'IEC 60099-1

Tension phase-neutre selon les tensions nominales AC ou DC[a]	Tensions nominales actuellement utilisées dans le monde				Tension assignée de choc pour les matériels [a]			
	Système triphasé à quatre fils avec neutre à la terre	Système triphasé à trois fils non mis à la terre	Système monophasé à deux fils AC ou DC	Système monophasé à trois fils AC ou DC	V			
					Catégorie de surtension			
V	V	V	V	V	I	II	III	IV
50			12,5; 24; 25; 30; 42; 48	30 / 60	330	500	800	1 500
100	66 / 115	66	60		500	800	1 500	2 500
150	120 / 208[b] 127 / 220	115; 120; 127	110; 120	110 / 220 120 / 240	800	1 500	2 500	4 000
300	220 / 380 230 / 400 240 / 415 260 / 440 277 / 480	220; 230; 240; 260; 277	220	220 / 440	1 500	2 500	4 000	6 000
600	347 / 600 380 / 660 400 / 690 417 / 720 480 / 830	347; 380; 400; 415; 440; 480; 500; 577; 600	480	480 / 960	2 500	4 000	6 000	8 000
1 000		660; 690; 720; 830; 1 000	1 000		4 000	6 000	8 000	12 000

[a] Ces colonnes proviennent de l'IEC 60664-1:2007, Annexe F, Tableau F.1, dans laquelle les valeurs de la **tension assignée de choc** sont spécifiées.

[b] Pratiqué aux Etats-Unis et au Canada.

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Annexe D
(normative)

Catégories de surtension

La **catégorie de surtension** est un chiffre caractérisant une condition de **surtension transitoire**.

Les informations suivantes sur les **catégories de surtension** reposent sur l'IEC 60664-1. La série IEC TR 60664-2 peut spécifier une **catégorie de surtension** différente pour des applications particulières.

Le matériel de la **catégorie de surtension** IV est prévu pour une utilisation à l'origine de l'installation.

NOTE 1 Des exemples de tels matériels sont les compteurs électriques et les matériels primaires de protection contre les surintensités.

Le matériel de la **catégorie de surtension** III est un matériel pour installations fixes et pour les cas où la fiabilité et la disponibilité du matériel sont soumises à des exigences particulières.

NOTE 2 Cette catégorie s'applique normalement aux **dispositifs de commande** prévus pour l'interconnexion au **câblage fixe** ou pour incorporation dans le matériel prévu pour une connexion permanente au **câblage fixe**. A moins que le **dispositif de commande** ou l'application du matériel fournisse des moyens de suppression de la tension transitoire, à des fins de coordination de l'isolation, la tension de choc attendue est basée sur la tension de calage du suppresseur de tension de choc.

Le matériel de la **catégorie de surtension** II est un matériel consommateur d'énergie à alimenter depuis l'installation fixe.

NOTE 3 Cette catégorie s'applique normalement aux **dispositifs de commande** ne comportant pas de bornes pour **câblage fixe** ou connectés en aval d'un socle de prise de courant ou pour incorporation dans un matériel connecté en aval d'un socle de prise de courant. Les **dispositifs de commande** prévus pour la connexion permanente au **câblage fixe** sont considérés comme appartenant à la catégorie de surtension III; cependant, lorsque les méthodes de suppression de la tension transitoire, telles que des moyens limiteurs de tension en bout de ligne ou les **distances dans l'air** entre parties conductrices, sont incorporées dans le **dispositif de commande** ou le matériel, à des fins de coordination de l'isolation, la tension de choc attendue est basée sur la tension de calage du suppresseur de tension de choc. Si les contacts des **dispositifs de commande** sont conçus pour permettre le contournement de la tension transitoire et sont aptes à résister au courant coupé limité, ils peuvent fournir une suppression adéquate. Ce sont, par exemple, des **dispositifs de commande** pour appareils domestiques satisfaisant aux descriptions ci-dessus.

Si un tel matériel est soumis à des exigences particulières au regard de la fiabilité et de la disponibilité, la **catégorie de surtension** III s'applique.

Le matériel de la **catégorie de surtension** I est un matériel pour connexion aux circuits dans lesquels sont prises des mesures pour limiter les **surtensions transitoires** à un niveau faible approprié.

NOTE 4 Cette catégorie s'applique normalement aux **dispositifs de commande** connectés après des matériels de catégorie II et qui, par exemple, comprennent des **systèmes** électroniques logiques, des **circuits secondaires limités isolés**, des circuits **TBTS** ou des circuits **TBTP**, et des circuits sur la partie secondaire des transformateurs.

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Annexe E
(informative)

Utilisation type des dispositifs de commande et des catégories de surtension associées

Tableau E.1 – Utilisations types

Situation du dispositif de commande	Catégorie de surtension			
	I	II	III	IV
Spécial				
Circuit secondaire limité isolé	X			
Alimentation limitée en transitoires	X	X	X	X
Matériel d'utilisation consommateur d'énergie				
Dispositifs de commande incorporés et intégrés dans des appareils domestiques		X		
Dispositifs de commande à montage indépendant câblés à poste fixe sur des charges consommatrices d'énergie		X	X	
Autres utilisations domestiques et analogues:				
Dispositifs de commande non intégrés, non incorporés ou non câblés à poste fixe sur des charges consommatrices d'énergie			X	
Dispositifs de commande utilisés à l'origine de l'installation (c'est-à-dire compteurs d'énergie et matériel de protection primaire contre les surintensités, matériel situé avant le tableau d'abonné)				X
Dispositifs de commande couverts par les considérations spéciales d'une Partie 2	X	X	X	X

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Annexe F
(normative)

Degrés de pollution

F.1 Pollution

Le **microenvironnement** détermine les effets de la **pollution** sur l'isolation. Le **macroenvironnement**, cependant, doit être prendre en compte quand le **microenvironnement** est à l'étude.

Des moyens peuvent être fournis pour réduire la **pollution** sur l'isolation à l'étude par l'usage efficace de revêtements, d'enveloppes, d'encapsulation ou de scellement hermétique. De tels moyens pour réduire la **pollution** ne sont pas efficaces si le matériel est soumis à de la condensation ou si, en fonctionnement normal, il génère lui-même des polluants.

De petites **distances dans l'air** peuvent être pontées complètement par des particules solides, de la poussière et de l'eau et, en conséquence, des **distances dans l'air** minimales sont spécifiées si de la **pollution** peut être présente dans le **microenvironnement**.

NOTE 1 La **pollution** devient conductrice en présence d'humidité. La **pollution** causée par de l'eau contaminée, de la suie, des poussières métalliques ou de charbon est naturellement conductrice.

NOTE 2 La **pollution** conductrice par gaz ionisés et dépôts métalliques se produit uniquement dans des emplacements spécifiques, par exemple dans les chambres à arc des disjoncteurs, et n'est pas couverte par le présent document.

F.2 Degrés de pollution dans le microenvironnement

Dans le but d'évaluer les **lignes de fuite** et **distances dans l'air**, les quatre degrés de **pollution** suivants ont été établis pour le **microenvironnement**:

– **Degré de pollution** 1

  Pas de **pollution** ou seule une pollution sèche non conductrice se produit. La **pollution** n'a pas d'influence.

NOTE 1 Des considérations spéciales (par exemple revêtement évalué selon l'Annexe L ou l'Annexe M, enveloppe scellée) sont nécessaires pour établir le **degré de pollution** 1.

– **Degré de pollution** 2

  Seule une **pollution** non conductrice se produit, excepté qu'occasionnellement, une conductivité temporaire causée par de la condensation peut être attendue.

NOTE 2 Le **degré de pollution** 2 est représentatif de la circulation normale de l'air en usage domestique.

NOTE 3 La **pollution** par le fonctionnement des contacts est classée comme **degré de pollution** 2 sauf si la zone est affectée par une autre **pollution**, auquel cas le **degré de pollution** correspondant à l'autre **pollution** s'applique.

– **Degré de pollution** 3

  La **pollution** conductrice ou de la **pollution** sèche non conductrice se produit et devient conductrice à cause de la condensation attendue.

– **Degré de pollution** 4

  La **pollution** génère une conductivité persistante causée par de la poussière conductrice, de la pluie ou de la neige.

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Annexe G
(normative)

Essais de résistance à la chaleur, au feu et aux courants de cheminement

G.1 Essai au fil incandescent

L'essai au fil incandescent est effectué conformément à l'IEC 60695-2-10 et à l'IEC 60695-2-11.

*L'essai au fil incandescent doit être effectué sur un **dispositif de commande** complet. Si cela n'est pas possible, sur des parties qui ont été retirées du **dispositif de commande**. Si cela n'est pas possible, sur des plaques d'essai d'épaisseur similaire mais qui ne sont pas plus épaisses que la partie.*

G.2 Essai de résistance et de tenue au cheminement

L'essai de résistance et de tenue au cheminement est effectué conformément à l'IEC 60112:2020.

Pour les besoins du présent document, ce qui suit s'applique:

– *dans l'IEC 60112:2020, Article 5, Eprouvette, la Note 3 s'applique aussi aux essais de résistance et de tenue au cheminement de l'Article 10 de l'IEC 60112:2020;*

– *dans l'IEC 60112:2020, Article 7, Appareillage d'essai, la Note 1 en 7.1 ne s'applique pas. La solution d'essai A décrite dans l'IEC 60112:2020, 7.3, est utilisée;*

– *dans l'IEC 60112:2020, 8.2, Préparation, la tension indiquée dans la dernière phrase est définie en 21.2.9 du présent document. L'essai de résistance et de tenue au cheminement de l'IEC 60112:2020, Article 10, est réalisé, cinq fois.*

G.3 Essai à la bille

G.3.1 Essais à la bille

L'essai à la bille est effectué selon l'IEC 60695-10-2.

G.3.2 Essai à la bille 1

Pour les besoins du présent document, la température dans le four chauffant est la plus grande des valeurs suivantes:

– *20 °C ± 2 K au-dessus de la température maximale mesurée pendant les essais de l'Article 16;*

– *75 °C ± 2 °C;*

– *selon déclaration.*

NOTE 1 Pour les **dispositifs de commande** destinés à être incorporés dans des appareils relevant du domaine d'application de l'IEC 60335-1:2020, la température peut différer selon 30.1 de la norme citée.

Le support et la bille doivent être à la température d'essai spécifiée avant le début de l'essai.

NOTE 2 Cet essai n'est pas effectué sur les parties en matière céramique ou en verre.

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G.3.3 Essai à la bille 2

L'essai à la bille est effectué comme décrit en G.3.2, excepté que la température dans le four chauffant doit être de T_b ± 2 °C, T_b étant égal à la plus grande des valeurs suivantes:

– *100 °C lorsque T_{max} est de 30 °C jusqu'à 55 °C non compris;*

– *125 °C lorsque T_{max} est de 55 °C jusqu'à 85 °C non compris;*

– *T_{max} + 40 °C if T_{max} est de 85 °C ou plus;*

– *20 K au-dessus de la température maximale enregistrée pendant l'essai d'échauffement de l'Article 16;*

– *la température obtenue pendant l'essai de 13.1.3.8 si elle est supérieure aux valeurs indiquées dans les quatre tirets précédents.*

NOTE Pour les **dispositifs de commande** destinés à être incorporés dans des appareils relevant du domaine d'application de l'IEC 60335-1:2020, la température peut différer selon 30.1 de la norme citée.

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Annexe H
(normative)

Exigences relatives à la sécurité fonctionnelle

L'Annexe H complète ou modifie les articles correspondants du présent document. Toutefois, cela ne s'applique pas à l'Article H.5 et à H.25.4 à H.25.10.

H.3 Termes et définitions

Ajouter les définitions suivantes:

H.3.16 Définitions relatives à la structure des dispositifs de commande utilisant des logiciels

H.3.16.1
deux voies
structure comportant deux moyens fonctionnels mutuellement indépendants pour exécuter des **manœuvres** spécifiées

Note 1 à l'article: Pour les dispositifs de commande ayant une erreur/**panne de mode commun**, une disposition spéciale peut être prise. Il n'est pas exigé que les deux voies soient chacune de nature algorithmique ou logique.

H.3.16.2
deux voies (différentes) avec comparaison
structure **deux voies** comportant deux moyens fonctionnels différents et mutuellement indépendants, chacun capable de fournir une réponse déclarée, et où est effectuée une comparaison des signaux de sortie pour une reconnaissance **panne**/erreur

H.3.16.3
deux voies (homogènes) avec comparaison
structure **deux voies** comportant deux moyens fonctionnels identiques et mutuellement indépendants, chacun capable de fournir une réponse déclarée, et où est effectuée une comparaison des signaux internes ou des signaux de sortie pour une reconnaissance **panne**/erreur

H.3.16.4
simple voie
structure dans laquelle un seul moyen fonctionnel est utilisé pour exécuter des **manœuvres** spécifiées

H.3.16.5
simple voie avec essai fonctionnel
structure **simple voie** dans laquelle une donnée d'essai est introduite dans l'unité fonctionnelle avant son **fonctionnement**

H.3.16.6
simple voie avec autotest périodique
structure **simple voie** dans laquelle les composants du **dispositif de commande** sont périodiquement soumis à essai au cours du **fonctionnement**

H.3.16.7
simple voie avec autotest périodique et contrôle
structure simple voie avec autotest périodique dans laquelle des moyens indépendants, capables chacun de fournir une réponse déclarée, contrôlent des aspects tels que les temporisations de sécurité, les séquences et le fonctionnement de logiciels

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H.3.17 Définitions relatives à l'absence d'erreur pour les dispositifs de commande utilisant des logiciels

H.3.17.1
analyse dynamique
méthode d'analyse dans laquelle les entrées d'un **dispositif de commande** sont simulées et les signaux logiques aux nœuds d'un circuit sont examinés pour s'assurer de leur valeur correcte et de la chronologie

H.3.17.2
calcul du taux de défaillance
calcul du nombre théorique de **défaillances** d'une catégorie donnée par unité

Note 1 à l'article: Par exemple, **défaillances** par heure ou par cycle de **fonctionnement**.

H.3.17.3
analyse du matériel
procédé d'évaluation dans lequel sont examinés le fonctionnement correct, selon les tolérances spécifiées et les caractéristiques assignées, du circuit et des composants, d'un **dispositif de commande**

H.3.17.4
simulation de matériel
méthode d'analyse dans laquelle la fonction du circuit et les tolérances des composants sont examinées à l'aide d'un modèle informatisé

H.3.17.5
inspection
procédé d'évaluation dans lequel la spécification du matériel (schéma) ou du logiciel (code) est examinée en détail par une personne ou un groupe autre que le concepteur ou le programmeur pour identifier des erreurs possibles

Note 1 à l'article: A la différence du **contrôle collectif**, le concepteur ou le programmeur sont passifs pendant cette évaluation.

H.3.17.6
essai opérationnel
procédé d'évaluation dans lequel un **dispositif de commande** fonctionne aux limites des conditions de fonctionnement prévues (par exemple, vitesse de cycle, température, tension) pour déceler des erreurs de conception ou de construction

H.3.17.7 Analyse statistique

H.3.17.7.1
analyse statique – matériel
procédé d'évaluation dans lequel un modèle de matériel est systématiquement évalué

Note 1 à l'article: L'évaluation peut être informatisée et peut comprendre l'examen de la nomenclature et du tracé des circuits, une analyse d'interface et des essais fonctionnels.

H.3.17.7.2
analyse statique – logiciel
procédé d'évaluation dans lequel un programme informatique est systématiquement évalué sans nécessairement exécuter le programme

Note 1 à l'article: L'évaluation peut être informatisée et peut ordinairement comprendre des caractéristiques telles que logique du programme, chemins de données, interfaces et variables.

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H.3.17.8
essai systématique
méthode d'analyse dans laquelle un **système** ou un programme informatique est évalué pour exécution exacte par l'introduction de données d'essai sélectionnées

Note 1 à l'article: Par exemple, voir **essai boîte noire** et **essai boîte transparente**.

H.3.17.8.1
essai boîte noire
essai systématique dans lequel des données d'essai dérivées de spécifications fonctionnelles sont introduites dans une unité fonctionnelle pour s'assurer de son **fonctionnement** correct

H.3.17.8.2
essai boîte transparente
essai systématique dans lequel des données d'essai basées sur des spécifications de logiciel sont introduites dans un programme pour s'assurer du **fonctionnement** correct des sous-programmes

Note 1 à l'article: Par exemple, des données peuvent être sélectionnées pour exécuter autant d'instructions, de branches, de sous-programmes, etc. que possible.

H.3.17.9
contrôle collectif
procédé d'évaluation dans lequel un concepteur ou un programmeur dirige les membres d'une équipe d'évaluation dans l'étude du matériel, du logiciel et/ou du code du logiciel que le concepteur ou le programmeur a développé pour identifier de possibles erreurs

Note 1 à l'article: A la différence de l'**inspection**, le concepteur ou le programmeur sont actifs pendant cet examen.

H.3.17.10
temps de détection de panne/erreur par logiciel
durée entre l'occurrence d'une **panne**/erreur et la **mise en marche** d'une réponse déclarée du **dispositif de commande** par le logiciel

H.3.18 Définitions relatives aux techniques de commande de panne/erreur des dispositifs de commande utilisant des logiciels

H.3.18.1 Redondance de bus

H.3.18.1.1
redondance de bus complète
technique de **commande** de **panne**/erreur dans laquelle des données et/ou des adresses entièrement redondantes sont fournies par une structure de bus redondante

H.3.18.1.2
parité de bus multibit
technique de **commande** de **panne**/erreur dans laquelle le bus est augmenté de deux bits ou plus, ces bits supplémentaires étant utilisés pour la détection d'erreurs

H.3.18.2
sécurité de code
technique de **commande** de **panne**/erreur dans laquelle la protection contre des erreurs systématiques et/ou de coïncidence des informations d'entrée ou de sortie est assurée par l'utilisation de la **redondance de données** et/ou de la **redondance de transfert** (voir aussi H.3.18.2.1 et H.3.18.2.2)

H.3.18.2.1
redondance de données
forme de **sécurité de code** dans laquelle est utilisé le stockage de données redondantes

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H.3.18.2.2
redondance de transfert
forme de **sécurité de code** dans laquelle des données sont transférées au moins deux fois à la suite et ensuite comparées

Note 1 à l'article: Cette technique reconnaît des erreurs intermittentes.

H.3.18.3
comparateur
dispositif utilisé pour la **commande** de **panne**/erreur dans les structures **deux voies**

Note 1 à l'article: Le dispositif compare les données des deux voies et émet une réponse déclarée si une différence est détectée.

H.3.18.4
mode de panne convertisseur numérique (panne DC)
mode de panne "collé à" incorporant des courts-circuits entre les lignes de signaux

Note 1 à l'article: A cause du nombre de courts-circuits possibles dans le dispositif en essai, ne sont habituellement considérés que les courts-circuits entre lignes de signaux connexes. Un niveau de signal logique est défini et persiste si les lignes tentent de passer au niveau inverse.

H.3.18.5
essai de classe d'équivalence
essai systématique prévu pour déterminer si le décodage des instructions et leur exécution sont effectués correctement

Note 1 à l'article: Les données d'essai proviennent des spécifications d'instruction des unités centrales (CPU).

Note 2 à l'article: Des instructions similaires sont groupées et l'ensemble de données d'entrée est subdivisé en intervalles de données spécifiques (classes d'équivalence). Chaque instruction dans un groupe traite au moins d'un ensemble de données d'essai, de façon que le groupe entier traite entièrement l'ensemble de données d'essai. Les données d'essai peuvent être formées comme suit:

– données de plage valide;
– données de plage non valide;
– données aux limites;
– valeurs extrêmes et leurs combinaisons.

Les essais sont effectués dans un groupe avec différents modes d'adressage, de façon que tous les modes d'adressage soient exécutés par le groupe entier.

H.3.18.6
moyen de reconnaissance d'erreur
moyen indépendant fourni dans le but de reconnaître les erreurs internes au **système**

Note 1 à l'article: Ce sont, par exemple, les dispositifs de surveillance, les **comparateurs** et les générateurs de code.

H.3.18.7
distance de Hamming (d'autocorrecteur)
mesure statistique représentant la capacité d'un code à détecter et à corriger des erreurs

Note 1 à l'article: Cette **distance de Hamming** de deux mots codes est égale aux nombres de positions différentes des deux mots codes.

Note 2 à l'article: Voir H. Holscher et J. Rader; "Microcomputers in safety techniques". Verlag TUV Bayern. TUV Rheinland. (ISBN 3-88585-315-9).

H.3.18.8
comparaison d'entrée
technique de **commande** de **panne**/erreur dans laquelle sont comparées les entrées prévues pour être dans des tolérances spécifiées

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H.3.18.9
détection d'erreur interne
technique de **commande** de **panne**/erreur dans laquelle sont incorporés des circuits spéciaux pour détecter ou corriger des erreurs

H.3.18.10 Séquence de programme

H.3.18.10.1
contrôle de fréquences
technique de **commande** de **panne**/erreur dans laquelle la fréquence d'horloge est comparée à une fréquence fixée indépendante

Note 1 à l'article: C'est, par exemple, la comparaison avec la fréquence de la ligne d'alimentation.

H.3.18.10.2
contrôle logique de la séquence de programme
technique de **commande** de **panne**/erreur dans laquelle l'exécution logique d'une séquence de programme est contrôlée

Note 1 à l'article: C'est, par exemple, l'utilisation de programmes de comptage ou de données sélectionnées du programme à proprement parler ou de dispositifs de contrôle indépendants.

H.3.18.10.3
contrôle logique et créneau de temps
combinaison de H.3.18.10.2 et H.3.18.10.4

H.3.18.10.4
contrôle de créneau de temps de la séquence de programme
technique de **commande** de **panne**/erreur dans laquelle sont périodiquement déclenchés des circuits temporisateurs à base de temps indépendante pour contrôler la fonction et la séquence de programme

Note 1 à l'article: Par exemple un **temporisateur** chien de garde.

H.3.18.11
sorties parallèles multiples
technique de **commande** de **panne**/erreur dans laquelle des sorties parallèles indépendantes sont fournies pour la détection d'erreurs opérationnelles ou pour des **comparateurs indépendants**

H.3.18.12
vérification de sortie
technique de **commande** de **panne**/erreur dans laquelle des sorties sont comparées aux entrées indépendantes

Note 1 à l'article: Cette technique peut lier une erreur à la sortie déficiente.

H.3.18.13
contrôle de vraisemblance
technique de **commande** de **panne**/erreur dans laquelle l'exécution d'un programme, des entrées ou des sorties sont contrôlées pour déceler des temporisations, des données ou des séquences de programme inadmissibles

Note 1 à l'article: Par exemple, introduction d'une interruption supplémentaire après accomplissement d'un certain nombre de cycles ou contrôles de division par zéro.

H.3.18.14
essai de protocole
technique de **commande** de **panne**/erreur dans laquelle des données sont transférées de et vers des composants de calculateur pour détecter des erreurs dans le protocole de communication interne

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H.3.18.15
comparaison réciproque
technique de **commande** de **panne**/erreur utilisée avec des structures **deux voies** (homogènes) dans lesquelles est effectuée une comparaison de données échangées réciproquement entre deux unités de traitement

Note 1 à l'article: Réciproquement se réfère à un échange de données similaires.

H.3.18.17
contrôle redondant
disponibilité de deux ou plusieurs moyens indépendants, tels que chiens de garde et **comparateurs**, pour effectuer la même tâche

H.3.18.18
transmission ordonnancée
procédure de communication dans laquelle l'envoi de l'information d'un transmetteur particulier est seulement autorisé vers un point prédéfini en temps et séquence, sinon le récepteur le traite comme une erreur de communication

H.3.18.19
diversité des logiciels
technique de **commande** de **panne**/erreur dans laquelle tout un logiciel ou des parties d'un logiciel sont incorporés deux fois sous forme de code logiciel alterné

Note 1 à l'article: Par exemple, les formes alternées de code logiciel peuvent être produites par des programmeurs différents, des langages différents ou des schémas de compilation différents et peuvent résider dans des voies matérielles différentes ou dans des zones mémoires différentes d'une structure **simple voie**.

H.3.18.20
mode de panne collé à
mode de **panne** représentant un circuit ouvert ou un niveau de signal invariant

Note 1 à l'article: Ces modes de panne sont généralement appelés "collé ouvert", "collé à 1" ou "collé à 0".

H.3.18.21
essai de contrôle
disposition de moyens indépendants tels que chiens de garde et **comparateurs** qui sont soumis à essai au départ ou périodiquement pendant le **fonctionnement**

H.3.18.22
gabarit d'essai
technique de **commande** de **panne**/erreur utilisée pour l'essai périodique des dispositifs d'entrée, de sortie et des interfaces du **dispositif de commande**

Note 1 à l'article: Un gabarit d'essai est introduit dans le dispositif et les résultats sont comparés aux valeurs espérées. Pour l'introduction du gabarit d'essai et l'évaluation des résultats, des moyens indépendants sont utilisés. Le gabarit d'essai est construit de façon à ne pas influencer le **fonctionnement** correct du **dispositif de commande**.

H.3.19 Définitions relatives aux essais de mémoire des dispositifs de commande utilisant des logiciels

H.3.19.1
essai d'Abraham
forme spécifique de gabarit d'essai de **mémoire variable** dans lequel toute **panne** "collée à" et de couplage entre cellules de mémoire est identifiée

Note 1 à l'article: Le nombre d'**opérations** exigées pour effectuer l'essai de la mémoire entière est d'environ 30 n, où n est le nombre de cellules de la mémoire. L'essai peut être transparent à l'utilisation pendant les cycles de fonctionnement, par partition de la mémoire et essai de chaque partition en différents segments de temps.

Note 2 à l'article: Voir Abraham, J.A.; Thatte, S.M.; "Fault coverage of test programs for a microprocessor", Proceedings of the IEEE Test Conference 1979, pp 18-22.

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H.3.19.2
essai GALPAT de mémoire
technique de **commande** de **panne**/erreur dans laquelle une seule cellule d'un champ de cellules de mémoire uniformément écrites est complémentée, après quoi le reste de la mémoire en essai est inspecté

Note 1 à l'article: Après chaque **opération** de lecture de l'une des cellules restantes du champ, la cellule écrite dans l'ordre inverse est aussi inspectée et lue. Ce processus est répété dans toutes les cellules de la mémoire en essai. Un deuxième essai est ensuite exécuté comme ci-dessus sur la même plage de mémoire sans écriture dans l'ordre inverse de la cellule d'essai.

Note 2 à l'article: L'essai peut être transparent à l'utilisation pendant les cycles de fonctionnement, par partition de la mémoire et essai de chaque partition en différents segments de temps (voir **essai GALPAT transparent**).

H.3.19.2.1
essai GALPAT transparent
essai GALPAT de mémoire dans lequel un mot de signature est d'abord formé pour représenter le contenu de la plage de mémoire à soumettre à essai et ce mot est sauvegardé

Note 1 à l'article: La cellule à soumettre à essai est complémentée et l'essai est effectué comme ci-dessus. Cependant, le reste des cellules n'est pas inspecté individuellement mais par formation de et comparaison avec un second mot de signature. Un deuxième essai est ensuite effectué comme ci-dessus par complémentation de la valeur de la cellule à soumettre à essai précédemment complémentée.

Note 2 à l'article: Cette technique reconnaît aussi bien toutes les erreurs de bit statique que les erreurs d'interface entre cellules de mémoire.

H.3.19.3 Somme de contrôle

H.3.19.3.1
somme de contrôle modifiée
technique de **commande** de **panne**/erreur dans laquelle un unique mot représentant le contenu de tous les mots en mémoire est généré et sauvegardé

Note 1 à l'article: Pendant l'autotest, une somme de contrôle est formée avec le même algorithme et comparée avec la somme de contrôle sauvegardée.

Note 2 à l'article: Cette technique reconnaît toutes les erreurs de bit impair et quelques erreurs de bit pair.

H.3.19.3.2
somme de contrôle multiple
technique de **commande** de **panne**/erreur dans laquelle des mots séparés représentant le contenu de zones mémoires soumises à essai sont générés et sauvegardés

Note 1 à l'article: Pendant l'autotest, le même algorithme est utilisé pour générer une somme de contrôle qui est comparée avec la somme de contrôle sauvegardée pour cette zone.

Note 2 à l'article: Cette technique reconnaît toutes les erreurs de bit impair et quelques erreurs de bit pair.

H.3.19.4 Contrôle de redondance cyclique (CRC)

H.3.19.4.1
mot unique de CRC
technique de **commande** de **panne**/erreur dans laquelle un unique mot est généré pour représenter le contenu de la mémoire

Note 1 à l'article: Pendant l'autotest, le même algorithme est utilisé pour générer un autre mot qui est comparé avec le mot sauvegardé.

Note 2 à l'article: Cette technique reconnaît toutes les erreurs de 1 bit ainsi qu'un pourcentage élevé d'erreurs multibit.

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H.3.19.4.2
mot double de CRC
technique de **commande** de **panne**/erreur dans laquelle au moins deux mots sont générés pour représenter le contenu de la mémoire

Note 1 à l'article: Pendant l'autotest, le même algorithme est utilisé pour générer le même nombre de mots de réponse qui sont comparés avec les mots sauvegardés.

Note 2 à l'article: Cette technique reconnaît toutes les erreurs de 1 bit ainsi qu'un nombre élevé d'erreurs multibit avec une précision plus grande qu'avec un **mot unique de CRC**.

H.3.19.5
mémoire redondante avec comparaison
structure dans laquelle le contenu de la mémoire relatif à la sécurité est stocké deux fois dans des formats différents dans des zones séparées de façon à pouvoir être comparé pour contrôle d'erreur

H.3.19.6
essai de mémoire statique
technique de commande de **panne**/erreur prévue pour détecter seulement les erreurs statiques

H.3.19.6.1
essai de mémoire damier
essai de mémoire statique dans lequel un gabarit en damier de zéros et de uns est écrit dans la zone mémoire en essai et où les cellules sont inspectées par paires

Note 1 à l'article: L'adresse de la première cellule de chaque paire est variable et l'adresse de la deuxième cellule dérive de la première adresse par complément d'un bit. Dans la première **inspection**, l'adresse est d'abord incrémentée jusqu'à la fin de l'espace d'adresse de la mémoire puis ramenée à sa valeur d'origine. L'essai est répété avec le gabarit en damier inverse.

H.3.19.6.2
essai de mémoire active
essai de mémoire statique dans lequel une donnée est écrite dans la zone mémoire en essai comme en fonctionnement normal

Note 1 à l'article: Chaque cellule est ensuite inspectée dans l'ordre ascendant et le complément d'un bit est effectué dans le contenu. L'**inspection** et le complément d'un bit sont ensuite répétés dans l'ordre descendant. Puis ce processus est répété après avoir d'abord effectué le complément d'un bit dans toutes les cellules de mémoire en essai.

H.3.19.7
essai walkpat des mémoires
technique de commande de **panne**/erreur dans laquelle un gabarit de données modèle est écrit dans la zone mémoire en essai comme en fonctionnement normal

Note 1 à l'article: Le complément d'un bit est effectué dans la première cellule et le reste de la zone mémoire est inspecté. Puis la première cellule est à nouveau complémentée et la mémoire inspectée. Ce processus est répété dans toutes les cellules de la mémoire en essai. Un deuxième essai est effectué par complément d'un bit de toutes les cellules en mémoire en essai et en procédant comme ci-dessus.

Note 2 à l'article: Cette technique reconnaît aussi bien toutes les erreurs de bit statique que les erreurs d'interface entre cellules de mémoire.

H.3.19.8 Protection de mot

H.3.19.8.1
protection de mot avec redondance multibit
technique de commande de **panne**/erreur dans laquelle des bits redondants sont générés et sauvegardés pour chacun des mots de la zone mémoire en essai

Note 1 à l'article: A la lecture de chacun des mots est effectué un contrôle de parité.

Note 2 à l'article: Par exemple, un code "Hamming" qui reconnaît aussi bien toutes les erreurs de un ou deux bits et certaines des erreurs de trois bits ou multibit.

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H.3.19.8.2
protection de mot avec redondance d'un seul bit
technique de commande de **panne**/erreur dans laquelle un seul bit est ajouté à chacun des mots de la zone mémoire en essai puis sauvegardé, créant ainsi une parité paire ou impaire

Note 1 à l'article: A la lecture de chacun des mots est effectué un contrôle de parité.

Note 2 à l'article: Cette technique reconnaît toutes les erreurs de bit impair.

H.3.20 Définitions de la terminologie des logiciels – Généralités

H.3.20.1
erreur de mode commun
erreur(s) dans une structure **double voie** ou une autre structure redondante telle que chaque voie ou structure est affectée simultanément et de la même manière

H.3.20.2
erreur de cause commune
erreurs de différents éléments, à la suite d'un événement unique, et n'étant pas des conséquences les unes des autres

Note 1 à l'article: Il convient de ne pas confondre les **erreurs de cause commune** avec les **erreurs de mode commun**.

H.3.20.3
analyse des modes de défaillance et de leurs effets
AMDE
technique analytique dans laquelle les types de **défaillances** de chaque composant du matériel sont identifiés et examinés quant à leurs effets sur les fonctions liées à la sécurité du **dispositif de commande**

H.3.20.4
indépendant
ne pas être influencé défavorablement par la circulation des données du **dispositif de commande** et ne pas être gêné par la défaillance d'autres fonctions de **commande**, ou par des effets de mode commun

H.3.20.5
mémoire invariable
plages de mémoire d'un **système** de traitement contenant des données qui n'est pas prévu pour varier pendant l'exécution du programme

Note 1 à l'article: **Mémoire invariable** peut comprendre une construction RAM où il n'est pas prévu de variation de données pendant l'exécution du programme.

H.3.20.6
mémoire variable
plages de mémoire d'un **système** de traitement contenant des données qui est prévu pour varier pendant l'exécution du programme

H.3.21 Définitions relatives aux classes de fonctions de commande

Pour l'évaluation des mesures de protection pour la tolérance aux **pannes** et la prévention de **dangers**, il est nécessaire de classer les fonctions de **commande** selon leur comportement par rapport aux **pannes**.

A la classification des fonctions de **commande**, leur intégration dans le concept de sécurité complète de l'appareil doit être prise en compte.

NOTE Une fonction de **commande** est constituée de la boucle entière commençant par le moyen sensible en passant par le circuit de traitement (matériel et logiciel s'il est utilisé) et comprenant la commande de l'actionneur.

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Dans le but d'évaluer la conception d'une fonction de **commande**, les présentes exigences reconnaissent trois classes distinctes, données dans les définitions suivantes.

H.3.21.1
fonction de commande de classe A
fonctions du **dispositif de commande** non prévues pour faire partie de la sécurité de l'application

Note 1 à l'article: Exemples: **thermostats** d'ambiance, **dispositif de commande** de température.

H.3.21.2
fonction de commande de classe B
fonctions du **dispositif de commande** qui sont destinées à prévenir un état non sécurisé de l'appareil

Note 1 à l'article: La **défaillance** de la fonction du **dispositif de commande** ne conduit pas directement à une situation dangereuse.

Note 2 à l'article: Exemples: limiteur de température, limiteur de pression.

H.3.21.3
fonction de commande de classe C
fonctions du **dispositif de commande** qui sont destinées à prévenir des **dangers** spéciaux tels qu'une explosion ou dont la **défaillance** est susceptible d'occasionner directement un **danger** dans l'appareil

Note 1 à l'article: Exemples: les **systèmes** de **commande** des brûleurs, les **coupe-circuit thermiques** pour les **systèmes** de chauffage de l'eau en circuit fermé (sans protection par mise à l'air libre).

H.3.22 Définitions concernant la sécurité fonctionnelle

H.3.22.1
sécurité fonctionnelle
fonctionnement correct de la ou des fonctions de sortie de sécurité déclarées, dont la défaillance ou le dysfonctionnement peut entraîner un danger

Note 1 à l'article: Le danger peut résulter d'une perte de la fonction de protection (fonction de sortie) entraînant un risque d'explosion, de température excessive, de choc électrique, d'incendie et/ou de blessures, etc.

H.3.22.2
temps de tolérance aux pannes
durée entre l'occurrence d'une **panne** et l'arrêt du matériel commandé, qui est tolérée par l'application sans créer de situation dangereuse

Note 1 à l'article: D'autres actions que l'arrêt du matériel commandé sont possibles s'il est démontré qu'elles préviennent les situations dangereuses.

H.3.22.3
temps de réaction aux pannes
durée entre l'occurrence d'une **panne** et le moment auquel le **dispositif de commande** a atteint un **état défini**

H.3.22.4
état défini
état d'un **dispositif de commande** avec la caractérisation suivante:

a) le **dispositif de commande** prend passivement un état dans lequel les bornes de sortie assurent une situation sécurisée en toutes circonstances. Lorsque la cause de la transition vers l'**état défini** est éliminée, il convient que l'application se lance conformément aux exigences appropriées; ou

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b) le **dispositif de commande** exécute activement une action de protection, dans le temps spécifié dans la Partie 2 appropriée, provoquant un arrêt ou empêchant une condition non sécurisée; ou

c) le **dispositif de commande** reste en **fonctionnement**, continuant à satisfaire à toutes exigences fonctionnelles de sécurité

H.3.22.5
électronique complexe
désignation des ensembles qui utilisent des composants électroniques avec les caractéristiques suivantes:

a) le composant fournit plus d'une sortie fonctionnelle;

b) il n'est pas envisageable dans la pratique ou il est impossible de représenter le mode de **défaillance** d'un tel composant par "collé à" et des liens croisés au niveau des broches ou par d'autres modes de **défaillance** qui sont décrits dans le Tableau 14.

H.3.22.6
réarmement
action qui assure une réinitialisation à partir de l'état de sécurité pour permettre au **système** de tenter un redémarrage

H.3.22.7
dégradation (de fonctionnement)
écart non désiré des caractéristiques de fonctionnement d'un dispositif, d'un matériel ou d'un **système** par rapport aux caractéristiques attendues

Note 1 à l'article: Une dégradation peut être un **défaut** de fonctionnement temporaire ou permanent.

[SOURCE: IEC 60050-161:1990, 161-01-19]

H.3.22.8
dommage
blessure physique ou atteinte à la santé des personnes, ou atteinte aux biens ou à l'environnement

[SOURCE: ISO/IEC Guide 51:2014, 3.1]

H.3.22.9
danger
source potentielle de **dommage**

[SOURCE: ISO/IEC Guide 51:2014, 3.2]

H.3.22.10
risque
combinaison de la probabilité d'un **dommage** et de sa gravité

[SOURCE: ISO/IEC Guide 51:2014, 3.9]

H.3.23 Définitions relatives à l'accès à l'échange de données

H.3.23.1
numéro de séquence
champ de données supplémentaire contenant un numéro qui varie de manière prédéfinie d'un message à l'autre

H.3.23.2
horodatage
information concernant le temps de **transmission** associé à un message par l'émetteur

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H.3.23.3
identifiant de source et de destination
identifiant qui est attribué à chaque entité

Note 1 à l'article: Cet identifiant peut être un nom, un numéro ou une configuration binaire arbitraire. Cet identifiant est utilisé pour la communication liée à la sécurité. Il est généralement ajouté aux données **utilisateur**.

H.3.23.4
message de réponse
réponse d'un destinataire à l'émetteur, par l'intermédiaire d'une voie de retour

H.3.23.5
procédure d'identification
procédure d'identification formant partie intégrante du processus d'application relative à la sécurité

Note 1 à l'article: Deux types de **procédures d'identification** peuvent être considérées:

– identification bidirectionnelle: dans laquelle une voie de communication de retour est disponible, l'échange des identifiants d'entité entre émetteurs et destinataires des informations peut permettre de mieux assurer que la communication est réellement établie entre les parties intéressées;

– **procédures d'identification** dynamiques: échange dynamique d'informations entre émetteurs et destinataires, y compris la transformation et la réponse en retour des informations reçues à l'émetteur. Peut permettre de mieux s'assurer que les parties en communication ne revendiquent pas seulement la détention de la bonne identité mais qu'elles se comportent également comme prévu. Ce type de **procédure d'identification** dynamique peut être utilisé pour introduire la transmission des informations entre les processus de communication relative à la sécurité et/ou il peut être utilisé au cours de la transmission des informations à proprement parler.

H.3.23.6
code de sécurité
données redondantes comprises dans un message relatif à la sécurité permettant à la fonction de transmission relative à la sécurité de détecter des altérations de données

H.3.23.7
techniques de chiffrement
données de sortie calculées par un algorithme utilisant comme paramètre des données d'entrée et une clé

Note 1 à l'article: En connaissant les données de sortie, il est impossible de calculer, dans un temps raisonnable, les données d'entrée sans connaître la clé. Il est également impossible, dans un temps raisonnable, de déduire la clé des données de sortie, même si les données d'entrée sont connues.

H.3.23.8
délai d'attente
délai entre deux messages, dépassant une durée maximale admise préalablement définie

Note 1 à l'article: Si c'est le cas, une erreur peut être envisagée.

H.3.23.9
réseau public
données et signaux non limités à l'espace physique au sein du foyer, ou aux emplacements spécifiés comme couverts par le domaine d'application du présent document

Note 1 à l'article: Les exemples de **réseaux publics** incluent, sans toutefois s'y limiter, les applications suivantes:

– Internet;

– dispositifs Wi-Fi;

– dispositifs Bluetooth situés à > 10 m.

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H.5 Information

Tableau H.1 – Points complémentaires au Tableau 1

	Information	Article ou paragraphe	Méthode
H.1	Pour les **dispositifs de commande électronique** intégrés et incorporés, si une protection contre les perturbations conduites par le réseau et les perturbations magnétiques et électromagnétiques est prévue, les essais de l'Article H.25 doivent être effectués, et les effets sur la fonction et les signaux de sortie après une **défaillance** de fonctionnement résultant de chaque essai	Tableau H.12, H.25.2 H.25.14	X
H.2	Pour les **dispositifs de commande** autres que les **dispositifs de commande électronique** intégrés et incorporés, les effets sur la fonction et les signaux de sortie après une **défaillance** de fonctionnement résultant des essais de l'Article H.25	H.25.1 H.25.14	X
H.3	Documentation sur la séquence du logiciel [a b c d]	H.9.12.2.9	X
H.4	Documentation sur le programme [a d e]	H.9.12.2.9 H.9.12.2.11	X
H.5	Analyse des **pannes** du logiciel [a c d]	H.9.12, 13.1.3	X
H.6	Classe(s) et structure du logiciel [f] Cette information n'est pas exigée pour les **dispositifs de commande** de classe A	H.9.12.2 H.9.12.3 H.13.2.2.1 H.13.2.3.1	D
H.7	Mesures analytiques et techniques de commande de **panne**/erreur employées [a g]	H.9.12.1.2 H.9.12.2.2 H.9.12.2.4	X
H.8	**Temps de détection de panne/erreur par logiciel des dispositifs de commande** de classe B ou C [a h]	H.3.17.10 H.9.12.2.6	X
H.9	Réponse(s) du **dispositif de commande** en cas de détection de **panne**/erreur [a]	H.9.12.2.7	X
H.10	**Dispositifs de commande** soumis à une seconde analyse de **panne** et condition déclarée résultant de cette seconde **panne**	H.13.2.3	X
H.11	Temps de réaction aux **pannes**	H.3.22.2 H.13.2.2.2 H.13.2.2.3 H.13.2.3.2 H.13.2.3.3 H.13.2.4.2 H.13.2.4.3	X
H.12	Classe ou classes de fonction(s) de **commande**	H.13.2.2 H.13.2.3	X

[a] Pour les **dispositifs de commande** déclarés comme entièrement de classe A, les exigences H.3, H.4, H.5, H.7, H.8 et H.9 du Tableau H.1 sont exemptées. Pour les **dispositifs de commande** avec logiciels de classe B ou C, l'information doit uniquement être donnée pour les segments de logiciel relatifs à la sécurité. Les informations sur les segments qui ne sont pas relatifs à la sécurité doivent être suffisantes pour établir qu'ils n'influencent pas les segments relatifs à la sécurité.

[b] La séquence du logiciel doit être décrite dans une documentation incluant, avec la **séquence de fonctionnement** de l'exigence 46 du tableau, la description de la philosophie du **système** de **commande**, du débit du **dispositif de commande**, de la circulation des données et des chronologies.

[c] Les données et les segments de sécurité de la séquence du logiciel dont les dysfonctionnements pourraient causer une non-conformité avec les Articles 13, 19, 24 et H.25 doivent être identifiés. Cette identification doit inclure la **séquence de fonctionnement** et peut, par exemple, prendre la forme d'une analyse d'arbre de **panne** qui doit inclure les **pannes**/erreurs du Tableau H.2 pouvant résulter en une non-conformité. L'analyse de **panne** du logiciel doit être reliée à l'analyse de **panne** du matériel en H.13.2.

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[d] Exemples d'autres informations pouvant convenir à une insertion dans la documentation exigée par les Notes a, b, c, e, f et g:

Spécification de **systèmes** logiciels à incorporer, par exemple:

- spécifications fonctionnelles comprenant une procédure de redémarrage sur perte d'alimentation;
- étude de module de programme comprenant une description des interfaces de matériel et des interfaces utilisateur;
- étude détaillée comprenant la description de l'utilisation de la mémoire;
- liste de codes comprenant l'identification du langage de programmation, les commentaires et les sous-programmes;
- spécifications d'essais;
- manuels d'installation, d'utilisation et/ou de maintenance.

[e] La documentation de programmation doit être fournie dans un langage d'étude de programmation déclaré par le fabricant.

[f] Dans un **dispositif de commande**, des classes différentes de logiciels peuvent s'appliquer à des fonctions de **commande** différentes. Des fonctions de **commande** pouvant comprendre des logiciels de classes A à C sont par exemple comme suit:

Classe A – Sont considérés comme des exemples les thermostats d'ambiance, les capteurs d'humidité, les dispositifs d'allumage, les temporisateurs et interrupteurs temporisés.

Classe B – Est considéré comme un exemple un coupe-circuit thermique.

Classe C – Sont considérés comme des exemples les **dispositifs de commande** automatique des brûleurs et les coupe-circuit thermiques pour les **systèmes** de chauffage de l'eau en circuit fermé (non ouverts).

[g] Les mesures à déclarer sont celles choisies par le fabricant dans les exigences de H.9.12.1.2 à H.9.12.2.4 inclus.

[h] Cela peut être exprimé comme le temps suivant l'exécution d'un segment spécifique de logiciel.

H.9 Exigences de construction

H.9.12 Dispositifs de commande utilisant des logiciels

Les **dispositifs de commande** utilisant des logiciels doivent être construits de façon que le logiciel ne compromette pas la conformité du dispositif de commande aux exigences du présent document.

*La conformité est vérifiée par les essais pour les **dispositifs de commande électronique** du présent document, par **inspection** selon les exigences de H.9.12 et par examen de la documentation exigée dans le Tableau H.1, exigences H.3 à H.9 incluse.*

Les alinéas H.9.12.1 à H.9.12.4 inclus ne sont applicables qu'aux fonctions de **commande** utilisant des logiciels de classe B ou de classe C.

L'alinéa H.9.12.4 comporte des exigences supplémentaires relatives aux **fonctions de commande à distance**.

H.9.12.1 Exigences relatives à l'architecture

H.9.12.1.1 Les fonctions de **commande** avec logiciels de classe B ou C doivent utiliser les mesures pour **commander** et éviter les **pannes**/erreurs logicielles des données et des segments du logiciel liés à la sécurité, comme détaillé de H.9.12.1.2 à H.9.12.3 inclus.

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H.9.12.1.2 Structure des fonctions de commande avec logiciels de classe B ou C

H.9.12.1.2.1 Les fonctions de **commande** avec logiciels de classe C doivent avoir l'une des structures suivantes:

– **simple voie avec autotest périodique et contrôle** (H.3.16.7);
– **deux voies (homogènes) avec comparaison** (H.3.16.3);
– **deux voies (différentes) avec comparaison** (H.3.16.2).

NOTE La comparaison entre les structures **deux voies** peut être faite par:

– utilisation d'un **comparateur** (H.3.18.3), ou
– **comparaison réciproque** (H.3.18.15).

H.9.12.1.2.2 Les fonctions de **commande** avec logiciels de classe B doivent avoir l'une des structures suivantes:

– **simple voie avec essai fonctionnel** (H.3.16.5);
– **simple voie avec autotest périodique** (H.3.16.6);
– **double voie** avec comparaison (H.3.16.1).

Une structure de logiciels de classe C est aussi acceptable pour une structure de logiciels de classe B.

H.9.12.1.3 D'autres structures sont permises s'il peut être montré qu'elles fournissent un niveau de sécurité équivalent à celui de H.9.12.1.2.

H.9.12.2 Mesures pour commander les pannes/erreurs

H.9.12.2.1 Quand une mémoire redondante avec comparaison est présente à deux endroits du même composant, les données d'une mémoire doivent être conservées dans un format différent de celui de l'autre mémoire (voir H.3.18.19 **diversité des logiciels**).

H.9.12.2.2 Les **dispositifs de commande** avec logiciels de classe C utilisant des structures deux voies avec comparaison doivent avoir un moyen de détection complémentaire de **panne**/erreur (tel que des **essais fonctionnels périodiques**, des **autotests périodiques** ou un contrôle indépendant) pour chacune des **pannes**/erreurs non détectées par la comparaison.

H.9.12.2.3 Les **dispositifs de commande** avec logiciels de classe B ou C doivent avoir les moyens de reconnaissance et de contrôle d'erreur dans la transmission aux chemins de données externes liées à la sécurité au sein d'un réseau fermé (réseau non public). De tels moyens doivent prendre en compte les erreurs de données, d'adressage, de chronologie de transmission et de séquence de protocole (voir Tableau H.2 "communication externe").

H.9.12.2.4 Pour le **dispositif de commande** avec **logiciels de classe B ou C**, le fabricant doit fournir dans le dispositif de commande les mesures pour traiter les pannes/erreurs dans les segments relatifs à la sécurité et les données indiquées dans le Tableau H.2 et déclarées dans le Tableau H.1, exigence H.5.

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Tableau H.2 – Mesures acceptables de traitement des pannes/erreurs[a]

Eléments constituants [b]	Panne/ erreur	Classe de logiciel		Exemple de mesures acceptables [c d e]	Définitions
		B	C		
1. CPU					
1.1 Registres	Collé à	rq		Essai fonctionnel ou	H.3.16.5
				autotest périodique utilisant, soit:	H.3.16.6
				– **essai de mémoire statique**,	H.3.19.6
				– **protection de mot avec redondance d'un seul bit**.	H.3.19.8.2
	Panne DC		rq	Comparaison des CPU redondantes par soit:	
				– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				détection d'erreur interne, soit	H.3.18.9
				mémoire redondante avec comparaison, soit	H.3.19.5
				autotests périodiques utilisant, soit:	
				– **essai walkpat des mémoires,**	H.3.19.7
				– **essai d'Abraham,**	H.3.19.1
				– **essai GALPAT transparent**,	H.3.19.2.1
				protection de mot avec redondance multibit, soit	H.3.19.8.1
				essai de mémoire statique et **protection de mot**	H.3.19.6
				avec redondance d'un seul bit	H.3.19.8.2
1.2 Décodage et exécution des instructions	Mauvais décodage et mauvaise exécution des instructions		rq	Comparaison des CPU redondantes par soit:	
				– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				détection d'erreur interne, soit	H.3.18.9
				autotest périodique utilisant un **essai de classe d'équivalence**	H.3.18.5
1.3 Compteur de programme	Collé à	rq		Essai fonctionnel ou	H.3.16.5
				autotest périodique, ou	H.3.16.6
				contrôle de créneau de temps indépendant de la séquence de programme, ou	H.3.18.10.4
				contrôle logique de la séquence de programme	H.3.18.10.2
				Autotest périodique et contrôle utilisant soit:	H.3.16.7
	Panne DC		rq	**– créneau de temps indépendant et contrôle logique,**	H.3.18.10.3
				– **détection d'erreur interne**, soit	H.3.18.9
				comparaison des voies fonctionnelles redondantes par soit:	
				– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**.	H.3.18.3

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Eléments constituants [b]	Panne/ erreur	Classe de logiciel		Exemple de mesures acceptables [c d e]	Définitions
		B	C		
1.4 Adressage	**Panne** DC		rq	Comparaison des CPU redondantes par soit:	
				– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				Détection d'erreur interne, ou	H.3.18.9
				autotest périodique utilisant un **gabarit d'essai**	H.3.16.7
				des lignes d'adresse, ou	H.3.18.22
				de la **redondance de bus complète**, ou	H.3.18.1.1
				parité de bus multibit	H.3.18.1.2
1.5 Décodage des instructions des chemins de données	**Panne** DC et exécution		rq	Comparaison des CPU redondantes par soit:	
				comparaison réciproque, soit	H.3.18.15
				comparateur de matériel **indépendant**, soit	H.3.18.3
				détection d'erreur interne, soit	H.3.18.9
				autotest périodique utilisant un **gabarit d'essai**, soit	H.3.16.7
				redondance de données, soit	H.3.18.2.1
				parité de bus multibit	H.3.18.2.2
2. Manipulation et exécution interrompues	Pas d'interruption ou interruptions trop fréquentes	rq		Essai fonctionnel, ou	H.3.16.5
				contrôle de créneau de temps	H.3.18.10.4
	Pas d'interruption ou interruptions trop fréquentes liées à différentes sources		rq	Comparaison des voies fonctionnelles redondantes soit par	
				comparaison réciproque,	H.3.18.15
				comparateur de matériel **indépendant**, soit	H.3.18.3
				créneau de temps indépendant et contrôle logique	H.3.18.10.3

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Eléments constituants [b]	Panne/ erreur	Classe de logiciel		Exemple de mesures acceptables [c d e]	Définitions
		B	C		
3. Horloge		rq		**Contrôle de fréquences**, ou	H.3.18.10.1
				contrôle de créneau de temps	H.3.18.10.4
	Mauvaise fréquence		rq	**Contrôle de fréquences**, ou	H.3.18.10.1
				contrôle de créneau de temps, ou	H.3.18.10.4
	(pour les horloges à quartz synchronisées:			comparaison des voies fonctionnelles redondantes	
				soit par:	
				– **comparaison réciproque,**	H.3.18.15
	harmoniques/			– **comparateur** de matériel **indépendant**.	H.3.18.3
	sous-harmoniques				
	uniquement)				
4. Mémoire					
4.1 Mémoire invariable	Toute panne simple bit	rq		**Somme de contrôle modifiée** périodique, ou	H.3.19.3.1
				somme de contrôle multiple; ou	H.3.19.3.2
				protection de mot avec redondance d'un seul bit	H.3.19.8.2
	99,6 %		rq	Comparaison des CPU redondantes par soit:	
	de couverture			– **comparaison réciproque,**	H.3.18.15
	de toutes les erreurs d'information			– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				mémoire redondante avec comparaison, soit	H.3.19.5
				contrôle de redondance périodique cyclique soit	
				– mot unique	H.3.19.4.1
				– mot double, soit	H.3.19.4.2
				protection de mot avec redondance multibit	H.3.19.8.1

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Eléments constituants [b]	Panne/ erreur	Classe de logiciel		Exemple de mesures acceptables [c d e]	Définitions
		B	C		
4.2 Mémoire variable	**Panne** DC	rq		**Essai de mémoire statique** périodique, ou	H.3.19.6
				protection de mot avec redondance d'un seul bit	H.3.19.8.2
	Panne DC		rq	Comparaison des CPU redondantes par soit:	
	et liens croisés			– **comparaison réciproque,**	H.3.18.15
	dynamiques			– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				mémoire redondante avec comparaison, soit	H.3.19.5
				autotests périodiques utilisant, soit:	
				– **essai walkpat des mémoires,**	H.3.19.7
				– **essai d'Abraham,**	H.3.19.1
				– **essai GALPAT transparent**, soit	H.3.19.2.1
				protection de mot avec redondance multibit	H.3.19.8.1
4.3 Adressage	Collé à	rq		**Protection de mot avec redondance d'un seul bit**	H.3.19.8.2
(lié à la mémoire				incluant l'adresse, ou	
	Panne DC		rq	comparaison des CPU redondantes par soit:	
variable et				– **comparaison réciproque**, soit	H.3.18.15
mémoire invariable)				– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				redondance de bus complète	H.3.18.1.1
				Gabarit d'essai, ou	
				contrôle de redondance périodique cyclique par, soit:	H.3.18.22
				– mot unique	H.3.19.4.1
				– mot double, soit	H.3.19.4.2
				protection de mot avec redondance multibit, y compris l'adresse	H.3.19.8.1
5. Chemins de données internes					
5.1 Données	Collé à	rq		**Protection de mot avec redondance d'un seul bit**	H.3.19.8.2
	Panne DC		rq	Comparaison des CPU redondantes par soit:	
				– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				protection de mot avec redondance multibit	H.3.19.8.1
				incluant l'adresse, soit **redondance de données**, soit	H.3.18.2.1
				gabarit d'essai, ou	H.3.18.22
				essai de protocole	H.3.18.14

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Eléments constituants [b]	Panne/ erreur	Classe de logiciel		Exemple de mesures acceptables [c d e]	Définitions
		B	C		
5.2 Adressage	Adresse erronée	rq		**Protection de mot avec redondance d'un seul bit** incluant l'adresse	H.3.19.8.2
	Adresse erronée		rq	Comparaison des CPU redondantes par soit:	
	et			– **comparaison réciproque,**	H.3.18.15
	adressage multiple			– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				protection de mot avec redondance multibit, incluant l'adresse, soit **redondance de bus complète**, soit **gabarit d'essai** incluant l'adresse	H.3.19.8.1 H.3.18.1.1 H.3.18.22
6. Communication externe					
6.1 Données					
	Distance de Hamming 3	rq		**Protection de mot avec redondance multibit**, ou **mot unique de CRC**, ou	H.3.19.8.1 H.3.19.4.1
				redondance de transfert, ou	H.3.18.2.2
				essai de protocole	H.3.18.14
	Distance de Hamming 4		rq	**redondance de données**, ou comparaison de voies fonctionnelles redondantes par soit:	H.3.18.2.1
				– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**.	H.3.18.3
6.2 Adressage	Adresse erronée	rq		**Protection de mot avec redondance multibit**,	H.3.19.8.1
				incluant l'adresse, ou **mot unique de CRC**	H.3.19.4.1
				incluant les adresses, ou	
				redondance de transfert, ou	H.3.18.2.2
				essai de protocole	H.3.18.14
	Adressage erroné		rq	**Mot double de CRC** incluant l'adresse, ou	H.3.19.4.2
	et multiple			**redondance de bus complète** de données et d'adresse, ou	H.3.18.1.1
				comparaison de voies de communication redondantes par soit:	
				– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**.	H.3.18.3

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Eléments constituants [b]	Panne/ erreur	Classe de logiciel		Exemple de mesures acceptables [c d e]	Définitions
		B	C		
6.3 Chronologie	Point de temps erroné	rq		Contrôle de créneau de temps, ou **transmission ordonnancée**	H.3.18.10.4 H.3.18.18
			rq	**Contrôle logique et créneau de temps**, ou	H.3.18.10.3
				comparaison de voies de communication redondantes par soit:	
				– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**.	H.3.18.3
	Séquence erronée	rq		Contrôle logique, ou	H.3.18.10.2
				contrôle de créneau de temps, ou	H.3.18.10.4
				transmission ordonnancée	H.3.18.18
			rq	(mêmes options que pour le point de temps erroné)	
7. Périphérique entrée/sortie	**Conditions de panne**	rq		**Contrôle de vraisemblance**	H.3.18.13
	spécifiées à		rq	Comparaison des CPU redondantes par soit:	
	l'Article 13			– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**, soit	H.3.18.3
7.1 E/S numériques				**comparaison d'entrée**, ou	H.3.18.8
				sorties parallèles multiples, ou	H.3.18.11
				vérification de sorties, ou	H.3.18.12
				gabarit d'essai, ou	H.3.18.22
				sécurité de code	H.3.18.2
7.2 E/S analogiques					
7.2.1 Convertisseur	Conditions de **panne**	rq		**Contrôle de vraisemblance**	H.3.18.13
A/N et N/A	spécifiées à		rq	Comparaison des CPU redondantes par soit:	
	l'Article 13			– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				comparaison d'entrée, soit	H.3.18.8
				sorties parallèles multiples, soit	H.3.18.11
				vérification de sorties, soit	H.3.18.12
				gabarit d'essai	H.3.18.22
7.2.2 Multiplexeur analogique	Adressage erroné	rq		**Contrôle de vraisemblance**	H.3.18.13
			rq	Comparaison des CPU redondantes par soit:	
				– **comparaison réciproque,**	H.3.18.15
				– **comparateur** de matériel **indépendant**, soit	H.3.18.3
				comparaison d'entrée, soit	H.3.18.8
				gabarit d'essai	H.3.18.22

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Eléments constituants [b]	Panne/ erreur	Classe de logiciel		Exemple de mesures acceptables [c d e]	Définitions
		B	C		
8. Dispositifs de contrôle et **comparateurs**	Toutes sorties hors des spécifications fonctionnelles statiques et dynamiques		rq	**Essai de contrôle**, ou **contrôle redondant** et comparaison, ou **moyen de reconnaissance d'erreur**	H.3.18.21 H.3.18.17 H.3.18.6
9. Composants sur mesure [f] Par exemple, circuit intégré spécifique, réseau prédiffusé, réseau logique	Toutes sorties hors des spécifications fonctionnelles statiques et dynamiques	rq		Autotest périodique	H.3.16.6
			rq	Autotest périodique et contrôle, ou	H.3.16.7
				deux voies (différentes) avec comparaison, ou	H.3.16.2
				moyen de reconnaissance d'erreur	H.3.18.6

CPU: unité centrale de programmation

rq: couverture de panne exigée pour la classe de logiciel indiquée.

[a] Le Tableau H.2 s'applique conformément aux exigences de H.9.12 à H.9.12.2.11 inclus.

[b] Pour l'évaluation de **panne**/erreur, certains éléments constituants sont divisés en leurs sous-fonctions.

[c] Pour chaque sous-fonction du tableau, la mesure de la classe de logiciel C couvre la **panne**/erreur de la classe de logiciel B.

[d] Il est reconnu que certaines des mesures acceptables procurent un niveau d'assurance supérieur à celui exigé par le présent document.

[e] Quand il y a plusieurs mesures données par sous-fonction, celles-ci sont alternatives.

[f] A diviser en sous-fonctions, autant que nécessaire, par le fabricant.

H.9.12.2.5 D'autres mesures que celles spécifiées en H.9.12.2.4 sont permises s'il peut être montré qu'elles satisfont aux exigences énumérées dans le Tableau H.2.

H.9.12.2.6 La détection de **pannes**/erreurs par logiciel doit avoir lieu dans un laps de temps inférieur ou égal à celui déclaré dans le Tableau H.1, exigence H.8. L'acceptabilité du ou des temps déclarés est évaluée pendant l'analyse des **pannes** du dispositif de commande.

Les Parties 2 de la présente norme peuvent limiter cette déclaration.

H.9.12.2.7 Pour les dispositifs de commande avec fonctions, classées dans la classe B ou C, la détection d'une **panne**/erreur doit avoir pour résultat la réponse déclarée dans le Tableau H.1, exigence H.9. Pour les dispositifs de commande avec fonctions déclarées comme de classe C, des moyens indépendants capables d'exécuter cette réponse doivent être fournis.

H.9.12.2.8 Pour une fonction de commande utilisant une structure deux voies avec logiciels de classe C, la perte de la capacité deux voies est jugée comme étant une erreur.

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H.9.12.2.9 Le logiciel doit faire référence aux parties concernées de la séquence de fonctionnement et aux fonctions associées du matériel.

H.9.12.2.10 Le logiciel doit être protégé contre les modifications par l'utilisateur des segments et des données liés à la sécurité.

H.9.12.2.11 Le logiciel et le matériel lié à la sécurité dans le dispositif de commande doivent être initialisés et refermés comme indiqué dans le Tableau H.1, exigence H.4.

H.9.12.3 Mesures pour éviter les erreurs

H.9.12.3.1 Généralités

Pour les **dispositifs de commande** avec logiciels de classe B ou C, les mesures présentées à la Figure H.1 pour prévenir les **pannes** systématiques doivent être appliquées.

Les mesures utilisées pour les logiciels de classe C sont intrinsèquement acceptables pour les logiciels de classe B.

Le contenu est extrait de l'IEC 61508-3 et adapté aux besoins du présent document.

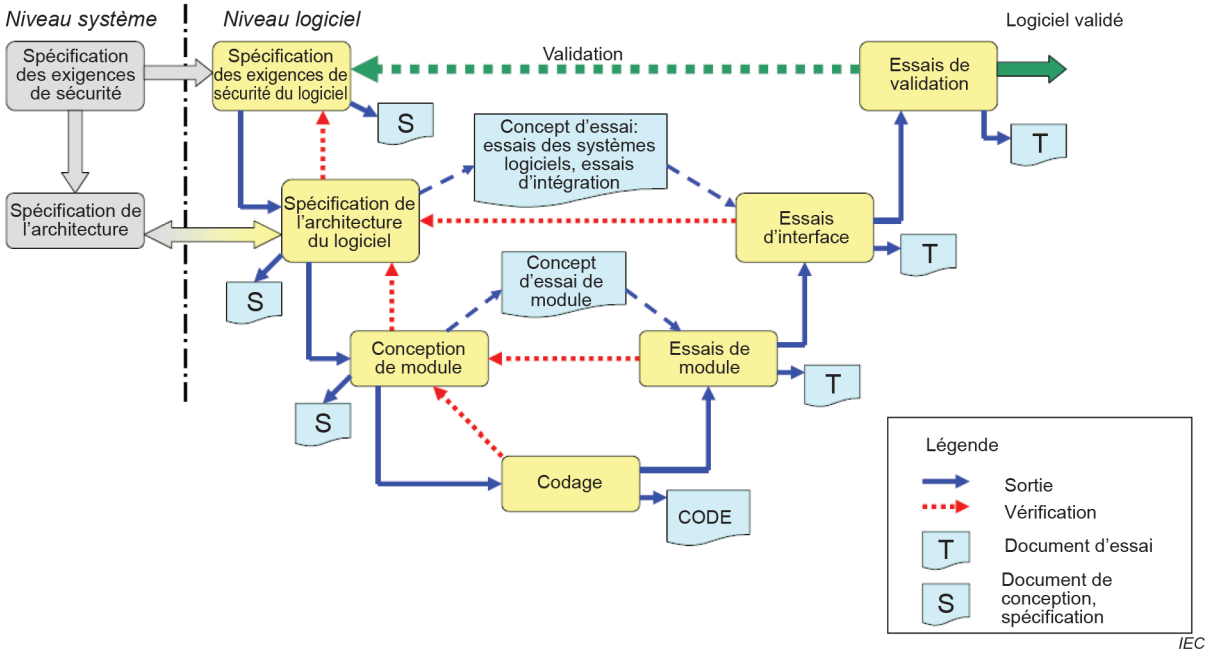


Figure H.1 – Modèle V pour le cycle de vie des logiciels

D'autres modèles pour le cycle de vie des logiciels sont autorisés s'ils incorporent des processus disciplinés et structurés comportant les phases de projet et d'essai.

H.9.12.3.2 Spécification

H.9.12.3.2.1 Exigences relatives à la sécurité des logiciels

H.9.12.3.2.1.1 La spécification des exigences relatives à la sécurité des logiciels doit comprendre

– une description de chaque fonction liée à la sécurité devant être mise en œuvre, y compris le ou les temps de réponse:

  • les fonctions liées à l'application, y compris leurs classes de logiciels correspondantes;

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- les fonctions liées à la détection, l'annonce et la gestion des **pannes** logicielles ou matérielles;

– une description des interfaces entre logiciel et matériel;

– une description des interfaces entre les fonctions liées et non liées à la sécurité.

Des exemples de techniques et de mesures peuvent être consultés dans le Tableau H.3.

Tableau H.3 – Exemples de techniques/mesures pour les méthodes semi-formelles

Technique/mesure	Références (informatives)
Identification des normes	
Méthodes semi-formelles	
– Ordinogrammes logiques/fonctionnels	
– Diagrammes de séquence	
– Automates finis/diagrammes de transition d'état	IEC 61508-7:2010, B.2.3.2
– Tables de décision/vérité	IEC 61508-7:2010, C.6.1

H.9.12.3.2.2 Architecture logicielle

H.9.12.3.2.2.1 La description de l'architecture logicielle doit comprendre les aspects suivants:

– techniques et mesures pour contrôler les **pannes**/erreurs de logiciel (voir H.9.12.2);

– interactions entre matériel et logiciel;

– partitionnement en modules et leur attribution aux fonctions de sécurité spécifiées;

– hiérarchie et structure d'appel des modules (flux de **commande**);

– gestion des interruptions;

– flux de données et restrictions sur l'accès aux données;

– architecture et stockage des données;

– dépendances temporelles des séquences et des données.

Des exemples de techniques et de mesures peuvent être consultés dans le Tableau H.4.

Tableau H.4 – Exemples de techniques/mesures pour la spécification de l'architecture logicielle

Technique/mesure	Références (informatives)
Détection de **panne** et diagnostic	IEC 61508-7:2010, C.3.1
Méthodes semi-formelles:	
– Ordinogrammes logiques/fonctionnels	
– Diagrammes de séquence	
– Automates finis/diagrammes de transition d'état	IEC 61508-7:2010, B.2.3.2
− Diagrammes de flux de données	IEC 61508-7:2010, C.2.2

H.9.12.3.2.2.2 La spécification d'architecture doit être vérifiée par rapport à la spécification des exigences relatives à la sécurité des logiciels par une analyse statique.

NOTE Les méthodes acceptables pour l'**analyse statique** sont:

– l'analyse des flux de **commande**,

– l'analyse des flux de données,

– les **contrôles collectifs**/revues de conception.

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H.9.12.3.2.3 Conception de module et codage

NOTE 1 L'utilisation d'outils de conception assistée par ordinateur est acceptée.

NOTE 2 Pour la programmation défensive (par exemple, contrôles de plages ou par fourchette, vérification pour division par zéro, **contrôles de vraisemblance**), voir IEC 61508-7:2010, C.2.5.

H.9.12.3.2.3.1 Sur la base de la conception de l'architecture, les logiciels doivent être convenablement affinés en modules. La conception de module de logiciel et le codage doivent être mis en œuvre d'une manière traçable par rapport à l'architecture et aux exigences des logiciels.

La conception du module doit préciser

– la ou les fonctions,
– les interfaces aux autres modules,
– les données.

Des exemples de techniques et de mesures peuvent être consultés dans le Tableau H.5.

Tableau H.5 – Exemples de techniques/mesures pour la spécification relative à la conception des modules

Technique/mesure	Références (informatives)
Taille limitée des modules de logiciels	IEC 61508-7:2010, C.2.9
Masquage/encapsulation des informations	IEC 61508-7:2010, C.2.8
Un point d'entrée/un point de sortie dans les sous-programmes et les fonctions	IEC 61508-7:2010, C.2.9
Interface complètement définie	IEC 61508-7:2010, C.2.9
Méthodes semi-formelles:	
– Ordinogrammes logiques/fonctionnels	
– Diagrammes de séquence	
– Automates finis/diagrammes de transition d'état	IEC 61508-7:2010, B.2.3.2
– Diagrammes de flux de données	IEC 61508-7:2010, C.2.2

H.9.12.3.2.3.2 Le code du logiciel doit être structuré.

NOTE La complexité de la structure peut être réduite au maximum en appliquant les principes suivants:

– maintenir faible le nombre de chemins possibles dans un module de logiciel et rendre aussi simple que possible la relation entre les paramètres d'entrée et de sortie;
– éviter les branchements compliqués et, en particulier, éviter les sauts inconditionnels (GOTO) dans les langages de plus haut niveau;
– dans la mesure du possible, relier les contraintes et les bifurcations aux paramètres d'entrée;
– éviter d'utiliser des calculs complexes comme base des décisions relatives aux bifurcations et aux boucles.

Des exemples de techniques et de mesures peuvent être consultés dans le Tableau H.6.

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Tableau H.6 —Exemples de techniques/mesures pour les normes de conception et de codage

Technique/mesure	Références (informatives)
Utilisation d'une norme de codage (voir H.9.12.3.2.4)	IEC 61508-7:2010, C.2.6.2
Pas d'utilisation d'objets ni de variables dynamiques (voir Note)	IEC 61508-7:2010, C.2.6.3
Utilisation limitée des interruptions	IEC 61508-7:2010, C.2.6.5
Utilisation limitée des pointeurs	IEC 61508-7:2010, C.2.6.6
Utilisation limitée de la récursion	IEC 61508-7:2010, C.2.6.7
Pas de saut inconditionnel dans les programmes en langages de plus haut niveau	IEC 61508-7:2010, C.2.6.2
L'utilisation d'objets et/ou de variables dynamiques est permise en cas d'utilisation d'un ordinateur qui assure qu'une mémoire suffisante pour tous les objets et/ou variables dynamiques est allouée avant l'exécution ou qui insère des contrôles d'exécution pour l'allocation en ligne correcte de la mémoire.	

H.9.12.3.2.3.3 Le logiciel codé doit être contrôlé par rapport à la spécification de modules et cette spécification de modules doit être contrôlée par rapport à la spécification d'architecture par une analyse statique.

NOTE Les exemples de méthodes pour l'**analyse statique** sont

– l'analyse des flux de **commande**,

– l'analyse des flux de données,

– les **contrôles collectifs**/revues de conception.

H.9.12.3.2.4 Normes de conception et de codage

Les normes de conception et de codage des programmes doivent être utilisées en conséquence pendant la conception et la maintenance des logiciels.

Les normes de codage doivent préciser la pratique de programmation, proscrire les caractéristiques dangereuses du langage et spécifier les procédures concernant la documentation du code source ainsi que les règles d'affectation de noms aux données.

H.9.12.3.3 Essais

H.9.12.3.3.1 Conception de module (conception de système logiciel, conception de module de logiciel et codage)

H.9.12.3.3.1.1 Un concept d'essai avec des essais élémentaires convenables doit être défini sur la base de la spécification relative à la conception des modules.

H.9.12.3.3.1.2 Chaque module de logiciel doit être soumis à essai comme spécifié dans le concept d'essai.

H.9.12.3.3.1.3 Les essais élémentaires, les données d'essai et les résultats d'essai doivent être documentés.

H.9.12.3.3.1.3 La vérification du code d'un module de logiciel par des moyens statiques comprend des techniques telles que les **inspections** de logiciels, les **contrôles collectifs**, l'**analyse statique** et la preuve formelle.

La vérification du code d'un module de logiciel par des moyens dynamiques comprend les essais fonctionnels, les essais de boîte blanche et les essais statistiques.

Elle est la combinaison des deux types de preuves qui fournit l'assurance que chaque module de logiciel satisfait à sa spécification associée.

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Des exemples de techniques et de mesures peuvent être consultés dans le Tableau H.7.

Tableau H.7 – Exemples de techniques/mesures pour les essais de module de logiciel

Technique/mesure	Références (informatives)
Analyse dynamique et essais:	IEC 61508-7:2010, B.6.5
– exécution d'essais élémentaires à partir de l'analyse des valeurs aux limites,	IEC 61508-7:2010, C.5.4
– essais basés sur la structure.	IEC 61508-7:2010, C.5.8
Enregistrement des données et analyse	IEC 61508-7:2010, C.5.2
Essais fonctionnels et de boîte noire:	IEC 61508-7:2010, B.5.1, B.5.2
– analyse des valeurs aux limites,	IEC 61508-7:2010, C.5.4
– simulation de processus.	IEC 61508-7:2010, C.5.18
Essais de performance:	IEC 61508-7:2010, C.5.20
– essais d'avalanche/contrainte,	IEC 61508-7:2010, C.5.21
– temps de réponse et contraintes de mémoire.	IEC 61508-7:2010, C.5.22
Essais d'interface	IEC 61508-7:2010, C.5.3

NOTE Les essais de module de logiciel constituent une activité de vérification.

H.9.12.3.3.2 Essai d'intégration de logiciel

H.9.12.3.3.2.1 Un concept d'essai avec des essais élémentaires convenables doit être défini sur la base de la spécification relative à la conception de l'architecture.

H.9.12.3.3.2.2 Le logiciel doit être soumis à essai comme spécifié dans le concept d'essai.

H.9.12.3.3.2.3 Les essais élémentaires, les données d'essai et les résultats d'essai doivent être documentés.

Des exemples de techniques et de mesures peuvent être consultés dans le Tableau H.8.

Tableau H.8 – Exemples de techniques/mesures pour les essais d'intégration de logiciel

Technique/mesure	Références (informatives)
Essais fonctionnels et de boîte noire:	IEC 61508-7:2010, B.5.1, B.5.2
– analyse des valeurs aux limites,	IEC 61508-7:2010, C.5.4
– simulation de processus.	IEC 61508-7, C.5.18
Essais de performance:	IEC 61508-7:2010, C.5.20
– essais d'avalanche/contrainte,	IEC 61508-7:2010, C.5.21
– temps de réponse et contraintes de mémoire.	IEC 61508-7:2010, C.5.22

NOTE Les essais d'intégration de logiciel constituent une activité de vérification.

H.9.12.3.3.3 Validation de logiciel

H.9.12.3.3.3.1 Un concept de validation avec des essais élémentaires convenables doit être défini sur la base de la spécification des exigences relatives à la sécurité des logiciels.

H.9.12.3.3.3.2 Le logiciel doit être validé par référence aux exigences de la spécification des exigences relatives à la sécurité des logiciels telle que définie dans le concept de validation.

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Le logiciel doit être exécuté par simulation ou stimulation des

– signaux d'entrée présents au cours du **fonctionnement** normal,
– occurrences anticipées,
– conditions indésirables exigeant une action du **système**.

H.9.12.3.3.3.3 Les essais élémentaires, les données d'essai et les résultats d'essai doivent être documentés.

Des exemples de techniques et de mesures peuvent être consultés dans le Tableau H.9.

Tableau H.9 – Exemples de techniques/mesures pour la validation de la sécurité des logiciels

Technique/mesure	Références (informatives)
Essais fonctionnels et de boîte noire:	IEC 61508-7:2010, B.5.1, B.5.2
– analyse des valeurs aux limites,	IEC 61508-7:2010, C.5.4
– simulation de processus.	IEC 61508-7:2010, C.5.18
Simulation, modélisation:	
– automates finis,	IEC 61508-7:2010, B.2.3.2
– modélisation du fonctionnement.	IEC 61508-7:2010, C.5.20

NOTE Les essais sont la principale méthode de validation des logiciels; la modélisation peut être utilisée en complément des activités de validation.

H.9.12.3.4 Autres éléments

H.9.12.3.4.1 Outils, langages de programmation

Les matériels utilisés pour la conception, la vérification et la maintenance des logiciels, tels que les outils de conception, les langages de programmation, les traducteurs et les outils d'essai, doivent être qualifiés de façon appropriée et il doit être montré qu'ils sont adaptés à l'emploi dans des applications multiples.

Ils sont considérés comme adaptés s'ils se conforment avec "confiance accrue résultant de l'utilisation" conformément à l'IEC 61508-7:2010, C.4.4.

H.9.12.3.4.2 Gestion des versions de logiciel

Un **système** de gestion des versions de logiciel au niveau du module doit être mis en place. Toutes les versions doivent être identifiées de façon unique pour la traçabilité.

H.9.12.3.4.3 Modification de logiciel

H.9.12.3.4.3.1 Les modifications de logiciel doivent être fondées sur une demande de modification qui précise dans le détail les points suivants:

– les **dangers** affectés,
– la modification proposée,
– les raisons de la modification.

H.9.12.3.4.3.2 Une analyse doit être effectuée pour déterminer l'impact de la modification proposée sur la sécurité fonctionnelle.

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H.9.12.3.4.3.3 Une spécification détaillée pour la modification doit être générée en comportant les activités nécessaires pour la vérification et la validation telles qu'une définition des essais élémentaires appropriés.

H.9.12.3.4.3.4 La modification doit être apportée comme prévu.

H.9.12.3.4.3.5 L'évaluation de la modification doit être effectuée sur la base des activités de vérification et de validation spécifiées. Cela peut comprendre:

– une revérification des modules de logiciel modifiés,
– une revérification des modules de logiciel affectés,
– une revalidation du **système** complet.

H.9.12.3.4.3.6 Tous les détails des activités de modification doivent être documentés.

H.9.12.3.5 Pour les **fonctions de commande de classe C**, le fabricant doit utiliser l'une des combinaisons (a-p) de mesures analytiques données dans les colonnes du Tableau H.10 pendant la mise au point du matériel.

Tableau H.10 – Combinaisons de mesures analytiques pendant la mise au point du matériel

Etape de mise au point du matériel		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
H.3.17.5	**Inspection**	x		x		x		x		x		x		x		x	
H.3.17.9	**Contrôle collectif**				x		x		x		x		x		x		x
H.3.17.7.1	**Analyse statique**	x	x							x	x						
H.3.17.1	**Analyse dynamique**			x	x							x	x				
H.3.17.3	**Analyse du matériel**					x	x							x	x		
H.3.17.4	**Simulation de matériel**							x	x							x	x
H.3.17.2	**Calcul du taux de défaillance**	x	x	x	x	x	x	x	x								
H.3.20.3	**AMDE**									x	x	x	x	x	x	x	x
H.3.17.6	**Essai opérationnel**	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

H.9.12.4 Fonctions de commande à distance

H.9.12.4.2.3 Communication des données relatives à la sécurité

H.9.12.4.2.3.1 Transmission

Les données relatives à la sécurité doivent être transmises avec authentification ou validation pour ce qui concerne:

– l'altération des données,
– l'altération des adresses,
– une temporisation ou séquence erronée.

La variation des données ou des données altérées ne doivent pas donner lieu à un état d'insécurité. Avant d'utiliser les données transmises, il faut s'assurer que les éléments ci-dessus sont traités au moyen des mesures spécifiées à l'Annexe H de la même classe de logiciel ou supérieure utilisée par la fonction considérée.

La conformité est vérifiée par évaluation conformément au Tableau H.11 qui fournit les menaces à prendre en compte, ainsi que des exemples de protections contre l'accès non autorisé et de modes de défaillance de transmission.

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NOTE Une attention particulière est accordée au Tableau H.2, point "6. Communication externe" pour ce qui concerne les éléments suivants:

- suppression de données du message d'origine;
- insertion de données dans le message d'origine;
- altération des données dans le message d'origine;
- modification de séquence des données dans le message d'origine;
- rédaction d'un message non authentifié s'assimilant à un message authentifié;
- adresse incomplète;
- altération de l'adresse du message d'origine;
- adresse erronée;
- plusieurs adresses;
- plusieurs réceptions de message;
- retard de transmission ou de réception du message;
- séquence erronée de transmission/réception;
- "transmission automatique" ou répétition permanente;
- interruption du transfert de données.

H.9.12.4.2.3.2 Accès à l'échange de données

Pour les données de fonctionnement associées à la **fonction de commande de classe B** ou la **fonction de commande de classe C**, il est admis de transmettre les paramètres de configuration et/ou les modules de logiciel par voie de communication, si des mesures adaptées d'ordre matériel/logiciel sont prises pour éviter tout accès non autorisé à la fonction de **commande**. Des exemples sont donnés dans le Tableau H.11.

Pour l'accès à l'échange des données de fonctionnement associées à la **fonction de commande de classe B** ou la **fonction de commande de classe C** par des **réseaux publics**, des **techniques de chiffrement** appropriées doivent être mises en œuvre. Voir H.9.12.4.6.

NOTE Les aspects concernant la sécurité relèvent des travaux du comité d'études mixte JTC 1/SC 27 de l'ISO/IEC (CE 205).

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Tableau H.11 – Exemples de protections contre l'accès non autorisé et de modes de défaillance de transmission

		Protections							
A couvrir	**Menaces**	**Numéro de séquence[b]**	**Horodatage[c]**	**Temporisation[d]**	**Message de réponse[e]**	**Identifiant de destination source[f]**	**Procédure d' identification**	**Code de sécurité[g]**	**Techniques de chiffrement**
Modes de défaillance de transmission[h]	Répétition d'un message	x	x						
	Suppression d'un message	x							
	Insertion d'un message	x			x	x	x		
	Reséquencement des données d'un message	x	x						
	Corruption, suppression ou insertion de données dans un message							x [a]	x
	Retard de transmission/réception du message		x	x					
Accès non autorisé	Déguisement[i]				x		x		x

Des exemples de protections contre les accès non autorisés peuvent aussi être trouvés dans les applications couvertes par l'IEC 62280.

[a] Voir Tableau H.2, points 6.1 et 6.2.

[b] Champ de données supplémentaire contenant un numéro qui varie de manière prédéfinie d'un message à l'autre.

[c] Information concernant le temps de transmission associé à un message par l'émetteur.

[d] Délai entre deux messages dépassant une durée maximale admise préalablement définie.

NOTE 1 Si c'est le cas, une erreur peut être envisagée.

[e] Réponse d'un destinataire à l'émetteur, par l'intermédiaire d'une voie de retour.

[f] Identifiant attribué à chaque entité.

NOTE 2 Cet identifiant peut être un nom, un numéro ou une configuration binaire arbitraire. Cet identifiant est utilisé pour la communication liée à la sécurité. Il est généralement ajouté aux données utilisateur.

[g] Données redondantes incluses dans un message lié à la sécurité permettant à la fonction de transmission liée à la sécurité de détecter la corruption de données.

[h] Ces modes de défaillance sont de nature aléatoire et systématique.

[i] Déguisement: action consistant à rendre un message non authentifié semblable à un message authentifié par un utilisateur non autorisé.

H.9.12.4.2.3.3 Révision des logiciels de classe B et de classe C

Les exigences de H.9.12.3 doivent s'appliquer aux révisions des logiciels de classe B et de classe C. En outre, la gestion de configuration matérielle doit être exigée et des mesures doivent être prises pour garantir que le **dispositif de commande** conserve ses fonctions de protection conformément au présent document.

NOTE La gestion de la configuration matérielle est censée venir en complément de la vérification logicielle afin de maintenir l'intégrité du **dispositif de commande**. Les implications au niveau du **système** sont prises en compte.

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H.9.12.4.5 Téléchargement et installation de logiciels

H.9.12.4.5.1 Les mises à jour du logiciel pour les logiciels de classe B et de classe C fournies par le fabricant et transmises au dispositif de commande par voie de communication à distance doivent être vérifiées, au dispositif de commande, avant son utilisation:

– pour ce qui concerne toute corruption par voie de communication assurant une **distance de Hamming** 3 pour les logiciels de classe B ou une **distance de Hamming** 4 pour les logiciels de classe C (se reporter au Tableau H.2 pour la communication externe);
– si la version du logiciel est compatible avec la version du matériel du **dispositif de commande** selon la documentation de gestion des versions.

De plus, le logiciel qui effectue les contrôles susmentionnés doit contenir les mesures de contrôle des conditions de **panne**/erreur spécifiées en H.9.12.2.

H.9.12.4.5.2 Dans le cas d'un téléchargement du logiciel par voie de communication à distance, les **techniques de chiffrement** décrites en H.9.12.4.6 doivent être fournies. Outre les exigences mentionnées en H.9.12.4.6, des procédures d'identification doivent également être fournies pour les progiciels.

Les **techniques de chiffrement** employées doivent faire partie intégrante du **dispositif de commande**, et ne doivent pas reposer sur une partie du routeur ou un dispositif de **transmission** des données analogue proprement dit, et doivent être appliquées préalablement à la **transmission**.

H.9.12.4.5.3 Pour chaque mise à jour du logiciel, le **dispositif de commande** doit comporter des dispositions d'autorisation par l'utilisateur et un numéro d'identification de version qui doit être accessible.

H.9.12.4.5.4 L'installation d'un logiciel de classe B ou d'un logiciel de classe C est admise lorsque, pendant et après le processus d'installation du logiciel, le **dispositif de commande** demeure conforme aux exigences du présent document.

La conformité est vérifiée par examen du logiciel.

H.9.12.4.6 Techniques de chiffrement

Dans les cas où les données de fonctionnement associées à la **fonction de commande de classe B** ou la **fonction de commande de classe C**, les paramètres de configuration et/ou les modules de logiciel sont transmis par un **réseau public**, et/ou lorsque les mises à jour de logiciels sont fournies par le fabricant par voie de communication à distance, des **techniques de chiffrement** doivent être employées.

La conformité est vérifiée par examen du logiciel et revue de la documentation technique qui assure le respect des méthodes de protection de l'intégrité des données communément acceptées.

NOTE Des exemples de **techniques de chiffrement** communément acceptées sont définis et décrits dans l'ISO/IEC 9796, l'ISO/IEC 9797, l'ISO/IEC 9798, l'ISO/IEC 10118, l'ISO/IEC 11770, l'ISO/IEC 14888, l'ISO/IEC 15946, l'ISO/IEC 18033, l'ISO/IEC 29192, ainsi que l'ISO/IEC 19772.

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H.13 Évaluation des pannes sur les circuits électroniques

H.13.2 Évaluation des pannes pour assurer la sécurité fonctionnelle

H.13.2.1 Exigences relatives à la conception et à la construction

H.13.2.1.1 Évitement des pannes et tolérance aux pannes

Les **dispositifs de commande** comportant des fonctions de **commande** de classe B ou de classe C doivent être conçus conformément à H.13.2 en tenant compte des modes de **défaillance** du Tableau 14 et de H.9.12 pour les logiciels, le cas échéant.

Les **défaillances** des **électroniques complexes** peuvent être dues soit à des erreurs systématiques (intégrées à la conception, voir H.9.12.3), soit à des **pannes** aléatoires (**pannes** de composants, voir H.9.12.2). Par conséquent, le **système** doit être conçu de telle manière que les erreurs systématiques soient évitées et les **pannes** aléatoires doivent être traitées par une configuration correcte du **système**.

La conception du logiciel et du matériel doit être basée sur l'analyse fonctionnelle de l'application ayant comme résultat une conception structurée qui incorpore explicitement le flux de **commande**, le flux de données et les fonctions temporelles exigées par l'application. Dans le cas des puces personnalisées, une attention spéciale est exigée en ce qui concerne les mesures prises pour réduire le plus possible les erreurs systématiques.

Cela doit donner lieu à une configuration **système** soit qui est à sécurité intrinsèque, soit dans laquelle les composants dotés de fonctions directement critiques pour la sécurité (par exemple commandes de valve de gaz, microprocesseurs avec leurs circuits associés, etc.) sont protégés par des dispositifs de protection conformes à H.9.12, logiciels de classe B ou de classe C. Ces dispositifs de protection doivent être intégrés dans le matériel (par exemple, chien de garde, supervision de la tension d'alimentation) et peuvent être complétés par des logiciels (par exemple ROM-test, RAM-test, etc.). Il est important que ces dispositifs de protection puissent provoquer un **arrêt de sécurité complètement indépendant**.

Si le contrôle de créneau de temps est utilisé, il doit être sensible tant à la limite supérieure qu'à la limite inférieure de l'intervalle de temps. Les **pannes** induisant un décalage de la limite inférieure et/ou de la limite supérieure doivent être prises en compte.

Dans le cas d'une fonction de **commande** qui est classée en classe C, si une première **panne** dans le dispositif de protection primaire peut rendre inopérant le dispositif de protection, un dispositif de protection secondaire doit être fourni. Le temps de réaction du dispositif de protection secondaire doit être conforme à H.13.2.3.

NOTE 1 Les temps de réaction de ces dispositifs de protection peuvent être inférieurs ou égaux au **temps de tolérance aux pannes** correspondant.

NOTE 2 La protection secondaire peut être réalisée par:

a) un circuit physiquement séparé qui surveille le dispositif de protection primaire; ou

b) une action mutuelle entre le circuit protégé et le dispositif de protection primaire (par exemple un chien de garde protégé par le microprocesseur); ou

c) une action entre les dispositifs de protection primaires (par exemple une ROM-test protégeant une RAM-test).

Les composants doivent être dimensionnés sur la base des conditions les plus défavorables susceptibles de se produire dans le **dispositif de commande**, comme indiqué par le fabricant.

NOTE 3 Une **défaillance** de composant est susceptible de causer la **détérioration** de l'isolation critique pour la sécurité.

H.13.2.1.2 Documentation

La documentation doit être basée sur H.9.12.3.

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H.13.2.2 Fonction de commande de classe B

H.13.2.2.1 Exigences relatives à la conception et à la construction

Une **fonction de commande de classe B** doit être conçue de manière à rester ou passer dans un **état défini** dans des conditions de première **panne**. Une deuxième **panne indépendante** n'est pas prise en considération.

NOTE Une **défaillance** d'une **fonction de commande de classe B** en présence d'une autre **panne** de l'appareil, ou une **défaillance** d'une **fonction de commande de classe C** seule, pourrait entraîner un dysfonctionnement dangereux, un choc électrique, un incendie, des **dangers** mécaniques ou autres.

Le logiciel doit être conforme à la classe B de logiciels.

La classe de la fonction de **commande** doit être déclarée dans le Tableau H.1, exigence H.12.

L'évaluation doit être effectuée conformément à H.13.2.2.2 et H.13.2.2.3, et dans les conditions d'essai et sous les critères d'essai de H.13.2.5.

H.13.2.2.2 Première panne

Toute première **panne** (voir Tableau 14) dans un composant quelconque ou **panne** quelconque accompagnée d'une autre **panne** quelconque découlant de cette première **panne** doit se traduire par l'un ou l'autre des événements suivants

a) le **dispositif de commande** devient inopérant avec toutes les bornes de sortie de sécurité mises hors tension ou passées à un état où elles assurent une situation sécurisée;

b) le **dispositif de commande** réagit dans le **temps de réaction aux pannes** (déclaré dans le Tableau H.1, exigence H.11) en passant à un **état défini**, à condition que le **réarmement** ultérieur à partir de l'**état défini** dans la même condition de **panne** renvoie le **système** au même **état défini**;

c) le **dispositif de commande** continue de fonctionner, la **panne** étant identifiée au cours de la prochaine séquence de démarrage, le résultat étant a) ou b);

d) le **dispositif de commande** reste opérationnel conformément aux exigences fonctionnelles de sécurité indiquées dans la Partie 2 applicable.

La Partie 2 applicable doit spécifier le **temps de réaction aux pannes**, ainsi que l'applicabilité de c).

Pour l'**état défini** avec un actionneur mécanique, un essai jusqu'aux contacts de commutation non compris est suffisant. Si l'essai de l'**état défini** échoue, le **système** doit passer à l'**arrêt de sécurité**. La fréquence d'essai est spécifiée dans la Partie 2 applicable. Les **pannes** internes sur les composants du circuit de contrôle ne sont pas prises en compte.

H.13.2.2.3 Panne introduite au cours de l'état défini

Chaque fois que le **dispositif de commande** est en **état défini** sans **panne** interne, les exigences suivantes s'appliquent.

Toute première **panne** (accompagnée de toute autre **panne** induite par cette **panne**) dans un composant quelconque (voir Tableau 14) induite alors que le **dispositif de commande** reste dans un **état défini**, doit entraîner l'un ou l'autre des événements suivants

a) le **dispositif de commande** reste à l'**état défini**, les bornes de sortie de sécurité restant hors tension; ou

b) le **dispositif de commande** devient inopérant, toutes les bornes de sortie de sécurité restant hors tension; ou

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c) le **dispositif de commande** retourne en **fonctionnement** avec comme résultat a) ou b) comme mentionné dans le présent article à condition que les bornes de sortie de sécurité soient sous tension pendant un temps inférieur ou égal au **temps de réaction aux pannes** (déclaré dans le Tableau H.1, exigence H.11). Si la cause de l'**état défini** disparaît et le **dispositif de commande** retourne en **fonctionnement**, il doit fonctionner conformément aux exigences fonctionnelles de sécurité de la Partie 2 applicable.

H.13.2.3 Fonction de commande de classe C

H.13.2.3.1 Exigences relatives à la conception et à la construction

Une **fonction de commande de classe C** doit être conçue de manière à rester ou passer dans un **état défini** en cas de conditions de première et de deuxième **panne**. Une troisième **panne indépendante** n'est pas prise en compte.

NOTE Une **défaillance** d'une **fonction de commande de classe B** en présence d'une autre **panne** de l'appareil, ou une **défaillance** d'une **fonction de commande de classe C** seule, pourrait entraîner un dysfonctionnement dangereux, un choc électrique, un incendie, des **dangers** mécaniques ou autres.

Le logiciel doit être conforme à la classe C de logiciels.

La classe de la fonction de **commande** doit être identifiée dans le Tableau H.1, exigence H.12.

L'évaluation doit être effectuée conformément à H.13.2.3.2, H.13.2.3.3 et H.13.2.4, et dans les conditions d'essai et sous les critères d'essai de H.13.2.5.

H.13.2.3.2 Première panne

Toute première **panne** (voir Tableau 14) dans un composant quelconque ou **panne** quelconque accompagnée d'une autre **panne** quelconque découlant de cette première **panne** doit se traduire par l'un ou l'autre des événements suivants

a) le **dispositif de commande** devient inopérant avec toutes les bornes de sortie de sécurité mises hors tension ou passées à un état où elles assurent une situation sécurisée;

b) le **dispositif de commande** réagit dans le **temps de réaction aux pannes** (voir Tableau H.1, exigence H.11) en passant à un **état défini**, à condition que le réarmement ultérieur à partir de l'**état défini** dans la même condition de **panne** renvoie le **système** à l'**état défini**;

c) le **dispositif de commande** continue de fonctionner, la **panne** étant identifiée au cours de la prochaine séquence de démarrage, le résultat étant a) ou b);

d) le **dispositif de commande** reste opérationnel conformément aux exigences fonctionnelles de sécurité indiquées dans la Partie 2 applicable.

La Partie 2 applicable doit spécifier le **temps de réaction aux pannes**, ainsi que l'applicabilité de c).

H.13.2.3.3 Deuxième panne

Si l'évaluation de la première **panne** a pour résultat que le **dispositif de commande** reste opérationnel conformément aux exigences fonctionnelles de sécurité de la Partie 2 applicable [voir H.13.2.3.2 d)], n'importe quelle autre **panne indépendante** considérée conjointement avec la première **panne** doit avoir pour résultat H.13.2.3.2 a), b), c) ou d).

Au cours de l'évaluation, la deuxième **panne** doit seulement être considérée comme se produisant:

a) lorsqu'une séquence de démarrage a été exécutée entre la première et la deuxième **panne**; ou

b) 24 h après la première **panne**.

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La Partie 2 applicable doit spécifier l'applicabilité de a) ou de b) et le **temps de réaction aux pannes** (voir Tableau H.1, exigence H.11).

Elle peut aussi spécifier une durée différente dans laquelle la deuxième **panne** ne se produit pas, si elle est différente de 24 h.

H.13.2.4 Pannes introduites au cours de l'état défini

H.13.2.4.1 Généralités

Chaque fois que le **dispositif de commande** est en **état défini** sans **panne** interne, une évaluation selon H.13.2.4.2 et H.13.2.4.3 doit être réalisée.

Chaque fois que le **dispositif de commande** est inopérant avec toutes les bornes de sortie de sécurité mises hors tension ou dans un état où elles assurent une situation sécurisée, en **état défini** avec une **panne** interne, une évaluation de première **panne** supplémentaire selon H.13.2.4.3 doit être effectuée.

NOTE Une borne de sortie de sécurité telle qu'utilisée en H.13.2.4.2 et en H.13.2.4.3 est une borne qui est liée à la sécurité même en **arrêt de sécurité** ou en **état défini**, par exemple une borne de valve à gaz, mais pas une borne pour un actionneur commandant l'élément de commande qui ne dégrade pas la sécurité en **état défini**.

H.13.2.4.2 Première panne introduite au cours de l'état défini

Toute première **panne** (accompagnée de toute autre **panne** induite par cette **panne**) dans un composant quelconque (voir Tableau 14), induite alors que le **dispositif de commande** reste dans une position d'**arrêt de sécurité**, doit entraîner l'un ou l'autre des événements suivants:

a) le **dispositif de commande** reste en **état défini**, les bornes de sortie de sécurité restant hors tension ou dans un état où elles assurent une situation sécurisée;

b) le **dispositif de commande** devient inopérant avec toutes les bornes de sortie de sécurité restantes mises hors tension ou passées à un état où elles assurent une situation sécurisée;

c) le **dispositif de commande** retourne en **fonctionnement** avec comme résultat a) ou b) comme mentionné en H.13.2.4.2 à condition que les bornes de sortie de sécurité soient sous tension pendant un temps inférieur ou égal au **temps de réaction aux pannes** (voir Tableau H.1, exigence H.11). Si la cause de la condition initiale d'**arrêt de sécurité** disparaît et le **dispositif de commande** retourne en **fonctionnement**, il doit fonctionner conformément aux exigences fonctionnelles de sécurité de la Partie 2 applicable et l'évaluation de la deuxième **panne** doit être effectuée conformément à H.13.2.3.3.

H.13.2.4.3 Deuxième panne introduite au cours de l'état défini

Toute deuxième **panne** (accompagnée de toute autre **panne** induite par cette **panne**) dans un composant quelconque (voir Tableau 14) induite alors que le **dispositif de commande** reste dans un **état défini**, doit entraîner l'un ou l'autre des événements suivants: H.13.2.4.2 a), b) ou c).

Au cours de l'évaluation, il ne faut pas considérer que la deuxième **panne** puisse se produire dans les 24 h après la première **panne**.

La Partie 2 applicable doit spécifier le **temps de réaction aux pannes**.

Elle peut aussi spécifier une durée différente dans laquelle la deuxième **panne** ne se produit pas, si elle est différente de 24 h.

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H.13.2.5 Évaluation du circuit et de sa construction

H.13.2.5.1 Conditions d'essai

Les effets des **pannes** internes doivent être évalués par simulation et/ou par examen de la conception du circuit.

La **panne** doit être considérée s'être produite à n'importe quel stade de la séquence de programme du **dispositif de commande**.

Le **dispositif de commande** doit fonctionner ou être considéré comme fonctionnant dans les conditions suivantes:

a) sous la tension la plus défavorable dans la plage allant de 85 % à 110 % de la tension assignée d'alimentation;

b) soumis à la charge la plus défavorable déclarée par le fabricant;

c) à une température ambiante de (20 ± 5) °C, à moins qu'il n'y ait des raisons valables d'effectuer l'essai à une autre température de la plage déclarée par le fabricant;

d) avec tout **organe de manœuvre** placé dans la position la plus défavorable;

e) avec du papier de soie placé sur la ou les surfaces d'appui du **dispositif de commande**;

f) avec des étincelles de 3 mm de longueur environ ayant une énergie d'au moins 0,5 J appliquées aux composants qui sont susceptibles de libérer des gaz inflammables pendant l'essai.

H.13.2.5.2 Critères d'essai

Au cours de l'étude, il doit être vérifié que dans les conditions décrites ci-dessus, les critères suivants sont respectés.

a) Le **dispositif de commande** ne doit pas émettre de flammes, de métal chaud ou de matières plastiques chaudes, le papier de soie ne doit pas s'enflammer, aucune explosion ne doit entraîner la libération de gaz inflammables et toute flamme produite ne doit pas continuer de brûler plus de 10 s après la mise hors tension du générateur d'étincelles. Lorsqu'un **dispositif de commande** est incorporé avec un appareil quelconque, toute enveloppe fournie par l'appareil est prise en considération.

b) Si le **dispositif de commande** continue de fonctionner, il doit être conforme aux Articles 6 et 15. S'il cesse de fonctionner, il doit encore continuer de se conformer à l'Article 6.

c) Il ne doit pas y avoir de perte de fonction de protection.

Après les essais, il ne doit y avoir aucune détérioration des différentes parties du **dispositif de commande** pouvant résulter dans la non-conformité à l'Article 11.

H.13.2.5.3 Évaluation

Une étude approfondie du circuit doit être effectuée pour déterminer sa performance dans les conditions de **panne** spécifiées. Cette étude doit prendre la forme d'une analyse théorique et d'un essai de simulation d'une **défaillance** de composant. Des simulations de **pannes** peuvent également être réalisées pour simuler les **pannes** dans les dispositifs complexes, par exemple essais de simulation des EPROM.

Seul le logiciel de sécurité (logiciels de classe B et C) tel qu'identifié selon H.13.2.1.2 doit subir une évaluation plus poussée. Pour l'identification de la classe, une analyse par arbre de **pannes** peut être utilisée.

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H.17 Tolérances de fabrication et dérive

H.17.1 Les parties des dispositifs de commande qui participent à une **action de type 2** doivent répondre à des tolérances de fabrication suffisamment étroites en ce qui concerne leurs valeurs, temps et séquences de fonctionnement déclarés.

H.17.2 *La conformité est vérifiée par les essais appropriés de cet article.*

H.17.3 Pour les dispositifs de commande dont le fonctionnement normal prévu se traduit par leur destruction complète ou partielle (par exemple, dispositif de manœuvre unique), les essais des paragraphes appropriés de l'Article 19 sont considérés comme suffisants.

H.17.4 Pour les dispositifs de commande dont le fonctionnement dépend de la méthode de montage sur un matériel ou d'incorporation dans un matériel, la tolérance de fabrication et la dérive doivent être déclarées séparément sous la forme de valeurs comparatives. Il convient d'exprimer la tolérance de fabrication sous la forme d'une plage ou d'une fourchette (par exemple 10 K) et la dérive sous la forme de la variation d'une valeur (par exemple ±10 K ou +5 K, −10 K).

H.17.5 L'étroitesse doit être déterminée en soumettant à essai trois échantillons de la manière suivante:

H.17.5.1 L'appareil d'essai doit être tel que le dispositif de commande soit monté de la manière déclarée par le fabricant.

H.17.5.2 Pour les dispositifs de commande sensibles, l'appareil d'essai doit de préférence être commandé par le fonctionnement normal du dispositif.

H.17.5.3 Cependant, la nature exacte de l'appareil d'essai n'est pas déterminante, car il est destiné à fournir des valeurs comparatives, et non des valeurs de réponse. Il convient, cependant, qu'il stimule aussi exactement que possible les conditions de service normal du dispositif de commande.

H.17.5.4 L'essai doit normalement être effectué dans les conditions électriques suivantes: tension assignée maximale ($V_{R\ max}$) et courant assigné maximal ($I_{R\ max}$) à moins que des valeurs différentes aient été déclarées dans le Tableau 1, exigence 35.

H.17.5.5 Pour les dispositifs de commande sensibles, le taux de variation de la grandeur de manœuvre doit être quelconque, à moins qu'une valeur particulière n'ait été déclarée dans le Tableau 1, exigence 31.

H.17.5.6 La valeur de fonctionnement, le temps de fonctionnement ou la séquence de fonctionnement appropriés doivent être consignés pour chaque échantillon. Entre deux échantillons quelconques, la différence de valeur relevée ne doit en aucun cas dépasser la tolérance de fabrication déclarée.

H.17.5.7 Les valeurs relevées sont également utilisées comme valeurs de référence pour chaque échantillon lors de la répétition des essais correspondants après les essais d'environnement de l'Article 18 et les essais d'endurance de l'Article 19 pour permettre de déterminer la dérive.

H.17.6 Pour les dispositifs de commande dont le fonctionnement ne dépend pas de la méthode de montage sur un matériel ou d'incorporation dans un matériel (par exemple les minuteries, les dispositifs sensibles au courant, les dispositifs sensibles à la tension, les régulateurs d'énergie ou le courant de relâchement des dispositifs à fonctionnement électrique), l'étroitesse des tolérances doit être déterminée comme indiqué ci-dessous**.**

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H.17.6.1 La tolérance de fabrication et/ou la dérive peuvent être exprimées sous la forme d'une valeur absolue. Dans ce cas, une déclaration unique couvrant à la fois la tolérance de fabrication et la dérive peut être effectuée.

H.17.6.2 La valeur de fonctionnement, le temps de fonctionnement ou la séquence de fonctionnement approprié doivent être initialement mesurés pour tous les échantillons et doivent être compris dans les limites déclarées par le fabricant.

H.17.6.3 L'appareil d'essai doit simuler les conditions d'usage normal les plus sévères déclarées.

H.17.6.4 Si une valeur de la dérive a été déclarée séparément dans le Tableau 1, exigence 36, les valeurs mesurées pour chaque échantillon doivent être relevées pour servir de valeurs de référence lors de la répétition des essais après les essais d'environnement de l'Article 18 et les essais d'endurance de l'Article 19, pour permettre de déterminer la dérive.

H.17.7 Essais d'étalonnage des thermistances CTP

Voir J.17.1.

H.17.8 Essais d'étalonnage des thermistances CTN

Voir J.17.2.

H.19 Endurance

H.19.1 Exigences générales

H.19.1.3.3 Essai thermique cyclique

L'essai a pour objet de soumettre les composants d'un circuit électronique à un cycle entre les températures extrêmes qui peuvent se produire en **usage normal** et qui peuvent résulter des variations de la température ambiante, de la température de la surface de montage, de la tension d'alimentation ou du passage d'une condition de fonctionnement à une condition de non-fonctionnement et inversement.

Les essais qui sont nécessaires pour obtenir les conditions ci-dessus dépendent dans une large mesure du type particulier du **dispositif de commande** et seront développés si nécessaire dans la Partie 2 appropriée du présent document.

Les conditions suivantes doivent constituer la base de l'essai:

a) *Durée*

*14 jours ou la durée spécifiée dans la Partie 2 applicable, selon la valeur la plus élevée. Pour des **dispositifs de commande** assurant une **coupure électronique** (type 2.Y), 14 jours ou le nombre de cycles fixé dans le Tableau 1, exigences 19 et 20, suivant la valeur qui correspond à la plus longue durée d'essai.*

b) *Conditions électriques*

*Le **dispositif de commande** doit être chargé conformément aux valeurs assignées déclarées par le fabricant, la tension étant augmentée à 1,1* V_R*, avec l'exception que pendant 30 min à chaque période de 24 h de l'essai, la tension est réduite à 0,9* V_R*. La modification de la tension ne doit pas être synchronisée avec la modification de la température. Chaque période de 24 h doit aussi inclure au moins une période d'environ 30 s pendant laquelle la tension d'alimentation est coupée.*

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c) *Conditions thermiques*

La température ambiante et/ou la température de la surface de montage varient entre T_{max} ($T_{s\ max}$) *et* T_{min} ($T_{s\ min}$) *pour que la température des composants du circuit électronique varie cycliquement entre ses valeurs extrêmes. La vitesse de variation de la température ambiante et/ou de la surface de montage doit être d'environ 1 K/min et les températures extrêmes doivent être maintenues pendant approximativement 1 h.*

d) *Vitesse de* ***fonctionnement***

Pendant l'essai, le ***dispositif de commande*** *doit fonctionner cycliquement selon ses modes de fonctionnement à la vitesse la plus grande possible jusqu'à un maximum de six cycles par minute, en tenant compte de la nécessité de faire varier cycliquement la température des composants entre ses valeurs extrêmes.*

*Si un mode opérationnel, comme la commande de la vitesse, peut être ajusté par l'****utilisateur****, la période d'essai doit être divisée en trois périodes, l'une correspondant au* ***réglage*** *maximal, une autre au réglage minimal et une autre à un réglage intermédiaire.*

Pour des ***dispositifs de commande*** *assurant une* ***coupure électronique*** *(type 2.Y), l'essai comporte aussi le nombre déclaré de* ***fonctionnements*** *de l'état de conduction à celui de non-conduction et vice versa.*

H.25 Exigences de compatibilité électromagnétique (CEM) – Immunité

H.25.1 Exigences générales

Les **dispositifs de commande électronique** doivent être construits de manière à pouvoir résister aux effets des perturbations induites par le réseau et aux phénomènes électromagnétiques qui **peuvent** survenir en usage normal (voir NOTE 3 à l'article de 3.13.4). Pour les dispositifs de commande à **action de type 2**, les essais de l'Article H.25 sont également réalisés après que le dispositif de commande a réalisé sa fonction de sécurité.

Les critères d'évaluation pour le **dispositif de commande** appropriés au niveau d'essai 2, 3 et/ou 4 doivent être donnés par la Partie 2 appropriée. Se référer à tous les paragraphes de l'Article H.25 pour les détails complémentaires. Si aucune Partie 2 n'est applicable, le Tableau H.12 ou H.25.2 s'applique. Ces niveaux correspondent aux niveaux d'essai spécifiés dans les parties concernées de l'IEC 61000. La Partie 2 doit fournir des effets acceptables, critères d'évaluation, sur le **dispositif de commande** résultant des essais utilisant les niveaux d'essai 2 et/ou 3, comme en **fonctionnement** normal après l'essai au niveau d'essai 2 et le **fonctionnement** en sécurité du dispositif/l'arrêt en sécurité après l'essai au niveau d'essai 3. Les Parties 2 peuvent spécifier des niveaux d'essai plus élevés.

La Partie 2 doit spécifier les niveaux d'essai pour les essais de l'Article H.25. Au minimum, l'essai de niveau 3 est applicable aux **dispositifs de commande de protection** destinés à éviter le **fonctionnement** non sécurisé du matériel commandé, tels que coupe-circuit, verrouillage de porte des équipements pour le linge.

Les essais de l'Article H.25 ne sont pas applicables aux **dispositifs de commande non électronique** en raison de leur tolérance à de telles perturbations. Les essais appropriés pour les types spécifiques de **dispositifs de commande non électronique** peuvent être inclus dans d'autres articles de la Partie 2 appropriée.

La conformité est vérifiée aux niveaux d'essais indiqués dans le Tableau H.12 suivant. Les dispositifs de commande doivent être conformes à H.25.14.

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Tableau H.12 – Niveaux d'essai applicables en plus de l'Article 25

Type de dispositif de commande	Type d'action/classe de la fonction de commande	Essais applicables de l'Article H.25	Niveaux d'essai applicables correspondant à H.25.14.3 [a]
Dispositif de commande de fonctionnement [b]	**Type 2, classe B, classe C**	H.25.4 à H.25.13	2, 3 ou 4 comme spécifié
Dispositif de commande de protection	**Type 2, classe B, classe C**	H.25.4 à H.25.13	3
Dispositifs de commande de protection[c] déclarés dans le Tableau 1, exigence 66, destinés à être utilisés conformément à l'IEC 60335-1:2020	**Type 2, classe B, classe C**	H.25.4 à H.25.13	Niveaux d'essai applicables conformément à l'IEC 60335-1:2020, 19.11.4

[a] Les niveaux d'essai inférieurs doivent être pris en compte conformément aux parties pertinentes de l'IEC 61000-4.

[b] Le **système** de commande automatique de brûleur (IEC 60730-2-5) est un exemple de **dispositif de commande** de fonctionnement avec **fonction de commande de classe C**. Pour de tels **dispositifs de commande**, les niveaux d'essai applicables sont donnés dans la Partie 2.

[c] Conformément à l'IEC 60335-1:2020, un **dispositif de commande de fonctionnement** avec **fonction de commande de classe B** ou **de classe C** est un circuit électronique de protection.

H.25.2 Exigences particulières pour les dispositifs de commande incorporés et intégrés avec action de type 2

Pour les dispositifs de commande incorporés et intégrés avec une **action de type 2**, la conformité est vérifiée par les essais de H.25.5 et tout autre essai de l'Article H.25 qui est déclaré dans le Tableau H.1, exigence H.1.

NOTE La pertinence de chacun des essais de H.25 à un **dispositif de commande** donné peut être déterminée par référence à la norme de produit appropriée ou à la déclaration du fabricant de l'utilisation prévue du **dispositif de commande**.

La détermination de la pertinence inclut une évaluation:

– si le dispositif de commande est exposé à un type particulier de perturbation dans son application;

– si la réponse du dispositif de commande au type particulier de perturbation se rapporte à la sécurité dans son application.

H.25.3 Échantillon exigé

Un échantillon différent, tel que proposé, peut être utilisé pour chacun des essais. Le fabricant de dispositifs de commande peut choisir de faire effectuer plusieurs essais sur un même échantillon.

H.25.4 Essais d'immunité basse fréquence aux harmoniques et interharmoniques incluant les signaux transmis sur le réseau sur électrique alternatif.

*Pour les **dispositifs de commande** de protection déclarés dans le Tableau 1, exigence 66, l'essai suivant s'applique:*

*Le **dispositif de commande** est soumis à des signaux transmis sur le réseau sur électrique conformément à l'IEC 61000-4-13, le niveau d'essai de classe 2 s'appliquant.*

*Pendant l'essai, le **dispositif de commande** est alimenté à la tension assignée. Les niveaux d'essai de l'environnement de classe 2 conformément à l'IEC 61000-4-13:2002, l'IEC 61000-4-13/A1:2009 et l'IEC 61000-4-13/A2:2015, Tableaux 1 à 4 doivent être appliqués au réseau électrique alternatif de l'EUT. Le **dispositif de commande** est soumis à essai dans les conditions d'essai spécifiées dans la norme spécifique du **dispositif de commande**.*

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Les essais suivants sont exécutés conformément à l'IEC 61000-4-13:2002, l'IEC 61000-4-13/A1:2009 et l'IEC 61000-4-13/A2:2015, Figure 1a, pour l'environnement de classe 2:

– "combinaison d'harmoniques" (IEC 61000-4-13:2002, IEC 61000-4-13/A1:2009 et IEC 61000-4-13/A2:2015, 8.2.1);

– "courbe de Meister" (IEC 61000-4-13:2002, IEC 61000-4-13/A1:2009 et IEC 61000-4-13/A2:2015, 8.2.4).

H.25.5 Creux de tension, coupures de tension et variations de tension dans le réseau d'alimentation

Le **dispositif de commande** doit tolérer des creux de tension, des coupures de tension et variations de tension dans le réseau d'alimentation.

La conformité est vérifiée par les essais décrits en H.25.5.1.

H.25.5.1 Creux et coupures de tension

L'essai a pour objet de vérifier l'immunité du matériel aux creux de tension et aux coupures de tension. Les creux et coupures de tension sont causés par des **pannes** dans les réseaux basse tension, moyenne tension et haute tension (court-circuit ou des **pannes** de mise à la terre).

H.25.5.1.1 Niveaux d'essai pour les creux et les coupures de tension

Les valeurs d'essai indiquées dans le Tableau H.13 doivent être appliquées à tous les niveaux d'essai.

Tableau H.13 – Creux de tension, coupures brèves et variations de tension

Durée (50 Hz/60 Hz)	ΔU		
	30 %	60 %	100 %
Un demi-cycle de la forme d'onde d'alimentation			X
Un cycle de la forme d'onde d'alimentation			X
2,5/3 cycles de la forme d'onde d'alimentation	X	X	X
25/30 cycles de la forme d'onde d'alimentation	X	X	X
50/60 cycles de la forme d'onde d'alimentation	X	X	X
NOTE Lorsque les durées intermédiaires des coupures de tension peuvent affecter soit la sécurité intrinsèque du **dispositif de commande**, soit la sortie d'un **dispositif de commande** avec **action de type 2**, les Parties 2 peuvent indiquer des coupures de tension en d'autres points.			

H.25.5.1.2 Procédure d'essai pour les creux et coupures de tension

L'appareil et la procédure d'essai doivent être tels que décrits dans l'IEC 61000-4-11. Durant l'essai, le **dispositif de commande** doit être initialement mis en fonctionnement à sa tension assignée.

Les creux et coupures de tension, à un angle de phase aléatoire par rapport à la fréquence du réseau, doivent être effectués au moins trois fois dans les modes de fonctionnement pertinents.

Il convient de porter une attention particulière aux modes de fonctionnement dans lesquels le **dispositif de commande** peut être particulièrement sensible aux creux et coupures de tension.

Entre les creux et coupures de tension, un temps d'attente d'au moins 10 s doit être observé.

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Dans le cas d'un matériel triphasé, il peut être nécessaire d'appliquer des creux et coupures de tension soit sur les trois phases simultanément, soit sur une ou deux phases seulement.

Les **dispositifs de commande** de protection déclarés conformément au Tableau 1, exigence 66, doivent être soumis à des creux et des coupures de tension à des angles de phase aléatoires par rapport à la fréquence du réseau, ainsi qu'au passage à zéro de la tension d'alimentation.

H.25.5.2 Essai de variations de tension

L'essai a pour objet de vérifier l'immunité du **dispositif de commande** aux variations de tension pouvant se produire sur une courte période en raison d'une variation de la charge ou de l'énergie emmagasinée dans les réseaux d'alimentation locaux.

H.25.5.2.1 Niveaux d'essai pour les variations de tension

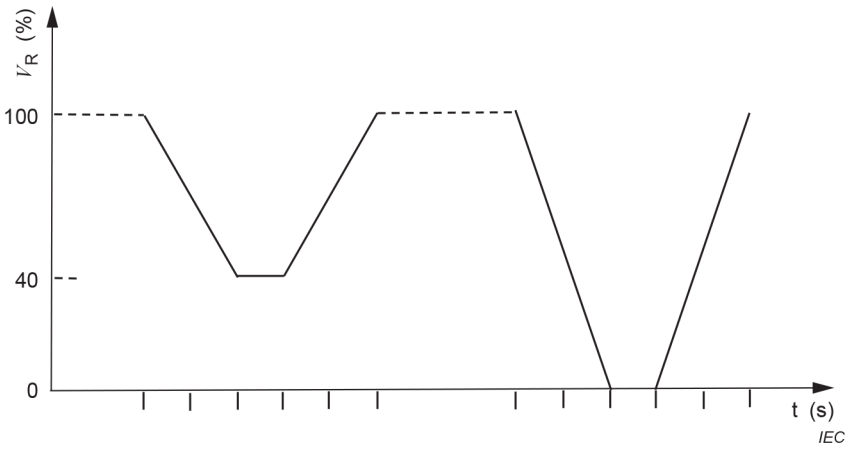
Les valeurs d'essai indiquées dans le Tableau H.14 doivent être appliquées à tous les niveaux d'essai.

H.25.5.2.2 Procédure d'essai

L'appareil et la procédure d'essai doivent être tels que décrits dans l'IEC 61000-4-11. La durée des variations de tension et le temps pendant lequel les tensions réduites sont à maintenir sont indiqués dans le Tableau H.14 et représentés à la Figure H.2. Le taux de variation de la tension doit être constant; toutefois, la tension peut varier par échelons. Les échelons doivent être positionnés à partir de 0 et ne doivent pas être plus élevés que 10 % de V_R. Les échelons en dessous de 1 % de V_R sont estimés à taux constant de la variation de tension.

Tableau H.14 – Valeurs d'essai pour les variations de tension

Niveau de tension d'essai	Temps pour réduction de tension	Temps à tension réduite	Temps pour augmentation de tension
40 % de V_R	2 s ± 20 %	1 s ± 20 %	2 s ± 20 %
0 % de V_R	2 s ± 20 %	1 s ± 20 %	2 s ± 20 %
	x	*x*	*x*
NOTE *x* représente un ensemble ouvert de durées et peut être spécifié dans une Partie 2.			



NOTE La tension décroît progressivement.

Figure H.2 – Essai de variation de tension

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Le **dispositif de commande** est soumis à chacun des cycles d'essai de tension spécifiés trois fois avec des intervalles de 10 s entre chaque cycle d'essai dans les modes de **fonctionnement** les plus représentatifs. Des niveaux d'essai de tension supplémentaires peuvent être spécifiés dans une Partie 2.

H.25.6 Essai d'influence du déséquilibre de tension

H.25.6.1 Objet de l'essai – Domaine d'application

Le présent essai ne s'applique qu'au matériel triphasé.

L'essai a pour objet d'étudier dans un **système** (circuit) de tension triphasée, l'influence du déséquilibre sur un matériel sensible à cette sorte de perturbation comme:

– la surchauffe des machines tournantes à courant alternatif;
– la génération d'harmoniques non caractéristiques dans les convertisseurs de puissance électroniques.

Le degré de déséquilibre est défini par le facteur de déséquilibre: $T_{\mathrm{i}} = \dfrac{U_{\mathrm{i}}}{U_{\mathrm{d}}} = \dfrac{\text{negative sequence voltage}}{\text{positive sequence voltage}}$

Anglais	Français
negative sequence voltage	tension de séquence négative
positive sequence voltage	tension de séquence positive

H.25.6.2 Caractéristique de la tension d'essai

Une tension triphasée à fréquence industrielle présentant le facteur de déséquilibre spécifié doit être appliquée au **dispositif de commande**.

NOTE Afin d'obtenir des résultats précis, une tension à très faible résidu harmonique peut être utilisée.

H.25.6.3 Matériel d'essai/générateur d'essai

Le montage d'essai doit consister en trois autotransformateurs monophasés, dont les sorties sont régulées individuellement, ou en des montages équivalents.

H.25.6.4 Niveau d'essai

L'essai doit être effectué avec un facteur de déséquilibre de 2 %.

H.25.7 Essai de l'influence du courant continu dans les réseaux à courant alternatif

NOTE Les exigences et essais sont à l'étude.

H.25.8 Essai d'immunité aux ondes de choc

Le **dispositif de commande** doit tolérer des tensions de choc sur l'alimentation principale et les bornes de signal appropriées.

La conformité est vérifiée par les essais décrits de H.25.8.2 à H.25.8.3 inclus.

H.25.8.1 Objet de l'essai

Cet essai s'applique aux bornes d'alimentation et, dans des cas spécifiques, aux bornes du ***dispositif de commande*** *(voir H.25.8.2).*

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*Les **dispositifs de commande** assurant la **coupure électronique** sont chargés comme indiqué en 19.2 et soumis aux mêmes niveaux d'essai que les classes d'installation spécifiées, pour les **dispositifs de commande**, par le fabricant (déclarées dans le Tableau 1, exigence 43), quand le **dispositif de commande** assure la **coupure électronique**. Pendant et après l'essai, le **dispositif de commande** doit continuer à assurer la **coupure électronique** comme déterminé par l'essai de 9.4.16.3. Si, durant l'essai, la **coupure électronique** devient conductrice pendant une demi-alternance de la fréquence d'alimentation après un choc, cela n'est pas considéré comme une **panne**.*

Cet essai a pour objet de vérifier l'immunité du **dispositif de commande** aux chocs unidirectionnels causés par différents phénomènes:

– phénomènes de commutation du réseau d'alimentation (par exemple commutation de batteries de condensateurs);
– **pannes** du réseau d'alimentation;
– coups de foudre.

La tension de choc induite peut avoir différents effets, selon l'impédance relative de la source et du **dispositif de commande**:

– si le **système** a une impédance élevée par rapport à la source, le choc produit une tension de choc;
– si le **dispositif de commande** a une impédance respective faible, le choc produit une impulsion de courant.

Ce comportement peut être représenté par un circuit d'entrée protégé par un suppresseur de surtension: aussitôt que ce dernier claque, l'impédance d'entrée devient très faible. Un essai réaliste doit correspondre à ce comportement et le générateur d'essai doit être capable de fournir une impulsion de tension sur une impédance élevée aussi bien qu'une impulsion de courant sur une impédance faible (générateur hybride).

H.25.8.2 Valeurs d'essai

Les essais présentés dans le Tableau H.15 doivent s'appliquer.

*Les essais sur les bornes des lignes de signaux, de données, de **dispositifs de commande** et d'autres lignes d'entrée ne doivent être effectués que si ces bornes sont conçues pour réaliser l'interconnexion avec des câbles de longueur supérieure à 10 m, conformément aux spécifications du fabricant.*

*Pour les **dispositifs de commande de protection** déclarés dans le Tableau 1, exigence 66, l'essai supplémentaire suivant s'applique:*

*Les bornes d'alimentation électrique du **dispositif de commande** sont soumises à une tension d'essai en circuit ouvert de 4 kV (applicable au mode de couplage entre phase et terre) en utilisant un générateur ayant une impédance de source utilisée de 12 Ω et à une tension d'essai en circuit ouvert de 2 kV (applicable au mode de couplage entre phases) en utilisant un générateur ayant une impédance de source utilisée de 2 Ω.*

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Tableau H.15 – Tensions d'essai pour le niveau d'essai 2 (en fonction des conditions de classe d'installation)

Valeurs d'essai crête kV										
Classe d'installation de l'IEC 61000-4-5	**Alimentation et E/S en courant alternatif**		**Alimentation et E/S en courant continu**		**Circuits et lignes non symétriques**		**Circuits et lignes symétriques**		**Circuits/lignes blindés**	
	Mode de couplage		**Mode de couplage**		**Mode de couplage**		**Mode de couplage**		**Mode de couplage**	
	Entre phases	**Entre phase et terre**	**Entre phases**	**Entre phase et terre**	**Entre phases[a]**	**Entre phase et terre**	**Entre phases**	**Entre phase et terre**	**Entre phases**	**Blindage à masse**
2	0,5	1,0	Pas d'essai	Pas d'essai	0,5	1,0	Pas d'essai	1,0	Pas d'essai	0.5
3	1,0	2,0	Pas d'essai	Pas d'essai	1,0	2,0	Pas d'essai	2,0	Pas d'essai	2,0
4	2,0	4,0	2,0	4,0	2,0	4,0	Pas d'essai	4,0	Pas d'essai	4,0

NOTE 1 Pour les exigences de niveau d'essai 3, appliquer la classe d'installation la plus élevée suivante. Pour les exigences de niveau d'essai 4, appliquer les valeurs de la classe d'installation 4.

NOTE 2 Les essais sont effectués quel que soit le suppresseur de chocs prévu correctement installé.

NOTE 3 Dans un **dispositif de commande**, une catégorie inférieure peut suivre une catégorie supérieure si des moyens de commande de **surtension transitoire** appropriés sont fournis.

NOTE 4 Voir Annexe N pour une description des classes d'installation et d'autres notes explicatives.

NOTE 5 Les lignes symétriques sont une paire de conducteurs entraînés symétriquement avec une perte de conversion entre le mode différentiel et le mode commun de plus de 20 dB. [SOURCE: IEC 61000-4-5:2014, 3.1.21].

[a] Dans les "circuits et lignes non symétriques", le mode de couplage "entre phases" n'est exigé pour ces essais que dans le cas de lignes de longue distance conformément à 3.24.9.

Aux niveaux d'essai 2) et 3), après les essais de H.25.8.2, les composants de protection contre les chocs ne doivent pas avoir été détruits.

H.25.8.3 Procédure d'essai

L'appareil et la procédure d'essai doivent être tels que décrits dans l'IEC 61000-4-5. Selon le présent document, le **dispositif de commande** est relié à une source d'alimentation appropriée fonctionnant à la tension assignée, le générateur d'impulsion étant connecté aux bornes.

Si le **système** a plus d'un mode de fonctionnement pertinent, les impulsions peuvent être réparties sur les modes de fonctionnement pertinents (Tableau 1, exigence 43) sous réserve que, pour chaque mode de fonctionnement, au moins une impulsion de chaque polarité (+, −) et de chaque angle de phase décrit dans l'IEC 61000-4-5, doit être appliquée.

Pour les **dispositifs de commande** dotés de séparateurs de dispositif de protection contre les chocs intégrant des éclateurs, l'essai est répété à un niveau d'essai égal à 95 % de la tension de contournement.

Le **dispositif de commande** est soumis à essai et évalué dans chacun des modes de fonctionnement pertinents, comme spécifié dans la Partie 2 applicable.

H.25.9 Essai d'immunité aux transitoires électriques rapides en salves

Le **dispositif de commande** doit supporter des transitoires rapides en salves au niveau du réseau d'alimentation et des lignes de signaux.

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La conformité est vérifiée par les essais décrits de H.25.9.2 à H.25.9.3 inclus.

H.25.9.1 Objet de l'essai

Cet essai s'applique aux bornes d'alimentation et, dans des cas spécifiques, aux bornes du dispositif de commande (voir H.25.9.2).

Cet essai a pour objet de démontrer l'immunité du dispositif de commande aux chocs de transitoires de faible énergie pouvant être produits par des relais, des contacteurs, etc., des charges inductives de commutation, et qui peuvent être induits dans des circuits de signaux et de données.

H.25.9.2 Niveaux d'essai

Les essais doivent être appliqués comme spécifié dans le Tableau H.16.

Les essais sur les bornes pour les câbles d'interface ne doivent être effectués que si ces bornes sont conçues pour réaliser l'interconnexion avec des câbles de longueur supérieure à 3 m, selon les spécifications du fabricant.

Générateur:	*interne*
Durée:	*1 min par polarité, positive (+) et négative (–)*
Conditions de fonctionnement:	*selon la Partie 2 applicable ou, en l'absence de Partie 2, selon les modes de fonctionnement pertinents.*

La tension d'essai sur l'accès d'alimentation électrique doit être appliquée simultanément entre le plan de référence de terre et toutes les bornes d'alimentation (mode commun).

Tableau H.16 – Niveau d'essai pour l'essai de transitoires rapides en salves

		Tension d'essai de sortie en circuit ouvert et fréquence de répétition des chocs			
		Sur l'accès d'alimentation électrique en courant alternatif, PE		Sur les accès d'entrée/sortie (E/S) de signal, de données et de commande	
Niveaux d'essai applicables correspondant à H.25.14.3	**Niveau d'essai conformément à l'IEC 61000-4-4**	**Crête de tension kV**	**Fréquence de répétition kHz**	**Crête de tension kV**	**Fréquence de répétition kHz**
2	2	1	5	0,5	5
3	3	2	5	1	5
Dispositifs de commande de protection déclarés dans le Tableau 1, exigence 66, destinés à être utilisés conformément à l'IEC 60335-1:2020	4	4	5	-	-

H.25.9.3 Procédure d'essai

L'appareil d'essai et les procédures d'essai doivent être tels qu'ils sont décrits dans l'IEC 61000-4-4.

Le **dispositif de commande** est soumis à essai selon chacun des modes de fonctionnement pertinents, comme spécifié dans la Partie 2 applicable.

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H.25.10 Essai de décharges électrostatiques

Cet essai est effectué conformément à l'IEC 61000-4-2.

Les valeurs d'essai doivent être appliquées au niveau d'essai 3.

Application directe de décharge: Les décharges de contact à 6 kV sur les parties métalliques accessibles, ou les décharges dans l'air à 8 kV sur les ***parties accessibles*** *des matériaux isolants doivent s'appliquer.*

Application indirecte de décharge: les décharges de contact à 6 kV sur la plaque de couple horizontale ou verticale doivent s'appliquer.

Pour les **dispositifs de commande de protection** déclarés dans le Tableau 1, exigence 66, l'essai supplémentaire suivant s'applique: cet essai est effectué conformément à l'IEC 61000-4-2:2008, Article 5, niveau d'essai 4. Les décharges de contact à 8 kV sur les parties métalliques accessibles, ou les décharges dans l'air à 15 kV sur les **parties accessibles** des matériaux isolants doivent s'appliquer.

H.25.11 Immunité aux champs électromagnétiques de fréquences radio

H.25.11.1 Objet de l'essai

L'essai a pour objet de vérifier l'immunité des **dispositifs de commande** aux champs électromagnétiques générés par des émetteurs de radiodiffusion ou tout autre dispositif émettant de l'énergie rayonnée sous forme d'onde électromagnétique entretenue. L'immunité des **dispositifs de commande** aux rayonnements des émetteurs/récepteurs tenus à la main (talkie-walkie) est le principal but de l'essai, mais d'autres sources de rayonnement électromagnétique sont concernées, telles que les émetteurs des stations fixes de radiodiffusion et de télévision, les émetteurs radio montés sur véhicules, et diverses sources électromagnétiques industrielles issues de sources intermittentes.

H.25.11.1.1 Si la criticité du niveau d'essai 2 n'est pas affectée après le niveau d'essai 3, le niveau d'essai 2 n'a pas besoin d'être effectué.

H.25.11.2 Immunité aux perturbations conduites

Le ***dispositif de commande*** *doit tolérer les signaux haute fréquence sur l'alimentation électrique et sur les bornes de signaux appropriées.*

La conformité est vérifiée par les essais décrits de H.25.11.2.1 à H.25.11.2.2 inclus.

H.25.11.2.1 Niveaux d'essai pour les perturbations conduites

Au minimum, les niveaux d'essai du Tableau H.17 doivent s'appliquer.

Les essais doivent seulement être appliqués aux câbles d'interface qui, selon les spécifications du fabricant, peuvent mesurer plus de 1 m.

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Tableau H.17 – Niveaux d'essai pour les perturbations conduites sur les lignes d'alimentation et les lignes d'entrée/sortie

Plages de fréquences d'essai: Entre 150 kHz et 80 MHz		
Niveau d'essai	Niveau de tension (efficace)	
	U_0 dBµV	U_0 V
2	130	3
3	140	10
NOTE Les niveaux d'essai dans les bandes ISM et CB sont choisis pour être 6 dB au-dessus (ISM: Industrial, scientific and medical radio-frequency equipment: 13,56 MHz ± 0,007 MHz et 40,68 MHz ± 0,02 MHz, CB: Citizen band: 27, 125 MHz ± 1,5 MHz).		

H.25.11.2.2 Procédure d'essai

Cet essai doit être effectué conformément à l'IEC 61000-4-6.

*Soumettre à essai le **dispositif de commande** en effectuant au moins un balayage sur la totalité de la plage de fréquences d'essai, le **système** étant dans chacun de ses modes de fonctionnement pertinents. Si la plage de fréquences est balayée par incréments, la taille des paliers ne doit pas dépasser 1 % de la valeur de fréquence précédente fondamentale avec une interpolation linéaire entre les points d'étalonnage. Le temps de palier de la porteuse modulée en amplitude à chaque fréquence ne doit pas être inférieur au temps nécessaire au **dispositif de commande** pour être excité et pouvoir répondre, mais en aucun cas il ne doit être inférieur à 0,5 s. Les bandes ISM et CB doivent être soumises à essai avec les fréquences d'essai utilisées pour le balayage sur toute la plage de fréquences d'essai et couvrir les bandes ISM et CB considérées.*

NOTE Les fréquences critiques ou les fréquences d'intérêt dominant peuvent être analysées séparément.

H.25.11.3 Immunité aux perturbations radioélectriques rayonnées

Le **dispositif de commande** doit tolérer les signaux haute fréquence sur l'alimentation électrique et sur les bornes de signaux appropriées.

La conformité est vérifiée par les essais décrits de H.25.11.3.1 à H.25.11.3.2 inclus.

H.25.11.3.1 Niveaux d'essai pour les champs électromagnétiques rayonnés

Les niveaux d'essai pour l'immunité aux champs électromagnétiques rayonnés doivent être appliqués conformément au Tableau H.18.

Les niveaux d'essai augmentés pour l'immunité aux champs électromagnétiques rayonnés doivent être appliqués conformément au Tableau H.19.

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Tableau H.18 – Niveau d'essai pour l'immunité aux champs électromagnétiques rayonnés

	Plages de fréquences d'essai/Niveau de champ[c] V/m		
Niveau d'essai	**Entre 80 MHz et 1,0 GHz** 80 % AM (1 kHz) [d]	**Entre 1,4 GHz et 2,0 GHz** 80 % AM (1 kHz) [d]	**Entre 2,0 GHz et 6,0 GHz** 80 % AM (1 kHz) [d]
2	3 [b] 6 [a, b]	3 [b] 6 [a, b]	3 [a, b]
3	10 [b] 20 [a, b]	3 [b] 10 [a, b]	3 [a, b]

[a] Ces valeurs accrues doivent être appliquées dans les plages de fréquences indiquées dans le Tableau H.19.

[b] Le niveau d'essai spécifié est la valeur efficace de la porteuse non modulée.

[c] Si des émetteurs portatifs peuvent être utilisés à moins de 20 cm, un avertissement doit être donné dans le manuel de sécurité pour signaler que le matériel concerné pourrait être perturbé.

[d] L'IEC 61000-4-3 exige d'effectuer l'essai à 80 % 1 kHz de modulation d'amplitude (AM). Toutefois, l'essai peut être étendu à d'autres schémas de modulation.

Tableau H.19 – Niveau d'essai augmenté pour l'immunité aux champs électromagnétiques rayonnés

Plage de fréquences d'essai MHz
84 000
137 à 174
219 500
380 à 400
420 à 470
698 à 960
1 240 à 1 300
1 428 à 2 700
3 300 à 3 600
5 150 à 5 925
Les informations relatives à la fréquence peuvent être consultées dans l'IEC 61000-6-7:2014.
NOTE 1 Pour les fréquences/plages où une seule fréquence d'essai est indiquée, l'essai est réalisé à cette seule fréquence. NOTE 2 Pour les essais, le schéma de modulation indiqué dans la norme fondamentale s'applique. D'autres paramètres de modulation sont possibles. NOTE 3 Pour plus d'informations sur l'attribution des fréquences par région, voir IEC TR 61000-2-5 ou les publications de l'UIT.

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H.25.11.3.2 Procédure d'essai

Cet essai doit être effectué conformément à l'IEC 61000-4-3.

*Soumettre à essai le **dispositif de commande** en effectuant au moins un balayage sur la totalité de la plage de fréquences d'essai et dans l'orientation verticale et horizontale de l'antenne, le système étant dans ses modes de fonctionnement pertinents. Si la plage de fréquences est balayée par incréments, la taille des paliers ne doit pas dépasser 1 % de la valeur de fréquence précédente fondamentale avec une interpolation linéaire entre les points d'étalonnage. Le temps de palier à chaque fréquence ne doit pas être inférieur au temps nécessaire au **dispositif de commande** pour être excité et pouvoir répondre, mais en aucun cas il ne doit être inférieur à 0,5 s.*

*L'essai doit généralement être réalisé en positionnant l'antenne de génération devant chaque côté du **dispositif de commande**. Lorsque le matériel peut être utilisé dans les différentes orientations (c'est-à-dire verticale ou horizontale), tous les côtés doivent être exposés au champ pendant l'essai. Lorsque la technique le justifie, certains **dispositifs de commande** peuvent être soumis à essai en exposant moins de faces à l'antenne de génération. Dans d'autres cas, déterminés par exemple par le type et les dimensions du **dispositif de commande** ou les fréquences d'essai, il peut être nécessaire d'exposer plus de quatre azimuts.*

NOTE Les fréquences critiques ou les fréquences d'intérêt dominant peuvent être analysées séparément.

H.25.12 Essai de l'influence des variations de la fréquence d'alimentation

Les **dispositifs de commande** basés sur des microprocesseurs utilisant des **fonctions de commande de classe B** et/ou des **fonctions de commande de classe C** qui reposent sur la fréquence industrielle d'alimentation pour leur **fonctionnement** correct doivent tolérer des variations de fréquence industrielle d'alimentation, si cela est déclaré dans le Tableau H.1.

H.25.12.1 Objet de l'essai

Cet essai a pour objet de vérifier l'effet sur le **dispositif de commande** des déviations de la fréquence de l'alimentation.

H.25.12.2 Niveaux d'essai

Les valeurs d'essai indiquées dans le Tableau H.20 doivent s'appliquer.

Tableau H.20 – Niveau d'essai pour les variations de la fréquence d'alimentation

Niveau d'essai	Variations de la fréquence d'alimentation % [a]
2	±1 et ±2
3	±3, ±4 et ±5
[a] D'autres valeurs peuvent être spécifiées dans la Partie 2.	

H.25.12.3 Procédure d'essai

L'appareil et la procédure d'essai doivent être tels que décrits dans l'IEC 61000-4-28.

Le **dispositif de commande** doit initialement fonctionner à sa tension assignée et doit ensuite être soumis aux variations de fréquences comme décrit en détail en H.25.12.2.

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H.25.13 Essai d'immunité au champ magnétique à la fréquence du réseau

Les **dispositifs de commande** sensibles au champ magnétique tels que les **dispositifs de commande** utilisant des dispositifs à effet Hall doivent tolérer les champs magnétiques à la fréquence industrielle.

La conformité est vérifiée par les essais de H.25.13.2 et de H.25.13.3.

NOTE Des exemples de tels **dispositifs de commande** comprennent les capteurs de pression utilisant des dispositifs à effet de hall, des **dispositifs de commande** incorporant des relais à lames souples et des **dispositifs de commande** utilisant des relais bistables.

H.25.13.1 Objet de l'essai

L'essai a pour objet de démontrer l'immunité des **dispositifs de commande** pouvant être affectés par les champs magnétiques à la fréquence industrielle liés à l'emplacement spécifique et aux conditions d'installation du **dispositif de commande** (par exemple proximité entre le matériel et la source de perturbation).

Le champ magnétique à la fréquence industrielle est généré des courants à la fréquence du réseau dans les conducteurs ou par d'autres dispositifs (par exemple fuites des transformateurs) à proximité du matériel.

Il convient de prendre uniquement en compte les influences des conducteurs avoisinants, dans lesquels le courant, dans des conditions normales de fonctionnement, produit un champ magnétique continu, avec une amplitude comparativement faible.

H.25.13.2 Niveaux d'essai

Les niveaux d'essai doivent être appliqués conformément au Tableau H.21.

Tableau H.21 – Niveau d'essai pour les champs continus

Niveau d'essai	Niveau de champ continu A/m
2	3
3	10

H.25.13.3 Procédure d'essai

Le **dispositif de commande** est alimenté à la tension assignée. Le matériel d'essai, le montage d'essai et la procédure d'essai doivent être conformes à l'IEC 61000-4-8. Le **dispositif de commande** est soumis à essai dans les conditions d'essai spécifiées dans la Partie 2 applicable.

H.25.14 Évaluation de la conformité

H.25.14.1 A l'issue de tous les essais de H.25.4 à H.25.13, le ou les échantillons doivent satisfaire aux exigences de l'Article 6, de l'Article 11 et de 19.5.

H.25.14.2 De plus, le dispositif de commande doit satisfaire aux exigences suivantes:

– les exigences de 19.14; ou
– la ou les sorties et fonctions doivent être conformes aux indications données dans le Tableau H.1, exigences H.1 et H.2.

La conformité avec la seconde alternative de H.25.14.2 peut rendre le dispositif de commande non acceptable pour certaines applications.

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Les Parties 2 peuvent contenir certaines restrictions concernant les effets admis sur la ou les sorties commandées pour des types particuliers de **dispositifs de commande** ou des fonctions de **commande** pour des niveaux d'essai.

H.25.14.3 Des sorties et des fonctions différentes peuvent être déclarées par le fabricant après le niveau d'essai 2 ou niveau d'essai 3, si applicable. La Partie 2 peut spécifier des critères particuliers après chacun de ces essais.

H.25.14.4 Les critères de conformité doivent être donnés dans la Partie 2 ou la norme du matériel en utilisation finale et être basés sur les conditions de fonctionnement de la sortie et les spécifications fonctionnelles du dispositif de commande en essai. Cependant, dans les cas où les critères de conformité ne sont pas spécifiés pour le dispositif de commande, ce dernier doit satisfaire à l'un des critères suivants:

a) performance normale sans perte de fonction de protection et **dispositif de commande** dans les spécifications ou limites déclarées;

b) perte de fonction de protection dans les limites déclarées;

c) perte de fonction de protection avec **arrêt de sécurité**.

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Annexe I
(normative)

Exigences pour certains types de dispositifs de commande alimentés en courant continu

L'Annexe I complète ou modifie les articles correspondants du présent document.

I.1 Domaine d'application

La présente annexe s'applique également aux dispositifs de commande alimentés en courant continu pour des applications non stationnaires telles que déclarées dans le Tableau 1, exigence 87 (par exemple véhicules routiers, véhicules de loisirs, caravanes avec alimentation en courant continu 12 V ou 24 V).

La présente annexe ne s'applique pas aux dispositifs de commande ayant un accès d'alimentation en courant continu destinés à être utilisés uniquement avec un adaptateur d'alimentation courant alternatif - courant continu.

NOTE Un tel dispositif de commande est soumis à essai comme un dispositif de commande alimenté en courant alternatif.

Les dispositifs de commande alimentés en courant continu pour les applications non stationnaires, dont l'alimentation peut être assurée par une alimentation électrique continue 12 V ou 24 V et un adaptateur d'alimentation courant alternatif - courant continu doivent être évalués au regard des exigences de la présente annexe et des exigences pertinentes de l'Article H.25.

I.25.8 Essais d'immunité aux ondes de choc

Ils doivent être effectués conformément à H.25.8, avec la modification suivante:

Cet essai ne s'applique pas.

I.25.9 Transitoires électriques rapides en salves

Ils doivent être effectués conformément à H.25.9, avec la modification suivante:

Cet essai ne s'applique pas.

I.25.11.2 Immunité aux perturbations conduites

Ils doivent être effectués conformément à H.25.11.2, avec l'ajout suivant:

Le dispositif de commande doit être soumis à essai conformément à l'ISO 7637-2 et à l'ISO 7637-3 avec les durées, la polarité et la tension des impulsions d'essai en fonction des amplitudes spécifiées dans le Tableau I.1 et le Tableau I.2.

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Tableau I.1 – Immunité aux perturbations électriques transitoires par conduction conformément à l'ISO 7637-2

Critères d'évaluation	Niveaux d'essai	Impulsions d'essai V				
		1	2a	2b	3a	3b
I	Niveau III					
	(**Systèmes** 12 V)	-112	+55	+10	-165	+112
	(**Systèmes** 24 V)	-450	+55	+20	-220	+220
II	Niveau IV					
	(**Systèmes** 12 V)	-150	+112	+10	-220	+150
	(**Systèmes** 24 V)	-600	+112	+20	-300	+300

Tableau I.2 – Immunité aux perturbations électriques transitoires par conduction conformément à l'ISO 7637-3

Critères d'évaluation	Niveaux d'essai	Impulsions d'essai V	
		a	b
I	Niveau III		
	(**Systèmes** 12 V)	-80	+60
	(**Systèmes** 24 V)	-110	+110
II	Niveau IV		
	(**Systèmes** 12 V)	-110	+75
	(**Systèmes** 24 V)	-150	+150

Essais:

Pour les valeurs indiquées dans le Tableau I.1, le **système** est soumis à essai conformément à l'ISO 7637-2 et pour les valeurs indiquées dans le Tableau I.2, le **système** est soumis à essai conformément à l'ISO 7637-3.

Pour les **systèmes** avec différents niveaux de tension d'alimentation électrique, les valeurs des impulsions d'essai doivent être adaptées en fonction des niveaux d'essai exigés.

I.25.12 Variations de la fréquence d'alimentation

Ils doivent être effectués conformément à H.25.12, avec la modification suivante:

Cet essai ne s'applique pas.

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Annexe J
(normative)

Exigences pour éléments de thermistance et dispositifs de commande utilisant des thermistances

L'Annexe J complète ou modifie les articles correspondants du présent document.

NOTE Les numéros de paragraphe de la présente annexe indiquent les ajouts/modifications apportés au même numéro de paragraphe que celui utilisé dans la partie principale du présent document.

J.1 Domaine d'application

Addition:

L'Annexe J s'applique:

– aux dispositifs de type à **thermistances CTP** et à **thermistances CTN**;
– aux dispositifs de type à **thermistance** discrète et aux **dispositifs de commande** utilisant des **thermistances** fabriquées avec des matériaux semiconducteurs céramiques ou polymères dopés;
– à la sécurité intrinsèque, aux valeurs de températures de fonctionnement et aux essais des **dispositifs de commande** utilisant des **thermistances** soit avec le **dispositif de commande**, soit avec télécommande.

NOTE Ces **thermistances** peuvent être utilisées

– en mode autochauffant comme les **radiateurs autocontrôlés** et dans des applications semblables;
– comme **élément de dispositif de commande à thermistance**; ou
– comme **éléments sensibles**.

Les **thermistances** de **dispositifs de commande** tels que les limiteurs de courant ne sont pas destinées à remplacer les dispositifs de coupure de courant tels que les fusibles, mais elles ont pour objet d'assurer un niveau de protection contre les surintensités conformes aux exigences relatives au matériel en utilisation finale.

Les Parties 2 de la norme peuvent contenir des exigences supplémentaires pour les **thermistances** faisant office de dispositifs de commande complets.

J.3 Termes et définitions

J.3.15 Définitions en rapport avec les thermistances

J.3.15.1
thermistance
résistance à semiconducteur sensible thermiquement qui présente, dans au moins une partie de sa caractéristique résistance/température (R/T), une variation non linéaire significative de sa résistance électrique pour une variation de température

Note 1 à l'article: La variation de température peut survenir soit en raison du passage du courant dans la **thermistance**, soit comme résultat du changement de la température ambiante, soit encore de la combinaison de deux de ces facteurs.

J.3.15.2
thermistance CTP
thermistance qui présente une augmentation de résistance avec l'accroissement de température dans la portion utile de la caractéristique résistance/température (R/T)

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Note 1 à l'article: CTP désigne le coefficient de température positif. Les **thermistances CTP** présentent également une résistance décroissante avec une tension appliquée comme un effet secondaire.

Note 2 à l'article: Pour une **thermistance CTP**, la portion significative de la caractéristique résistance/température est habituellement la portion dans laquelle un accroissement brusque de la résistance provient d'une augmentation de température, habituellement précédée par une variation progressive de la résistance aux plus basses températures et une variation progressive similaire aux températures au-dessus de l'accroissement brusque. La caractéristique résistance/température de certaines **thermistances CTP** peut avoir une pente négative après une augmentation progressive de peu d'importance après l'accroissement brusque.

J.3.15.3
thermistance CTN
thermistance qui présente une diminution de résistance avec l'accroissement de température dans la portion utile de la caractéristique résistance/température

Note 1 à l'article: CTN signifie coefficient de température négatif.

J.3.15.4
élément de dispositif de commande à thermistance
thermistance CTP ou **CTN** qui contrôle directement une charge en étant connectée en série avec elle

Note 1 à l'article: Un **élément de dispositif de commande à thermistance** n'est pas destiné à être raccordé au réseau.

Note 2 à l'article: Les utilisations types sont les limiteurs de courant, les limiteurs de **courant d'appel**, les limiteurs de courant de bobine démagnétisante et les limiteurs de courant de démarrage de moteur.

J.3.15.5
radiateur autocontrôlé
thermistance CTP qui n'a pas de **limiteur de température** supplémentaire et qui est utilisée comme élément de chauffage à cause de son effet autochauffant

Note 1 à l'article: Généralement utilisé en branchement direct au secteur.

Note 2 à l'article: Normalement un **radiateur autocontrôlé** provoque une **action de type 2**.

J.3.15.6
élément sensible à thermistance
thermistance CTP ou **CTN** utilisée comme capteur et qui ne transporte pas de courant de charge

J.3.15.7
valeur B
indice de **thermistance CTN** qui exprime le niveau de variation de la résistance calculé à partir de deux points quelconques spécifiés par le fabricant sur la courbe résistance/température (R/T)

J.3.15.8
courant de maintien
$I_{\mathbf{h}}$
courant maximal qu'une **thermistance CTP** de limitation de courant peut maintenir à l'état "activé" de faible résistance à la température ambiante assignée et pendant une durée spécifiée par le fabricant

J.3.15.9
courant d'appel
$I_{\mathbf{n}}$
courant de crête mesuré après mise sous tension à la tension assignée et à une température de 25 °C ± 2 K ou à la température ambiante spécifiée par le fabricant

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J.3.15.10
courant de déclenchement
I_t
pour une **thermistance CTP** de limitation de courant, courant minimal déclaré par le fabricant pour lequel une **thermistance CTP** passe d'une valeur de résistance faible à élevée à une température ou plage de températures spécifiée

Note 1 à l'article: $I_t = Y \times I_h$, où Y est le multiplicateur de **courant de déclenchement** déclaré par le fabricant.

J.3.15.11
courant maximal
I_{max}
valeur de courant attribuée par le fabricant et qui satisfait à toutes les exigences du présent document

Note 1 à l'article: Pour les différents dispositifs, le courant associé désigné I_{max} est indiqué dans le Tableau J.1.

Tableau J.1 – Courant maximal

Dispositif	Courant associé désigné I_{max}
Radiateur autocontrôlé CTP	**Courant maximal en régime établi** [a]
Démarreur de moteur CTP	Courant maximal d'enroulement au démarrage
Limiteur de courant, démagnétiseur CTP	**Courant de déclenchement** maximal [b]
Limiteur de **courant d'appel** CTN	**Courant maximal en régime établi**
Capteur CTP ou CTN	Ne s'applique pas.
[a] Pour les dispositifs dont les valeurs assignées en watts sont déclarées par le fabricant, I_{max} est calculé. Ce courant ne correspond pas au **courant d'appel**.	
[b] Pour les dispositifs dont la courbe **temps jusqu'à déclenchement** en fonction du courant est assignée par le fabricant, le **courant maximal** (I_{max}) doit être identifié.	

J.3.15.12
courant de court-circuit
I_{sc}
courant maximal disponible à partir de la source à impédance limitée (telle qu'une alimentation)

J.3.15.13
courant en régime établi
I_{ss}
courant mesuré après stabilisation de la température de la **thermistance** dans l'air à la température ambiante de 25 °C ± 2 K ou à une température ambiante spécifiée par le fabricant, lorsqu'elle est raccordée à la tension assignée et fonctionne dans son état de résistance élevée pour les **thermistances CTP** ou de faible résistance pour les **thermistances CTN**

Note 1 à l'article: Pour certaines **thermistances CTN**, I_{ss} est identique à I_{max}.

J.3.15.14
résistance
R_{min}
pour une **thermistance CTP** céramique, point de résistance minimale sur la courbe R/T

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J.3.15.15
résistance
R_x ou R_{25}
résistance assignée à une température spécifiée par le fabricant pour R_x ou à la température de 25 °C ± 2 K pour R_{25}

J.3.15.16
résistance de commutation
R_{sw}
pour une **thermistance CTP** céramique, valeur de **résistance** à laquelle la **résistance** commence à augmenter brusquement en fonction de l'augmentation de la température

Note 1 à l'article: Pour le présent document, R_{sw} est la valeur à laquelle la **résistance** est égale au double de R_{min}; à moins que le fabricant spécifie la valeur de R_{sw} en référence à R_{min} avec un facteur de multiplication autre que deux, ou en référence à R_x.

J.3.15.17
résistance déclenchée
R_{tr}
pour une **thermistance** CTP de dispositif de commande, valeur de la **résistance** de la **thermistance** dans son état déclenché à la tension maximale (V_{max})

Note 1 à l'article: R_{tr} est calculée en divisant la chute de tension au niveau de la **thermistance** par le **courant en régime établi** (I_{ss}) circulant dans la **thermistance**.

J.3.15.18
température de commutation
T_{sw}
pour une **thermistance CTP** céramique, température à laquelle la **résistance** est à la valeur de R_{sw}

J.3.15.19
température de surface
T_{surf}
température de la surface d'une **thermistance** lorsque la **thermistance** est mise sous tension dans les conditions de fonctionnement normal

Note 1 à l'article: Le Tableau J.2 spécifie les conditions de fonctionnement normal types pour les **thermistances**.

Tableau J.2 – Conditions de fonctionnement normal

Type de thermistance	Tension	Courant
Radiateur autocontrôlé CTP	V_{max}	I_{ss}
Démarreur de moteur CTP	V_{max}	I_{ss}
Démagnétiseur CTP	V_{max}	I_{ss}
Limiteur de courant CTP	V_{max}	I_h et I_{ss} [a]
Limiteur de **courant d'appel** CTN	V_{max}	I_{max}

[a] La température de surface mesurée à I_{ss} reflète les conditions à l'état déclenché de la **thermistance** (conditions de fonctionnement normal pour le CTP, condition de fonctionnement anormal pour le circuit/l'application contrôlés par le CTP).

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J.3.15.20
temps jusqu'à déclenchement
temps nécessaire à une **thermistance CTP** pour limiter le **courant de déclenchement**(I_t) déclaré par le fabricant à 50 % de sa valeur lorsqu'elle est mise sous tension à la tension assignée et à température ambiante

J.3.15.21
température d'emballement thermique
T_R
point de température élevée sur la courbe R/T auquel la **résistance** d'une **thermistance CTP** n'augmente plus en fonction de l'augmentation de la température

J.3.15.22
tension maximale
V_{max}
tension maximale d'une **thermistance** telle que déclarée par le fabricant

Note 1 à l'article: V_{max} est supérieure à la tension assignée (V_r) lorsqu'une tension de service plus élevée se produit dans certaines conditions dans le matériel en utilisation finale, comme pour les limiteurs de bobine de démarrage de moteur.

J.4 Généralités

J.4.3 Généralités sur les essais

J.4.3.3 Echantillons exigés

Addition:

J.4.3.3.1 Sauf indication contraire, les échantillons représentatifs indiqués dans le Tableau J.3 doivent faire l'objet des essais spécifiés en J.19.17. De nouveaux échantillons doivent être utilisés pour tous les essais autres que les essais de surcharge et d'endurance.

Tableau J.3 – Échantillons pour l'essai (article de référence)

		Condition-nement thermique	**Etablissem-ent de cycle chaleur-froid-humidité**	**Surcharge**	**Endurance**	**Etablissem-ent de cycle fonctionnel à froid**	**Etablissem ent de cycle thermique à froid**	**Emballem-ent thermique**
		(J.19.17.3)	(J.19.17.1)	(J.19.17.2.1, J.19.17.7.1)	(J.19.17.2.2, J.19.17.7.2)	(J.19.17.4, J.19.17.8)	(J.19.17.6)	(J.19.17.5)
Nombre d'échantillons par essai		3	3	3 [a]	3 [a]	3	3	3
Application de **thermist-ance**	**Radiateur autocontrôlé** CTP	X	X	X	X	X	-	X
	Elément de dispositif de commande à thermist-ance CTP	X	X	X	X	X	-	X
	Capteur CTP	X	X	X	X	-	X	-
	Elément de dispositif de commande à thermist-ance CTN	X	X	X	X	X	-	-
	Capteur CTN	X	X	X	X	-	X	-
Les essais d'étalonnage de J.17.1 et J.17.2 doivent être réalisés avant et après chacun des essais ci-dessus (sauf pour l'emballement thermique).								
[a] Les trois mêmes échantillons doivent être utilisés pour les essais de surcharge et d'endurance.								

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J.4.3.4.2 Selon les caractéristiques assignées

Alinéa supplémentaire:

Pour les besoins du présent document, la tension assignée (V_r) d'une **thermistance** est la tension d'entrée d'une **thermistance** déclarée par le fabricant.

NOTE V_r est en général égale à la tension de la source d'alimentation.

J.4.3.4.2.11 *Paragraphe supplémentaire:*

Les caractéristiques assignées électriques et thermiques d'une **thermistance** doivent être conformes au Tableau J.4 et être fonction de son application prévue.

Tableau J.4 – Caractéristiques assignées électriques et thermiques d'une thermistance

Caractéristique	Type de thermistance						
	CTP					CTN	
	Radiateur autocontrôlé	Démarreur de moteur	Limiteur de courant[a]	Capteur [a]	Démagnétiseur	Capteur [a]	Limiteur de courant d'appel
Valeur bêta (B)	-	-	-	-	-	R	-
Numéro de classe d'étalonnage	-	-	-	R	-	R	-
Capacité – charge ou caractéristique assignée Joule	-	-	-	-	-	-	R
Courant de déclenchement (I_t)	-	-	R	-	-	-	-
Courant d'appel (I_n)	R	R	-	-	R	-	R
Courant de maintien (I_h)	-	-	R	-	-	-	-
Courant maximal (I_{max})	-	R	R	-	R	-	R
Courant en régime établi (I_{ss})	R	R	R	-	R	-	R
Impédance de bobine	-	-	-	-	R	-	-
Résistance – R_{25} et tolérance	R	R	R	R	R	R	R
Température ambiante de fonctionnement maximale	-	R	R	R	R	R	R
Température de commutation (T_{sw})	R	R	R	R	R	-	-
Température de surface maximale (T_{surf})	R	R	R	-	R	-	R
Temps jusqu'à déclenchement	-	-	R	-	-	-	-
Tension maximale (V_{max})	R	R	R	-	R	-	R
Tension assignée (V_r)	R	R	R	-	R	-	R
La désignation "R" indique les caractéristiques assignées pour le dispositif devant être fourni par le fabricant.							
[a] La gamme de températures ambiantes de fonctionnement doit être spécifiée.							

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J.4.3.4.5 Selon la fonction

Paragraphes supplémentaires:

J.4.3.4.5.4 En fonction du type de **thermistance** et de l'application particulière, les **thermistances** doivent être soumises aux essais indiqués dans le Tableau J.3 et aux essais d'étalonnage de J.17.1 ou J.17.2, selon ce qui s'applique.

Cependant, **les thermistances** utilisées dans les **dispositifs de commande à action de type 1** conformes aux séries IEC 60539, IEC 60738 ou IEC 62319 doivent uniquement faire l'objet des essais d'emballement thermique de J.19.17.5 à condition que cela respecte la déclaration applicable du Tableau J.5 pour le dispositif de commande. La conformité aux séries IEC 60539, IEC 60738 ou IEC 62319 n'est pas exigée si les **thermistances** satisfont aux exigences de l'Annexe J.

J.5 Information

Le Tableau J.5 fournit des exigences supplémentaires au Tableau 1.

Tableau J.5 – Points complémentaires au Tableau 1

	Information	Article ou paragraphe	Méthode
J.1	Selon la construction et l'utilisation d'une **thermistance**	J.3.15.4, J.3.15.5, J.3.15.6	X
J.2	Caractéristiques R/T, spécifications d'étalonnage [a]	J.17.1, J.17.2	X
J.3	Caractéristiques R/T, spécifications d'étalonnage, **dérive** [b]	J.17.1, J.17.2, J.19.16.2	X
J.4	Nombre de cycles	J.19.17.2	X
J.5	Méthode de mesure de R/T	J.17.1.4, J.17.2.3	X
J.6	Limiteurs de courant CTP dont le courant maximal est réduit à une valeur inférieure ou égale à 8 A en ≤ 5 s.	J.17.1.6.1.1	X

[a] Les caractéristiques R/T doivent être présentées sous forme d'une courbe, d'un tableau ou de points de fonctionnement divers et doivent comporter la déviation déclarée.

[b] Des indications supplémentaires peuvent être indiquées à des nombres intermédiaires de cycles pour l'essai de J.19.17.2.

J.9 Exigences de construction

Paragraphes supplémentaires:

J.9.3.10 Les **thermistances** utilisées dans les dispositifs de commande pour assurer une sécurité fonctionnelle ou comme dispositifs de commande pour assurer une sécurité fonctionnelle à une application contrôlée, doivent fournir une **action de type 2**, pour d'autres applications au moins une **action de type 1**.

NOTE Exemples de **thermistances** utilisées pour assurer la **sécurité fonctionnelle** d'une application contrôlée: capteurs de température pour applications de coupe-circuit de température ou dispositifs CTP de limitation de courant dans les circuits à énergie non limitée.

J.9.4.17 Action de type 1.YJ ou 2.YJ

Une **thermistance** à action de type 1.YJ ou de type 2.YJ doit fonctionner pour fournir une variation intrinsèque de sa résistance.

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Dans le cadre du présent document, une **thermistance CTP** qui est en mode ouvert (résistance élevée) ou une **thermistance CTN** en mode fermé (résistance élevée) sont considérées comme fournissant l'équivalent d'une **coupure électronique** et sont classées comme à action de type 1.YJ ou 2.YJ.

La conformité est vérifiée par les essais spécifiés dans les exigences correspondantes de la présente Annexe J.

J.12 Éléments constituants

J.12.8.2 *Ajouter ce qui suit:*

Le paragraphe 12.8.2 s'applique aux **thermistances** déjà soumises aux essais de l'IEC 60539 ou de l'IEC 60738.

J.15 Rigidité diélectrique et résistance d'isolement

J.15.2 Rigidité diélectrique

Modification de la Note b du Tableau 16:

Ajouter le mot "thermistances" *après* "les parties électroniques".

J.17 Tolérance de fabrication et dérive

J.17.1 Essais d'étalonnage des thermistances CTP

J.17.1.1 Les **thermistances** céramiques ne sont pas affectées par la séquence des essais d'étalonnage de J.17.1.4 à J.17.1.8 réalisés sur les échantillons. Cependant les types polymères peuvent être affectés en raison de la nature du matériau. Ainsi, pour les **thermistances** polymères, il est recommandé de réaliser l'essai de J.17.1.4 à la fin de tous les essais d'étalonnage.

J.17.1.2 En l'état de livraison, chaque échantillon de **thermistance CTP** doit être soumis aux essais spécifiés dans le Tableau J.6 et doit satisfaire aux critères applicables à chaque essai tels que spécifiés dans le Tableau J.6.

J.17.1.3 A l'issue des essais décrits en J.19.16 a), les mêmes échantillons de **thermistance CTP** doivent être soumis aux essais spécifiés dans le Tableau J.6 et doivent satisfaire aux critères applicables à chaque essai tels que spécifiés dans le Tableau J.6. Pour les capteurs CTP, les résultats d'essai doivent satisfaire aux critères applicables à chaque essai tels que spécifiés dans le Tableau J.7.

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Tableau J.6 – Séquence des essais d'étalonnage et de conditionnement des thermistances CTP

Type de thermistance CTP	Essais d'étalonnage réalisés sur des échantillons avant les essais de conditionnement spécifiés en J.19.17 [a]	Désignation des critères de conformité (avant conditionnement) [b]	Essais d'étalonnage réalisés sur des échantillons de thermistances après les essais de conditionnement spécifiés en J.19.17 [a]	Désignation des critères de conformité (après conditionnement) [b]
Radiateur autocontrôlé	R/T	A	T_{surf}	D
	T_{surf}		I_n	
	I_n			
Démarreur de moteur	R/T	A	T_{surf}	D
	T_{surf}		I_n	
	I_n			
Démagnétiseur	R/T	A	T_{surf}	D
	T_{surf}		I_n	
	I_n			
Limiteur de courant	R/T	B	TT	E
	T_{surf}			
	TT			
	I_{ss}			
	I_h			
Capteur	R/T	C	R/T	F

Mesure R/T R/T pour **thermistances CTP** – tous les types (J.17.1.4)

I_h Essai de courant de maintien pour limiteurs de courant CTP (J.17.1.5)

TT Essai de temps jusqu'à déclenchement pour limiteurs de courant CTP (J.17.1.6)

T_{surf} Essai de température de surface (J.17.1.7)

I_n **Courant d'appel** (la conformité est déterminée par mesure, J.17.1.8)

I_{ss} Courant en régime établi (la conformité est déterminée par mesure)

A - Les valeurs de **résistance** à 25 °C, de **température de surface** et de **courant d'appel** doivent s'inscrire dans les tolérances d'écart déclarées spécifiées par le fabricant.

B - Les valeurs de **résistance** à 25 °C, de **température de surface**, de **courant en régime établi** et de **temps jusqu'à déclenchement** doivent s'inscrire dans les tolérances d'écart déclarées spécifiées par le fabricant. La **thermistance** doit maintenir le **courant de maintien** pendant la durée spécifiée et à la température ambiante spécifiée par le fabricant, sans déclenchement.

C - Les températures correspondant à la **résistance de commutation** (R_{sw}) et deux points supplémentaires, situés au-dessus et au-dessous de R_{sw} sur la courbe R/T doivent s'inscrire dans les tolérances d'écart déclarées spécifiées par le fabricant.

D - Les valeurs de **température de surface** et de **courant d'appel** doivent s'inscrire dans la tolérance de **dérive** déclarée spécifiée par le fabricant.

E - Les valeurs de temps jusqu'à déclenchement doivent s'inscrire dans les tolérances de **dérive** déclarées spécifiées par le fabricant.

F - Les températures correspondant à la **résistance de commutation** (R_{sw}) et deux points supplémentaires, situés au-dessus et au-dessous de R_{sw} sur la courbe R/T ne doivent pas s'écarter des valeurs en l'état de livraison correspondantes de plus de celles spécifiées dans le Tableau J.7.

[a] Abréviations pour l'essai.

[b] Critères de conformité.

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Tableau J.7 – Classes pour thermistances sensibles CTP

Propriété	Classe n°			
	C_1	C_2	C_3	C_4
Dérive de température, K pour une résistance donnée	±0,5	±1,0	±2,0	±5,0
Il convient que les valeurs de température soient "normalisées" par rapport à l'échelle Kelvin lors de la détermination de la **dérive** de température.				

J.17.1.4 Mesure de R/T pour thermistances CTP

J.17.1.4.1 Les échantillons de **thermistance** doivent être placés dans une étuve à air circulant entièrement ventilée ou milieu fluide, tel que de l'huile de silicone, la température étant maintenue à ±1 K de la température spécifiée pour l'essai. L'essai doit être réalisé à différentes températures en commençant à la température ambiante de la pièce jusqu'à la température de commutation (T_{sw}) sans dépasser la température d'emballement thermique (T_R) de la courbe R/T. La résistance est mesurée à l'aide d'un ohmmètre à autant de valeurs de température que nécessaire pour générer une courbe R/T complète.

J.17.1.5 Essai de courant de maintien (I_h) pour limiteurs de courant CTP

J.17.1.5.1 Une **thermistance** de limitation de courant doit maintenir le courant de maintien (I_h) spécifié pendant la durée spécifiée par le fabricant à la température ambiante spécifiée par le fabricant sans déclenchement.

J.17.1.6 Essai de temps jusqu'à déclenchement pour limiteurs de courant CTP

J.17.1.6.1 Une **thermistance** de limitation de courant avec une spécification de temps jusqu'à déclenchement doit déclencher au courant de déclenchement (I_t) spécifié et à la tension assignée (V_r) correspondante dans le temps jusqu'à déclenchement spécifié. Une **thermistance** à plusieurs courants de déclenchement et temps jusqu'à déclenchement doit être soumise à essai aux courants maximal et minimal spécifiés. Le courant ne doit pas dépasser le point du courant maximal ($\boldsymbol{I_{max}}$) sur la courbe temps jusqu'à déclenchement en fonction du courant.

J.17.1.6.1.1 Une **thermistance** de limitation de courant, telle que déclarée au point J.5 du Tableau J.5, doit déclencher au courant de déclenchement (I_t) déclaré et à la tension assignée (V_r) correspondante dans le temps jusqu'à déclenchement spécifié.

J.17.1.7 Essai de température de surface

J.17.1.7.1 La température de surface ($\boldsymbol{T_{surf}}$) d'une **thermistance CTP** doit être mesurée en utilisant des thermocouples ou dispositifs équivalents. Pour une **thermistance CTP** autre qu'un limiteur de courant, la température de surface ($\boldsymbol{T_{surf}}$) doit être mesurée alors que la **thermistance** fonctionne à la tension maximale ($\boldsymbol{V_{max}}$) et au courant en régime établi. Pour un limiteur de courant CTP, la température de surface ($\boldsymbol{T_{surf}}$) doit être mesurée dans deux conditions:

a) *condition de fonctionnement en état maintenu dans laquelle le dispositif doit fonctionner à sa **tension maximale** (V_{max}) assignée et à son **courant de maintien** (I_h) assigné; et*

b) *condition de fonctionnement en état déclenché dans laquelle le dispositif doit fonctionner à la **tension maximale** (V_{max}) assignée et au **courant en régime établi** (I_{ss}) assigné.*

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La température de surface est mesurée à une température ambiante de 25 °C.

Voir Tableau J.2.

J.17.1.8 Mesure du courant d'appel

J.17.1.8.1 Pour les **thermistances CTP** destinées à être utilisées comme radiateurs autocontrôlés, démarreurs de moteur ou démagnétiseurs, le courant d'appel doit être mesuré en utilisant un oscilloscope alors que la **thermistance** fonctionne à la tension maximale sous charge assignée.

J.17.2 Essais d'étalonnage des thermistances CTN

J.17.2.1 En l'état de livraison, chaque échantillon de **thermistance CTN** doit être soumis aux essais spécifiés dans le Tableau J.8 et doit satisfaire aux critères applicables à chaque essai tels que spécifiés dans le Tableau J.8.

J.17.2.2 A l'issue des essais décrits en J.19.16 b), les mêmes échantillons de **thermistance CTN** doivent être soumis aux essais spécifiés dans le Tableau J.8 et doivent satisfaire aux critères applicables à chaque essai tels que spécifiés dans le Tableau J.8. Pour les capteurs CTP, les résultats d'essai doivent satisfaire aux critères spécifiés dans le Tableau J.9.

Tableau J.8 – Séquence des essais d'étalonnage et de conditionnement des thermistances CTN

Type de thermistance CTN	Essais d'étalonnage réalisés sur des échantillons avant les essais de conditionnement spécifiés en J.19.17 [a]	Désignation des critères de conformité (avant conditionnement) [b]	Essais d'étalonnage réalisés sur des échantillons de thermistances après les essais de conditionnement spécifiés en J.19.17 [a]	Désignation des critères de conformité (après conditionnement) [b]
Limiteur de **courant d'appel**	R/T	A	T_{surf}	C
	T_{surf}		I_n	
	I_n			
Capteur	R/T	B	R/T	D
	Bêta			

Mesure de R/T R/T pour **thermistances CTN** (J.17.2.3)

T_{surf} Essai de température de surface (J.17.2.4)

Bêta Essai de **résistance** (R_{25}) et de la **valeur bêta** (**B**) pour **thermistances CTN** (J.17.2.6)

I_n **Courant d'appel** (la conformité est déterminée par mesure [J.17.2.5])

A Les valeurs de **résistance** à 25 °C, de **température de surface** et de **courant d'appel** doivent s'inscrire dans les tolérances d'écart déclarées spécifiées par le fabricant.

B La résistance à deux points de température ou plus sur la courbe R/T et la valeur bêta (si déclarée) doivent s'inscrire dans les tolérances d'écart déclarées spécifiées par le fabricant. Une des températures doit être de 25 °C.

C Les valeurs de **température de surface** et de **courant d'appel** doivent s'inscrire dans la tolérance de **dérive** déclarée spécifiée par le fabricant.

D La résistance à deux points de température ou plus sur la courbe R/T ne doit pas s'écarter des températures en l'état de livraison correspondantes sur la courbe R/T en l'état de livraison de plus des valeurs indiquées dans le Tableau J.9. L'une des températures doit être de 25 °C.

[a] Abréviations pour l'essai.

[b] Critères de conformité.

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Tableau J.9 – Classes pour thermistances sensibles CTN

Propriété	Classe n°			
	C_1	C_2	C_3	C_4
Dérive de température pour une résistance donnée	±0,5	±1,0	±2,0	±5,0
Il convient que les valeurs de température soient "normalisées" par rapport à l'échelle Kelvin lors de la détermination de la **dérive** de température.				

J.17.2.3 Mesure de R/T pour thermistances CTN

J.17.2.3.1 Les échantillons de **thermistance** doivent être placés dans une étuve à air circulant entièrement ventilée ou milieu fluide, tel que de l'huile de silicone, la température étant maintenue à ±1 K de la température spécifiée pour l'essai. L'essai doit être réalisé à différentes températures, en commençant à la température ambiante de la pièce sans dépasser la température maximale de détection déclarée (capteurs) ou la température de surface ($\boldsymbol{T_{surf}}$) maximale déterminée selon J.17.2.4 (limiteurs de courant d'appel). La résistance doit être mesurée à autant de valeurs de température que nécessaire pour générer une courbe R/T complète.

J.17.2.4 Essai de température de surface (limitation du courant d'appel uniquement)

J.17.2.4.1 La température de surface ($\boldsymbol{T_{surf}}$) d'un limiteur de courant d'appel CTN doit être mesurée en utilisant des thermocouples ou des dispositifs équivalents alors que la **thermistance CTN** fonctionne à la tension maximale ($\boldsymbol{V_{max}}$) et au courant maximal ($\boldsymbol{I_{max}}$) avec la valeur assignée de la capacité en parallèle avec la charge. La température doit s'inscrire dans les limites spécifiées par le fabricant. Voir Tableau J.8.

J.17.2.5 Mesure du courant d'appel (limitation du courant d'appel uniquement)

J.17.2.5.1 Pour un limiteur de courant d'appel CTN, le courant d'appel doit être mesuré en utilisant un oscilloscope alors que la **thermistance** fonctionne à la tension maximale ($\boldsymbol{V_{max}}$) et au courant maximal ($\boldsymbol{I_{max}}$) avec la valeur assignée de capacité en parallèle avec la charge.

J.17.2.6 Essai de résistance (R_{25}) et de la valeur bêta (B) pour thermistances CTN

J.17.2.6.1 Les caractéristiques assignées de la valeur bêta (B) d'une **thermistance** à valeur bêta (B) doivent s'inscrire dans les limites spécifiées par le fabricant. La **résistance** (R_{25}) d'une **thermistance CTN** doit être mesurée à 25 °C, opération suivie par la mesure des résistances R_1 et R_2 aux températures T_1 et T_2 telles que spécifiées par le fabricant. La valeur bêta (B) doit être calculée en appliquant la formule suivante:

$$B = (\boldsymbol{I_n}\ R_1 - \boldsymbol{I_n}\ R_2) / (1/T_1 - 1/T_2)$$

où

B est la valeur bêta calculée,

R_1 est la résistance à T_1,

R_2 est la résistance à T_2,

T_1 est une température en K sur la courbe R/T spécifiée par le fabricant, et

T_2 est une deuxième température en K sur la courbe R/T spécifiée par le fabricant.

J.19 Endurance

Paragraphes supplémentaires:

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J.19.16 La séquence des essais est la suivante:

a) *pour les **thermistances CTP**:*
   – *vieillissement (J.19.17.3.1 ou J.19.17.3.2);*
   – *chaleur-froid-humidité (J.19.17.1);*
   – *surcharge (J.19.17.2.1);*
   – *endurance (J.19.17.2.2);*
   – *établissement de cycle fonctionnel à froid (J.19.17.4);*
   – *établissement de cycle thermique à froid (J.19.17.6);*
   – *emballement thermique (J.19.17.5).*
b) *pour les **thermistances CTN**:*
   – *vieillissement (J.19.17.3.1);*
   – *chaleur-froid-humidité (J.19.17.1);*
   – *surcharge (J.19.17.7.1);*
   – *endurance (J.19.17.7.2);*
   – *établissement de cycle fonctionnel à froid (J.19.17.8);*
   – *établissement de cycle thermique à froid (J.19.17.6).*

J.19.16.1 Après les essais appropriés de J.19.17.1 à J.19.17.4 inclus, le fonctionnement du dispositif de commande ne doit pas être perturbé et il doit fonctionner comme prévu et annoncé. La conformité est vérifiée par les essais de J.17.1 ou de J.17.2, selon le cas applicable.

J.19.16.2 Après les essais appropriés de J.19.17, le dispositif de commande doit continuer à être conforme aux exigences des Articles 6 et 15. Pendant et après les essais, il ne doit pas y avoir d'émission de flammes ou de projection de particules.

J.19.17 Essais de conditionnement

J.19.17.1 Chaleur-froid-humidité

A la suite de l'essai spécifié ci-dessous, chaque **thermistance** doit satisfaire aux exigences du Tableau J.6, du Tableau J.7, du Tableau J.8 ou du Tableau J.9, selon le cas applicable.

Trois échantillons hors tension d'une **thermistance** doivent être soumis à trois cycles complets de la séquence spécifiée en a) ou b):

a) *utilisation de la température intérieure:*
   1) *24 h à la **température de surface** (T_{surf}) mesurée ou à la température maximale de fonctionnement déclarée. Dans tous les cas, la température ne doit pas être inférieure à 70 °C. La température de l'étuve doit être maintenue à ±5 K de la température spécifiée pour l'essai. La température doit être surveillée dans la zone de l'étuve où les échantillons sont soumis à essai;*
   2) *168 h dans une atmosphère sans condensation d'une humidité relative de 90 % à 95 % à 40 °C; et*
   3) *8 h à 0 °C ou à la température ambiante spécifiée par le fabricant, selon la valeur la plus basse;*
b) *utilisation de la température extérieure:*
   1) *24 h en immersion dans de l'eau à 25 °C;*
   2) *8 h à moins 35 °C ou à la température ambiante spécifiée par le fabricant, selon la valeur la plus basse;*

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3) *24 h à la **température de surface*** (T_{surf}) *mesurée ou à la température maximale de fonctionnement déclarée. Dans tous les cas, la température ne doit pas être inférieure à 70 °C. La température de l'étuve doit être maintenue à ±5 K de la température spécifiée pour l'essai. La température de l'étuve doit être surveillée dans la zone de l'étuve où les échantillons sont soumis à essai;*

4) *168 h dans une atmosphère sans condensation d'une humidité relative de 90 % à 95 % à 40 °C.*

J.19.17.2 Etablissement de cycle étendu (CTP)

J.19.17.2.1 Surcharge

J.19.17.2.1.1 A l'issue des essais spécifiés en J.19.17.2.1.2**, en** J.19.17.2.1.3 ou en J.19.17.2.1.4 et en J.19.17.2.2, une **thermistance** doit être conforme au Tableau J.6 ou au Tableau J.7.

J.19.17.2.1.2 Pour un radiateur autocontrôlé, trois échantillons doivent être installés et mis en fonctionnement comme prévu pendant 50 cycles en connexion à 120 % de la tension maximale (V_{max}). Chaque cycle doit couvrir la portion de la courbe R/T entre le coude inférieur et l'état de résistance élevée.

J.19.17.2.1.3 Pour une **thermistance** de dispositif de commande, trois échantillons doivent être installés et mis en fonctionnement comme prévu pendant 50 cycles en connexion à la tension maximale (V_{max}) et la plus faible valeur de:

a) 120 % du **courant maximal** assigné (I_{max});

b) 120 % du **courant de court-circuit** *assigné* (I_{sc}).

Chaque cycle doit commencer avec l'échantillon en équilibre thermique à 25 °C ± 5 K. Chaque cycle doit couvrir la portion de la courbe R/T entre le coude inférieur et l'état de résistance élevée.

J.19.17.2.1.4 Pour une **thermistance** sensible, trois échantillons doivent être installés et mis en fonctionnement comme prévu pendant 50 cycles de fonctionnement en commençant avec l'échantillon en équilibre thermique à 25 °C ± 5 K et en augmentant la température jusqu'à 120 % de la température maximale de détection de la **thermistance**.

J.19.17.2.2 Endurance

Les trois échantillons de **thermistances** déjà soumis à l'essai de surcharge de J.19.17.2.1 doivent fonctionner dans les conditions spécifiées en a), b) ou c) pendant le nombre de cycles spécifiés dans le Tableau J.10. Chaque cycle doit couvrir une portion significative de la courbe R/T.

a) ***Radiateur autocontrôlé*** *– Une **thermistance** de **radiateur autocontrôlé** ou d'ensemble d'appareil de chauffage doit être installée et soumise à essai à la puissance maximale assignée ou au courant maximal (I_{max}) sous la **tension maximale** (V_{max}). Une **thermistance** dont la consommation varie en fonction de la quantité de dissipation thermique, du débit d'air ou variables analogues fournies dans le matériel en utilisation finale, doit être soumise à essai à la puissance maximale assignée ou au **courant maximal** (I_{max}) en utilisant la dissipation thermique, le débit d'air ou autres conditions du matériel en utilisation finale.*

b) *Dispositif de commande – Une **thermistance** de dispositif de commande doit être soumise à essai à la **tension maximale** (V_{max}) et aux courants suivants:*

   1) *limiteur de courant – Le courant d'essai ne doit pas être inférieur au courant minimal de déclenchement (I_t);*

   2) *démagnétiseur – Le courant d'essai doit être le **courant maximal***(I_{max});

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3) *démarreur de moteur – Le courant d'essai doit être le* ***courant maximal*** (I_{max}).

c) *Détection – Une* ***thermistance*** *sensible doit être soumise aux cycles entre 25 °C ± 5 K et la température maximale de fonctionnement.*

Tableau J.10 – Nombre de cycles pour l'essai d'endurance

Type de thermistance	Nombre de cycles de fonctionnement
Radiateur autocontrôlé	100 000
Limiteur de courant destiné à être utilisé dans un circuit de **sécurité fonctionnelle**	100 000 [a]
Limiteur de courant non destiné à être utilisé dans un circuit de **sécurité fonctionnelle**	6 000
Démagnétiseur ou démarreur de moteur	30 000
Capteur non destiné à être utilisé dans un circuit de **sécurité fonctionnelle**	6 000
Capteur destiné à être utilisé dans un circuit de **sécurité fonctionnelle**	100 000

[a] Le nombre minimal de cycles est réduit à 6 000 dans les conditions suivantes:
– l'état déclenché de la **thermistance** est apparent dans l'application d'utilisation finale;
– une intervention manuelle est exigée pour procéder au réarmement des **thermistances**.

J.19.17.3 Conditionnement thermique

J.19.17.3.1 Vieillissement passif

A la suite des essais spécifiés ci-dessous et en J.19.17.3.2, chaque ***thermistance*** *doit satisfaire aux exigences du Tableau J.6, du Tableau J.7, du Tableau J.8 ou du Tableau J.9, suivant le cas.*

Trois échantillons hors tension d'une **thermistance** doivent être conditionnés pendant 1 000 h à une température de 30 K supérieure à la température spécifiée dans le Tableau J.11 dans une étuve à air circulant. Dans tous les cas, la température ne doit pas être inférieure à 70 °C. La température de l'étuve doit être maintenue à ±5 K de la température spécifiée pour l'essai. La température de l'étuve doit être surveillée dans la zone de l'étuve où les échantillons sont soumis à essai.

Tableau J.11 – Température d'essai de vieillissement

Type de thermistance	Température
Tous les types sauf les capteurs	Température déterminée d'après l'**essai de température de surface**, J.17.1.8 (CTP) et J.17.2.4 (CTN)
Détection	Caractéristiques assignées de la température la plus élevée

J.19.17.3.2 Vieillissement actif

Outre l'essai décrit en J.19.17.3.1, un limiteur de courant doit être soumis à cet essai. Trois échantillons d'une **thermistance** de limitation de courant CTP doivent être mis sous tension et conditionnés pendant 1 000 h à l'état déclenché à la tension maximale (V_{max}) et transportant le courant en régime établi (I_{ss}).

J.19.17.4 Établissement de cycle fonctionnel à froid (CTP)

A l'issue de l'essai spécifié ci-dessous, une **thermistance** doit être conforme au Tableau J.6.

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Trois échantillons d'une **thermistance** doivent être soumis à 1 000 cycles de fonctionnement à une température ambiante de 0 °C ou à la température ambiante spécifiée par le fabricant, selon la valeur la plus basse. Les conditions d'essai doivent être telles que spécifiées en J.19.17.2.2 a) pour un radiateur autocontrôlé ou en J.19.17.2.2 b) pour une **thermistance** de dispositif de commande. La température de la **thermistance** doit être revenue à la température de démarrage avant chaque cycle.

J.19.17.5 Emballement thermique

*Les **thermistances** doivent être mises sous tension et placées dans les conditions assignées maximales jusqu'à stabilisation thermique. La tension doit alors être augmentée progressivement jusqu'au claquage, ou jusqu'à obtenir deux fois la **tension de service** de la **thermistance**, à partir de quoi l'essai peut être arrêté.*

NOTE L'augmentation de la tension par paliers de 0,1 fois la **tension de service** de la **thermistance** toutes les 2 min constitue une vitesse de montée appropriée.

J.19.17.6 Établissement de cycle thermique à froid

A l'issue de l'essai spécifié ci-dessous, une **thermistance** doit être conforme au Tableau J.7 ou au Tableau J.9, selon le cas applicable.

Trois échantillons d'une **thermistance** sensible doivent être soumis à 1 000 cycles thermiques de fonctionnement à froid. Chaque cycle doit commencer à 0 °C ou à la température ambiante spécifiée par le fabricant, selon la valeur la plus basse, et couvrir la portion de la courbe R/T entre la température de démarrage et la température maximale assignée.

J.19.17.7 Établissement de cycle étendu (CTN)

J.19.17.7.1 Surcharge

J.19.17.7.1.1 A l'issue des essais spécifiés en J.19.17.7.1.2 ou en J.19.17.7.1.3 et en J.19.17.7.2, une **thermistance** doit être conforme au Tableau J.8.

J.19.17.7.1.2 Pour une **thermistance** de limitation de courant d'appel, trois échantillons doivent être installés et mis en fonctionnement comme prévu pendant 50 cycles en étant connectés à la tension maximale ($V_{\mathbf{max}}$) et à 120 % du courant maximal ($I_{\mathbf{max}}$). Chaque cycle doit commencer avec l'échantillon en équilibre thermique à 25 °C.

J.19.17.7.1.3 Pour une **thermistance** sensible, trois échantillons doivent être installés et mis en fonctionnement comme prévu pendant 50 cycles de fonctionnement en commençant avec l'échantillon en équilibre thermique à 25 °C ± 5 K et en augmentant la température jusqu'à 120 % de la température maximale de détection de la **thermistance**.

J.19.17.7.2 Endurance

Les trois échantillons de **thermistances** déjà soumis à l'essai de surcharge de J.19.17.7.2 doivent fonctionner dans les conditions spécifiées en a) ou b) pendant le nombre de cycles spécifiés dans le Tableau J.12. Chaque cycle doit couvrir une portion significative de la courbe R/T.

a) *Limitation de **courant d'appel** – Une **thermistance** de limitation de **courant d'appel** doit être soumise à essai à la **tension maximale** (V_{max}) et au courant maximal (I_{max}) avec la valeur de capacité assignée parallèle à la charge. Voir Figure J.1.*

b) *Détection – Une **thermistance** sensible doit être soumise aux cycles entre 25 °C ± 5 K et la température maximale de fonctionnement.*

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Tableau J.12 – Nombre de cycles pour l'essai d'endurance

Type de thermistance	Nombre de cycles de fonctionnement
Limiteur de **courant d'appel** destiné à être utilisé dans un circuit de **sécurité fonctionnelle**	100 000
Limiteur de **courant d'appel** non destiné à être utilisé dans un circuit de **sécurité fonctionnelle**	6 000
Capteur destiné à être utilisé dans un circuit de **sécurité fonctionnelle**	100 000
Capteur non destiné à être utilisé dans un circuit de **sécurité fonctionnelle**	6 000

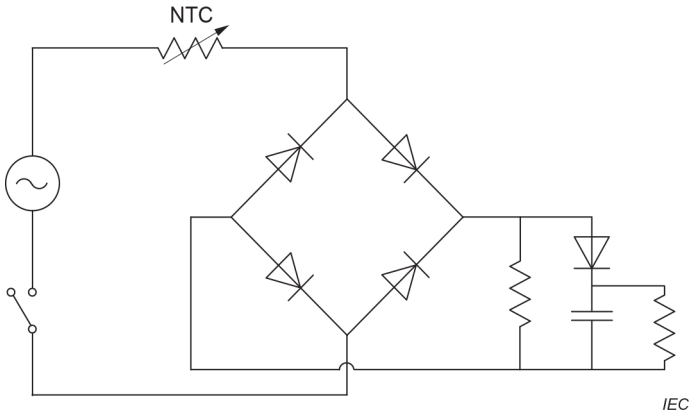


Figure J.1 – Circuit générique d'essai pour essai d'endurance de thermistance de limitation de courant d'appel

J.19.17.8 Établissement de cycle fonctionnel à froid (pour thermistances de limitation de courant d'appel CTN uniquement)

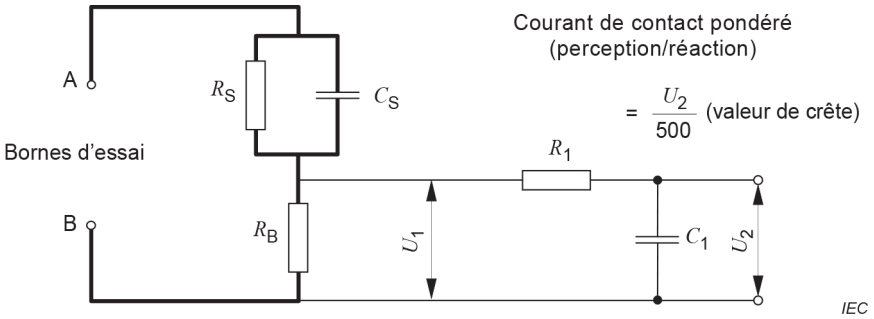
A l'issue de l'essai spécifié ci-dessous, une **thermistance** doit être conforme au Tableau J.8.

Trois échantillons d'une **thermistance** doivent être soumis à 1 000 cycles de fonctionnement à la tension maximale ($V_{\mathbf{max}}$) conduisant le courant maximal ($I_{\mathbf{max}}$), à une température ambiante de 0 °C ou à la température ambiante spécifiée par le fabricant, selon la valeur la plus basse. Chaque cycle doit couvrir la portion de la courbe R/T entre la température de démarrage et les conditions en régime établi. La température de la **thermistance** doit être stabilisée à la température de démarrage ± 2 K avant chaque cycle.

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Annexe K
(normative)

Circuit de mesure du courant de contact



R_S 1 500 Ω R_1 10 000 Ω

R_B 500 Ω C_1 0,022 µF

C_S 0,22 µF

NOTE 1 Cette figure est issue de l'IEC 60990:2016, Figure 4.

NOTE 2 La valeur 500 est exprimée en ohms et U_1 comme U_2 sont exprimées en volts.

Figure K.1 – Circuit de mesure des courants de contact

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Annexe L
(normative)

Essai de performance des revêtements de cartes de circuits imprimés

L.1 Un revêtement prévu pour être utilisé sur une carte de circuit imprimé qui a des lignes de fuite en accord avec l'Article 11, degré de pollution 1, doit satisfaire aux exigences de l'Annexe P.

L.2 L'utilisation d'un ensemble carte de circuit imprimé utilisé avec un revêtement, comme des encres, des épargnes de brasage et des composants montés, doit être acceptable en matière de température, de conditions de brasure, de section des conducteurs et d'adhérence au matériau de base comme déterminé par les exigences de la série IEC 61249.

L.3 Un revêtement doit résister à l'essai de rigidité diélectrique de 13.2 pour l'**isolation fonctionnelle** à la tension d'essai déterminée dans le Tableau 16, en fonction de la tension de service maximale fournie à l'assemblage de cartes, après conditionnement selon c) et d).

a) Dix échantillons d'essai doivent être préparés avec les lignes de fuite minimales applicables et l'épaisseur minimale de revêtement en utilisant le schéma de la Figure L.1. Les échantillons sont à préparer par des moyens de production normaux en utilisant le nettoyant ou l'apprêt employé avant d'appliquer le revêtement sur la carte. Un câblage approprié aux tensions et aux températures atteintes doit y être raccordé.

b) Essai de vieillissement: cinq échantillons des cartes revêtues comme décrit en a) doivent être soumis à une température de 130 °C ± 2 K pendant 1 000 h.

c) Conditionnement humide: les cinq échantillons de cartes revêtues soumis à l'essai de vieillissement de P.3.2 doivent être conditionnés pendant 48 h dans une étuve à une température de (35 ± 1) °C et une humidité relative de (90 ± 5) %. Immédiatement après le retrait de l'étuve, chaque échantillon doit être soumis à l'essai de rigidité diélectrique décrit en e) et en f).

d) Cycle de conditionnement d'environnement: cinq des échantillons de cartes revêtues décrits en a) sont à soumettre à trois cycles complets de conditionnement d'environnement décrit dans le Tableau L.1. Immédiatement après ce conditionnement, chaque échantillon doit être soumis à l'essai de rigidité diélectrique décrit en e) et en f).

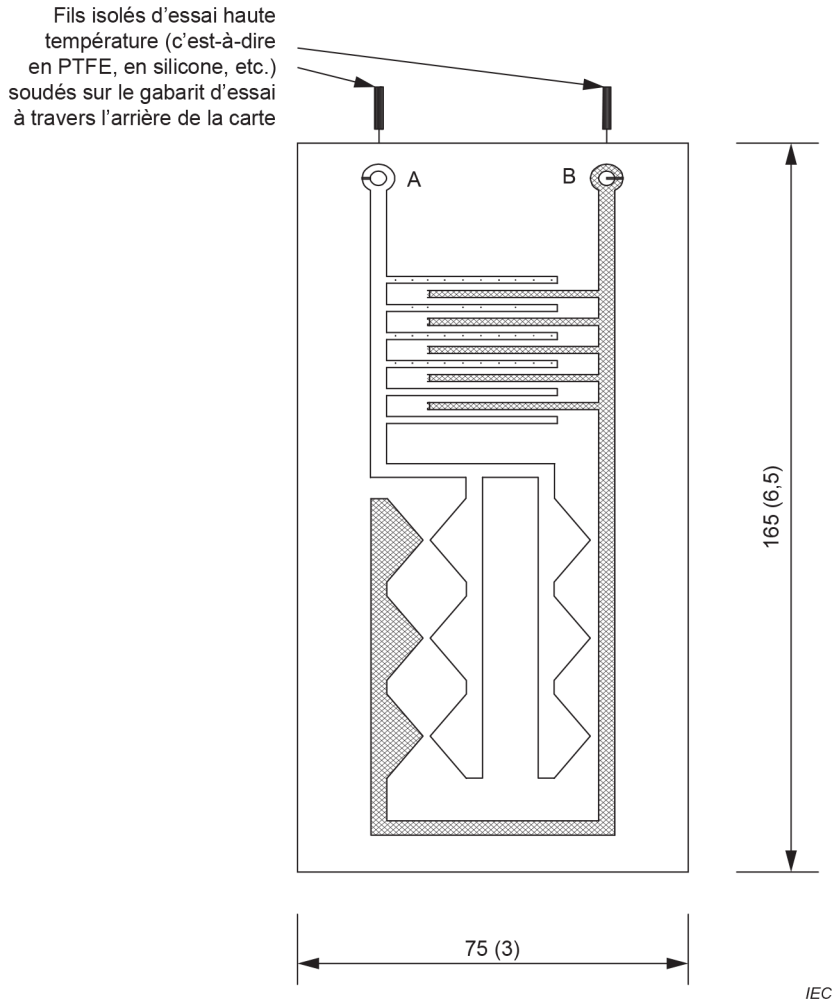
e) Après conditionnement, les échantillons de cartes revêtues comme décrit en a) sont à envelopper de façon serrée dans une feuille de papier aluminium (représentant un dépôt électriquement conducteur sur la surface du revêtement) qui couvre le gabarit d'essai sauf le fil isolé d'essai et les points de soudure.

f) La contrainte de tension doit être appliquée conformément à l'Article L.3 à chacun des échantillons conditionnés entre chacun des fils A, B et C et le fil commun (voir Figure L.1). Il ne doit se produire ni contournement ni avarie. Les décharges luminescentes sans chute de tension sont ignorées.

Tableau L.1 – Conditions d'établissement de cycles d'environnement

Pour utilisations intérieures	Pour utilisations extérieures
24 h à T_{max}; suivies d'au moins 96 h à (35 ± 2) °C et une humidité relative de (90 ± 5) %; suivies de 8 h à (0 ± 2) °C	Immersion d'au moins 24 h à (25 ± 2) °C; immédiatement suivie d'au moins 96 h à (35 ± 2) °C et une humidité relative de (90 ± 5) %; suivie de 8 h à (-35 ± 2) °C

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NOTE La plus petite distance entre pistes (point à point, point à ligne et ligne à ligne) représente la distance minimale permise sur les montages en production.

Figure L.1 – Echantillon d'essai

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Annexe M
(normative)

Revêtement de protection de la carte de circuit imprimé

M.1 Les cartes de circuits imprimés conformes à toutes les exigences de protection de type 1 (Figure M.1) telles qu'elles sont spécifiées dans l'IEC 60664-3:2016 doivent satisfaire aux exigences minimales des lignes de fuite de l'Article 11, degré de pollution 1, du présent document.

NOTE La protection de type 1 améliore le microenvironnement des parties sous protection. [Source: IEC 60664-3:2016, Article 1].

M.2 Les cartes de circuits imprimés conformes à toutes les exigences de protection de type 2 (Figure M.2) telles qu'elles sont spécifiées dans l'IEC 60664-3:2016 doivent satisfaire aux exigences minimales pour l'isolation solide comme spécifié en 11.4 du présent document. L'espacement entre les conducteurs placés avant la protection ne doit pas être inférieur aux valeurs indiquées dans l'IEC 60664-3:2016, Tableau 1, mais il doit être supérieur ou égal à 0,2 mm pour l'**isolation fonctionnelle** ou principale et supérieur ou égal à 0,7 mm pour l'**isolation renforcée** ou supplémentaire.

NOTE La protection de type 2 est considérée comme similaire à l'isolation solide. [Source: IEC 60664-3:2016, Article 1].

M.3 Six échantillons de cartes de circuits imprimés réelles sont exigés:

– pour les essais de protection:
  - des spécimens d'essai conformes à l'IEC 60664-3:2016, Annexe C, qui s'applique spécifiquement aux cartes de circuits imprimés; le spécimen utilisé pour les essais doit avoir les mêmes distances minimales que ceux issus de la production; ou
  - des spécimens issus de la production; ou
  - toute carte de circuit imprimé, tant que les spécimens d'essai sont représentatifs de ceux issus de la production;
– pour les essais des moulages et de l'empotage:
  - des spécimens de production doivent être utilisés ou ils doivent être représentatifs de ceux issus de la production.

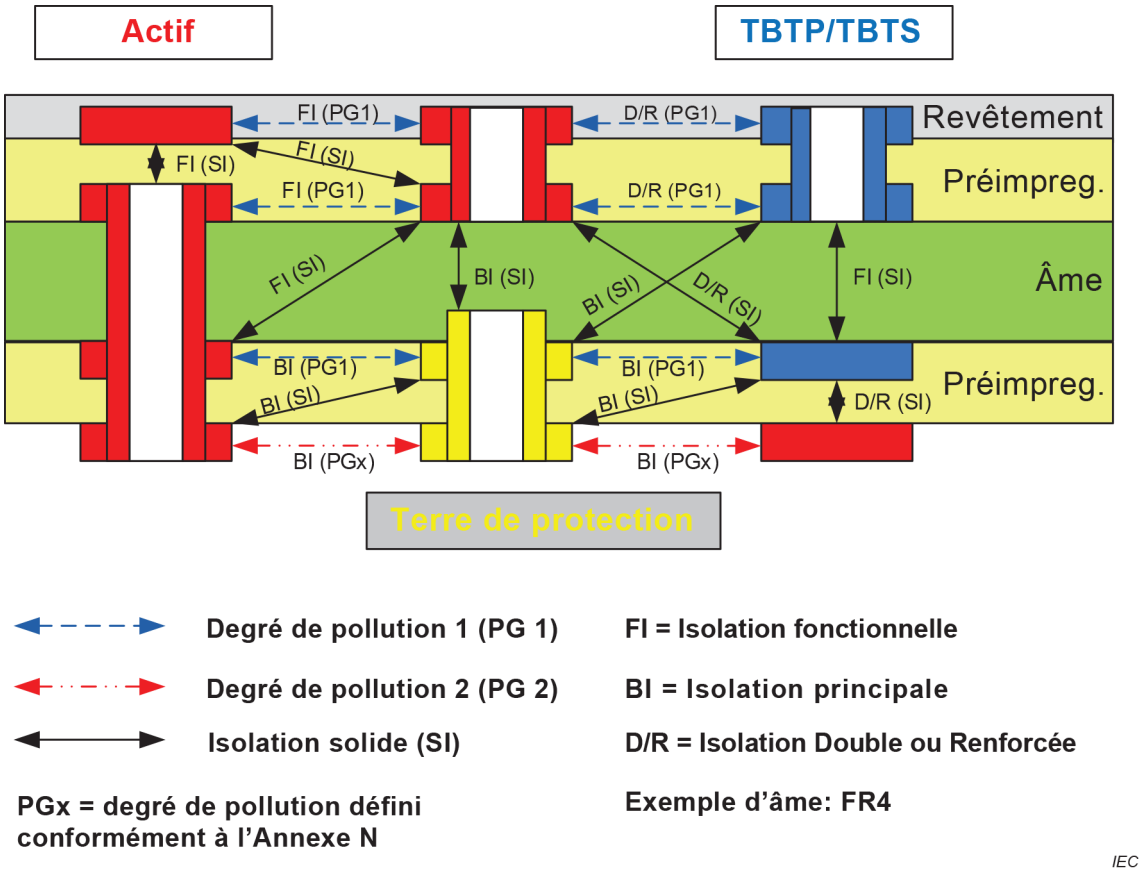
M.4 La conformité avec les exigences de protection de type 1 ou de type 2 doit être vérifiée par les essais de l'IEC 60664-3:2016, Article 5.

M.5 Pour les essais de l'IEC 60664-3:2016, Article 5, les niveaux ou conditions d'essai donnés dans le Tableau M.1 s'appliquent:

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Tableau M.1 – Niveaux ou conditions d'essai de l'IEC 60664-3

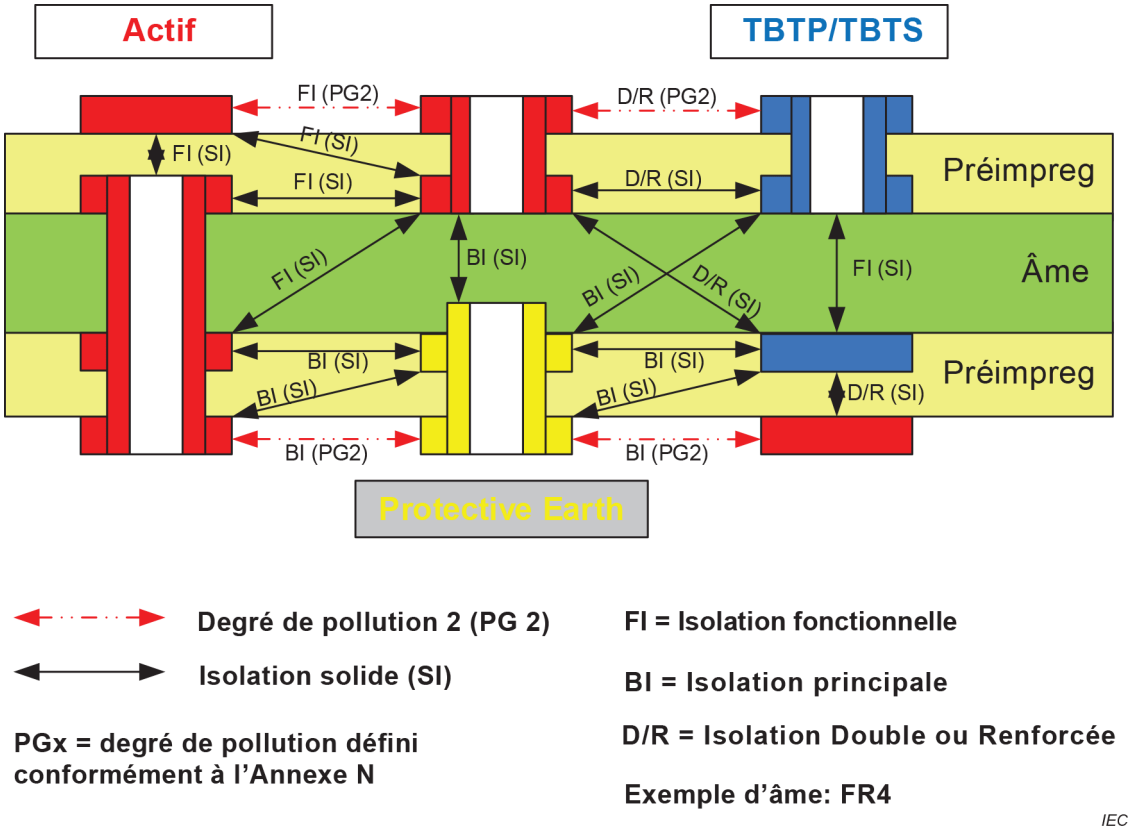
Paragraphe/alinéa de l'IEC 60664-3:2016		Niveau d'essai du présent document
5.6	Essai de résistance aux éraflures	Non applicable aux couches internes de cartes multicouches dont la protection est de type 2
5.7.2	Conditionnement froid	–25 °C
5.7.3	Conditionnement de chaleur sèche	La température maximale de la surface de travail donnée dans l'IEC 60664-3:2016, Tableau 2, est la température de la surface de la carte de circuit imprimé en fonctionnement normal. Cet essai couvre aussi l'essai de 11.4.5, deuxième tiret.
5.7.4	Variations rapides de température	Degré de sévérité 2 (–25 °C à +125 °C)
5.7.5.2	Electromigration	21 jours
5.8.2	Adhérence du revêtement	Non applicable aux couches internes de cartes multicouches dont la protection est de type 2
5.8.5	Décharge partielle	Applicable uniquement si la tension de crête dépasse 700 V et si le niveau de champ > 1 kV/mm, voir IEC 60664-1:2007, 6.1.3.1.
La séquence d'essai doit être conforme à l'IEC 60664-3:2016, Tableau A.1.		



NOTE Pour faciliter la lisibilité, la figure ne représente pas toutes les relations possibles. Au moins une relation est donnée pour chaque combinaison.

Figure M.1 – Exemple de protection de type 1

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NOTE Pour faciliter la lisibilité, la figure ne représente pas toutes les relations possibles. Au moins une relation est donnée pour chaque combinaison.

Figure M.2 – Exemple de protection de type 2

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Annexe N
(informative)

Notes explicatives pour l'essai d'immunité aux ondes de choc

N.1 Différentes impédances de source

La sélection de l'impédance de source du générateur dépend:

– du genre de câble/conducteur/ligne (alimentation en courant alternatif, alimentation en courant continu, interconnexion, etc.);
– de la longueur des câbles/des lignes;
– des conditions intérieures/extérieures;
– de l'application de la tension d'essai (entre phases ou entre phase et terre).

L'impédance de 2 Ω représente l'impédance de source du réseau d'alimentation basse tension.

Un générateur avec une impédance de sortie effective de 2 Ω est utilisé.

L'impédance de 12 Ω (10 Ω + 2 Ω) représente l'impédance de source du réseau d'alimentation basse tension et de la terre.

Le générateur avec une résistance supplémentaire en série de 10 Ω est utilisé.

L'impédance de 42 Ω (40 Ω + 2 Ω) représente l'impédance de source entre les autres lignes du réseau et la terre.

Le générateur avec une résistance supplémentaire en série de 40 Ω est utilisé.

N.2 Application des essais

N.2.1 Généralités

Il faut distinguer deux types différents d'essais: au niveau du matériel et au niveau du **système**.

N.2.2 Immunité au niveau du matériel

L'essai doit être effectué au laboratoire sur un seul EUT. Il est fait référence à l'immunité de l'EUT ainsi soumis à essai comme à l'immunité au niveau du matériel.

La tension d'essai ne doit pas dépasser la capacité spécifiée de l'isolation à supporter les contraintes de la haute tension.

N.2.3 Immunité au niveau du système

Il est fait référence à l'EUT pour l'essai effectué au laboratoire. L'immunité au niveau du matériel n'assure pas l'immunité d'un **système** dans tous les cas. Pour cette raison, un essai au niveau du **système** est conseillé pour simuler l'installation réelle. L'installation simulée comprend les dispositifs de protection (parafoudres, varistances, lignes blindées, etc.) et la longueur et le type réels des lignes d'interconnexion.

Cet essai vise à simuler le fidèlement possible les conditions d'installation dans lesquelles il est prévu que le ou les EUT fonctionnent ultérieurement.

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Dans le cas de l'immunité dans des conditions réelles d'installation, de plus hauts niveaux d'essai peuvent être appliqués, mais l'énergie concernée est limitée par les dispositifs de protection selon leurs caractéristiques de limitation du courant.

L'essai est aussi destiné à montrer que les effets secondaires produits par les dispositifs de protection (modifications de la forme d'onde, du mode, de l'amplitude des tensions ou des courants) ne causent pas d'effets inacceptables sur l'EUT.

N.3 Classification d'installation

N.3.1 Généralités

Les classifications d'installation sont les suivantes.

Classe 2: environnement électrique où les câbles sont bien séparés, même sur de faibles longueurs.

L'installation est mise à la terre, par l'intermédiaire d'une ligne de terre séparée, au **système** de mise à la terre de l'alimentation, qui peut être essentiellement soumis à des interférences de tension générées par l'installation elle-même ou par la foudre. L'alimentation des matériels électroniques est séparée de celle des autres circuits, principalement par un transformateur spécial pour l'alimentation. Il peut y avoir dans l'installation des circuits non protégés s'ils sont bien séparés et en nombre réduit.

Cette classe s'applique au matériel de catégorie de surtension I. La catégorie de surtension I s'applique aux **dispositifs de commande** raccordés après un matériel de catégorie de surtension II et qui, par exemple, comprend des **systèmes** électroniques logiques **TBT**, des **circuits secondaires limités isolés**, des circuits **TBT**, des circuits **TBTS**, des circuits **TBTP** et des circuits sur la partie secondaire des transformateurs.

La surtension ne dépasse pas 1 kV.

Classe 3: environnement électrique où les câbles d'alimentation et de signaux sont posés parallèlement.

L'installation est mise à la terre au **système** commun de mise à la terre de l'alimentation qui peut être principalement soumis à des interférences de tension générées par l'installation elle-même ou par la foudre.

Le courant dû à des **pannes** à la terre, à des opérations de commutation et à des coups de foudre sur l'installation de puissance peut générer des interférences de tension avec des amplitudes relativement grandes dans le **système** de mise à la terre. Le matériel électronique protégé et les matériels électriques moins sensibles sont raccordés au même réseau d'alimentation électrique. Les câbles d'interconnexion peuvent être posés en partie comme câbles extérieurs, mais à proximité du réseau de mise à la terre. Il reste dans l'installation des charges inductives non supprimées et il n'y a habituellement pas de séparation des différentes nappes de câbles.

Cette classe s'applique au matériel de catégorie de surtension III ou au matériel de catégorie de surtension II.

La catégorie de surtension III s'applique normalement aux **dispositifs de commande** prévus pour la connexion au **câblage fixe** ou pour l'incorporation dans le matériel prévu pour une connexion permanente au **câblage fixe**, à moins que l'utilisation du **dispositif de commande** ou du matériel fournisse des moyens de suppression de la tension transitoire, auquel cas une catégorie inférieure s'applique.

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La catégorie de surtension II s'applique normalement aux **dispositifs de commande** connectés en aval d'un socle de prise de courant ou pour l'incorporation dans un matériel connecté en aval d'un socle de prise de courant. Les **dispositifs de commande** prévus pour la connexion permanente au **câblage fixe** peuvent aussi entrer dans cette catégorie, où les méthodes de suppression de la tension transitoire, telles que des moyens limiteurs de tension en bout de ligne ou les **distances dans l'air** entre parties actives, sont incorporées dans les **dispositifs de commande** ou le matériel. Si les contacts des **dispositifs de commande** sont conçus pour permettre le contournement de la tension transitoire et sont aptes à résister au courant coupé limité, ils peuvent fournir une suppression adéquate. Ce sont, par exemple, des **dispositifs de commande** pour appareils domestiques satisfaisant aux descriptions ci-dessus.

La surtension ne dépasse pas 2 kV.

Classe 4: environnement électrique où les câbles d'interconnexion sont posés comme des câbles extérieurs avec les câbles d'alimentation, et où les câbles sont utilisés à la fois pour les circuits électroniques et pour les circuits électriques.

L'installation est reliée au **système** de mise à la terre de l'alimentation électrique qui peut être soumis à des interférences de tension générées par l'installation elle-même ou par la foudre. Les courants, dans la gamme des kiloampères, dus à des **pannes** à la terre, à des opérations de commutation et à des coups de foudre sur l'installation d'alimentation électrique peuvent générer des interférences de tension avec des amplitudes relativement grandes dans le **système** de mise à la terre. Le matériel électronique et le matériel électrique peuvent être reliés au même réseau d'alimentation. Les câbles d'interconnexion peuvent passer comme câbles extérieurs, même pour le matériel haute tension.

Un cas particulier de cet environnement est celui où le matériel électronique est connecté au réseau de télécommunications dans une zone densément peuplée. Il n'y a pas réseau de mise à la terre systématiquement construit à l'extérieur du matériel électronique et le **système** de mise à la terre est seulement composé de conduits, câbles, etc.

La surtension ne dépasse pas 4 kV.

Des exemples d'installation du matériel électronique dans les différents cas sont donnés à la Figure N.1, à la Figure N.2 et à la Figure N.3.

N.3.2 Immunité au niveau du matériel des accès raccordés au réseau d'alimentation électrique

Le niveau minimal d'immunité pour connexion au réseau d'alimentation public est

– couplage entre phases: 0,5 kV

– couplage entre phase et terre: 1 kV

N.3.3 Immunité au niveau du matériel des accès raccordés à des lignes d'interconnexion

Les essais de chocs électriques sur les circuits d'interconnexion sont uniquement exigés pour les connexions externes (à l'extérieur du coffret/enveloppe). Si l'essai est possible au niveau du **système** (EUT avec des câbles d'interconnexion raccordés), il n'est pas nécessaire de faire l'essai au niveau du matériel (par exemple accès de la commande de processus ou des entrées/sorties de signaux) particulièrement dans les cas où le blindage du câble d'interconnexion fait partie des mesures de protection. Si l'installation de l'appareil est effectuée par quelqu'un d'autre que les fabricants du matériel, il convient que la tension admissible pour les entrées/sorties (particulièrement pour les interfaces de commande de processus) de l'EUT soit spécifiée.

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Il convient que le fabricant soumette à essai son matériel sur la base des niveaux d'essai spécifiés pour confirmer l'immunité au niveau du matériel, par exemple avec la protection secondaire des accès de l'EUT pour un niveau de tension d'essai de 0,5 kV. Il convient que l'**utilisateur** de l'installation ou les responsables de son installation appliquent les mesures (par exemple blindage, équipotentialité, mise à la terre, protection) nécessaires pour assurer que la tension d'interface causée, par exemple, par des coups de foudre ne dépasse pas le niveau d'immunité choisi.

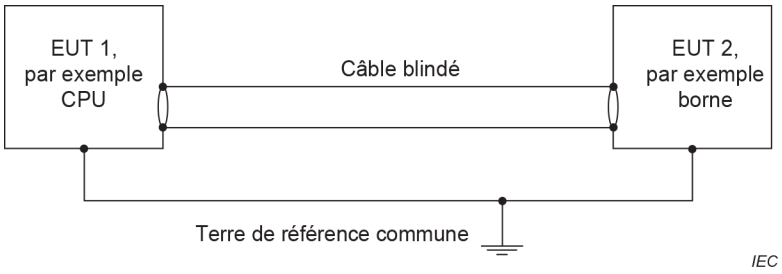


Figure N.1 – Exemple de protection contre les chocs électriques par blindage dans les bâtiments avec des systèmes de terre de référence commune

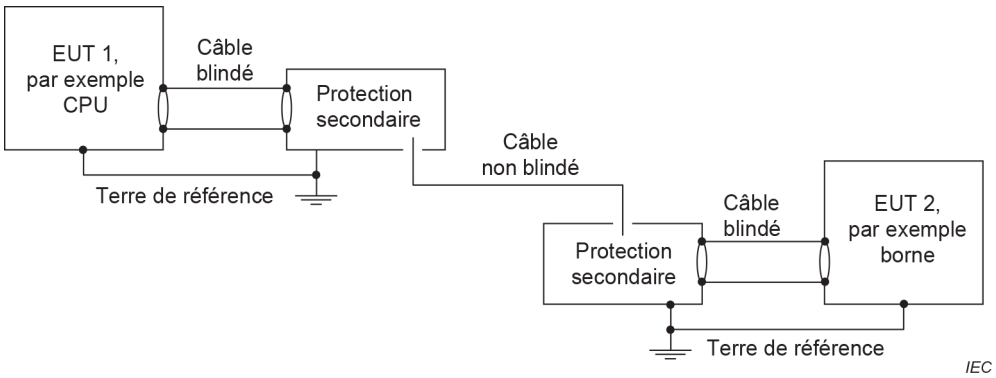


Figure N.2 – Exemple de protection secondaire contre les chocs électriques dans les bâtiments avec des systèmes de terre de référence commune séparés

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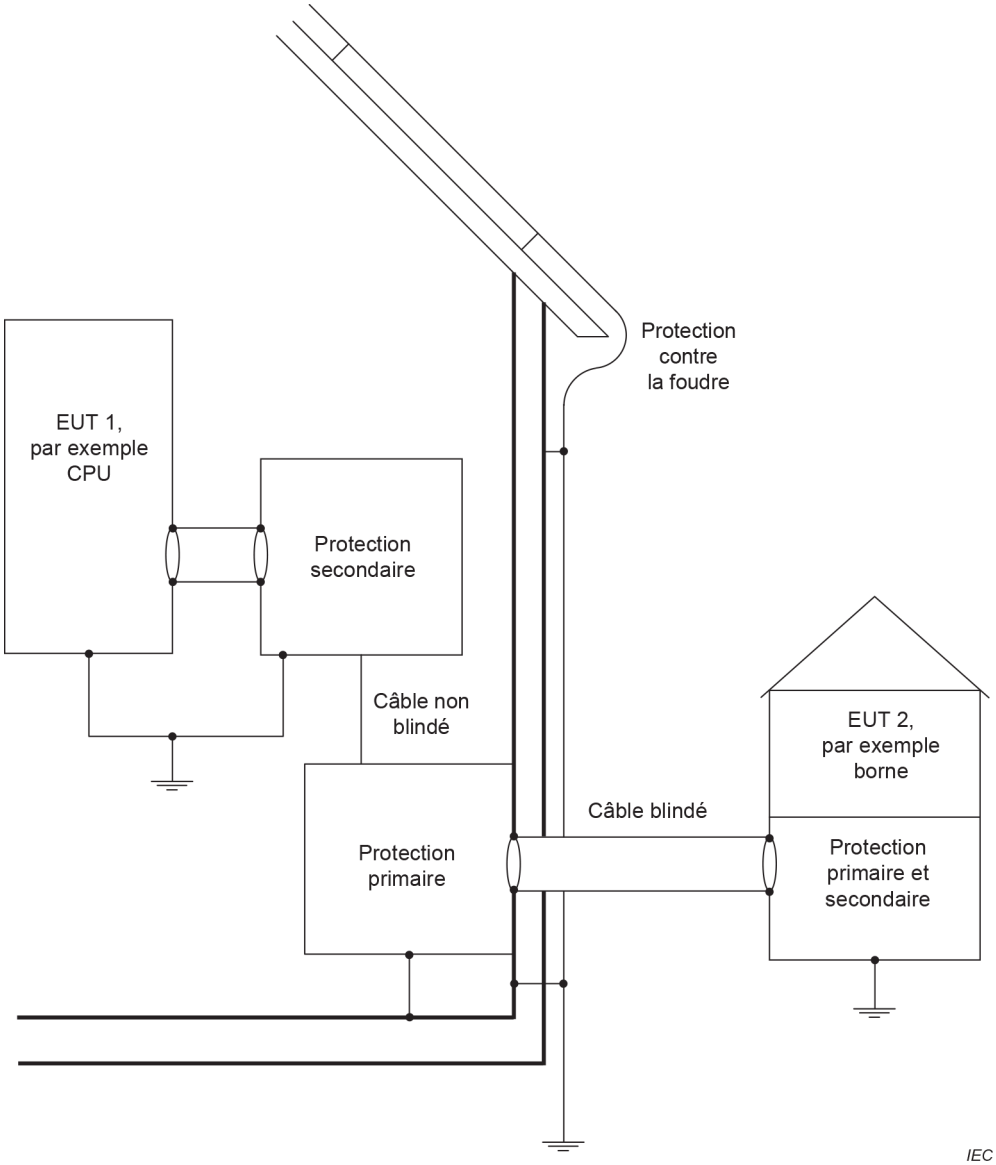


Figure N.3 – Exemple de protection primaire et secondaire contre les chocs électriques du matériel intérieur et extérieur

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Annexe O
(informative)

Recommandations pour l'application de l'Article 11

Les recommandations pour l'application de l'Article 11 sont fournies à la Figure O.1, dans le Tableau O.1 et dans le Tableau O.2.

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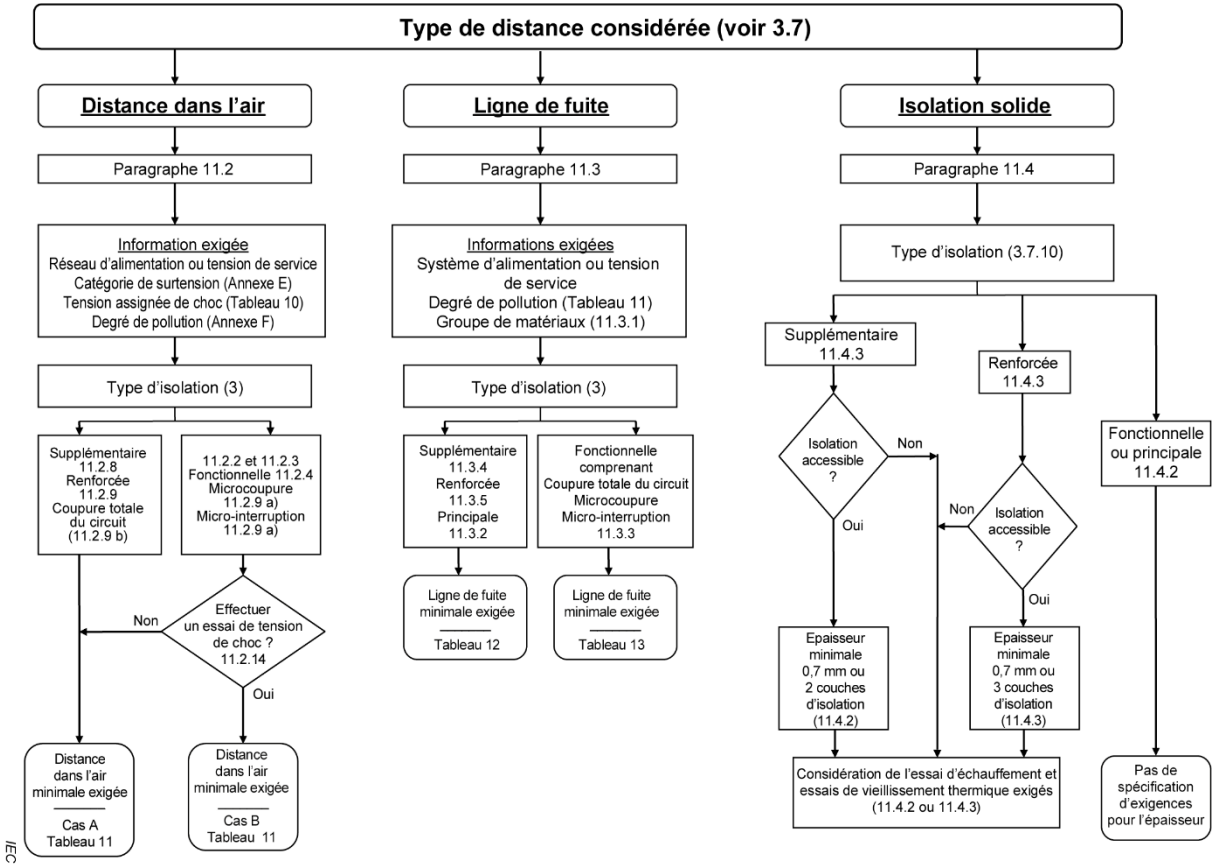


Figure O.1 – Recommandations sous forme d'organigramme pour l'application des exigences de l'Article 11

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Tableau O.1 – Exemple A – Utilisation des recommandations de l'Annexe O pour l'application de l'Article 11

Question	Réponse	Instruction
La distance considérée est-elle dans l'air ou sur une surface?	Dans l'air	Suivre le trajet des **distances dans l'air** de l'organigramme
Quelle est la tension d'alimentation du **système** ou, pour l'**isolation fonctionnelle**, la **tension de service**?	230 V/400 V, triphasée, 4 fils	Enregistrer en a)
Quelle est la **catégorie de surtension**? (voir Annexe D)	Voir catégorie II	Enregistrer en b)
Quelle est la **tension assignée de choc**?	A déterminer dans le Tableau 10 en utilisant a) et b)	Enregistrer en c)
Quel est le **degré de pollution**? (voir Annexe F)	**Degré de pollution** 2	Enregistrer en d)
Quel est le type d'isolation? (se référer aux définitions, etc.)	**Isolation renforcée**	Voir 11.2.11. Pour l'isolation renforcée, utiliser le cas A et le niveau de tension de choc immédiatement supérieur dans le Tableau 11. Enregistrer en e).
Quelle est la limite pour cette distance?	Voir Tableau 11.	Déterminer la limite en utilisant d) et e)
	La limite est 3 mm	

Tableau O.2 – Exemple B – Utilisation des recommandations de l'Annexe O pour l'application de l'Article 11

Question	Réponse	Instruction
La distance considérée est-elle dans l'air ou sur une surface?	Sur une surface	Suivre le trajet des **lignes de fuite**
Quelle est la tension d'alimentation du **système** ou, pour l'**isolation fonctionnelle**, la **tension de service**?	230 V	Enregistrer en a)
Quel est le **degré de pollution**? (voir Annexe F)	**Degré de pollution** 2	Enregistrer en b)
Quel est le groupe de matériau? (se référer à 11.3.1, Note b du Tableau 12 et Note d du Tableau 13)	IIIb)	Enregistrer en c)
Quel est le type d'isolation? (se référer aux définitions, etc.)	**Isolation fonctionnelle**	Voir 11.3.3.
Quelle est la limite pour cette distance?	Voir Tableau 13.	Déterminer la limite en utilisant a), b) et c)
	La limite est 2,5 mm	

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Annexe P
(normative)

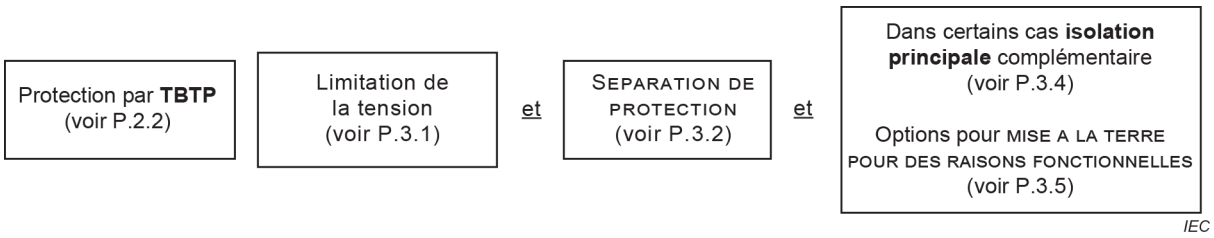
Exigences pour la TBTS et la TBTP

P.1 Vue d'ensemble des exigences pour la TBTS et la TBTP

P.1.1 Protection par TBTS



P.1.2 Protection par TBTP



(Adapté de l'IEC 61140)

NOTE Les exigences de l'IEC 61140 pour les séparations ont été prises en compte et incluses dans les exigences du présent document y compris, sans toutefois s'y limiter, les Articles 6, 9, 11 et 20 du présent document.

P.2 Protection contre les chocs électriques par l'utilisation d'un schéma TBTS ou d'un schéma TBTP

P.2.1 Schéma TBTS

La protection contre les chocs électriques doit être fournie par les mesures suivantes:

– une limitation de la tension, selon P.3.1, dans un circuit (le **schéma TBTS**); et
– une séparation de protection, selon P.3.2, du **schéma TBTS** de tous les circuits autres que les circuits **TBTS** et les circuits **TBTP**;
– une séparation simple, selon P.3.4, du **schéma TBTS** des autres **schémas TBTS**, des **schémas TBTP** et de la terre.

Le raccordement délibéré des **masses** du **dispositif de commande** à un **conducteur de protection** ou à un conducteur de terre n'est pas admis.

Dans les locaux particuliers où la **TBTS** est exigée et lorsque la **protection par écran conducteur** selon P.3.3 est appliquée, l'**écran de protection conducteur** doit être séparé de chaque circuit adjacent par une **isolation principale** assignée pour la tension la plus élevée présente.

Les exigences pour les éléments du **schéma TBTS** sont données dans l'ArticleP.3.

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P.2.2 Schéma TBTP

La protection contre les chocs électriques doit être fournie par les mesures suivantes:

– une limitation de la tension, conformément à P.3.1, dans un circuit qui peut être mis à la terre et/ou dont les **parties conductrices accessibles** peuvent être mises à la terre (**schéma TBTP**);

– une **séparation de protection** conformément à P.3.2 du **schéma TBTP** de tous les circuits autres que les circuits **TBTS** et les circuits **TBTP**.

Si le circuit **TBTP** est mis à la terre et si la **protection par écran conducteur** selon P.3.3 est utilisée, il n'est pas nécessaire de fournir une **isolation principale** entre l'**écran de protection conducteur** et le schéma **TBTP**.

Si les **parties actives** du **schéma TBTP** sont accessibles (au toucher) simultanément avec les parties conductrices qui, en cas de **panne**, sont susceptibles d'atteindre le potentiel du circuit primaire, la protection contre les chocs électriques dépend de la **liaison équipotentielle de protection** (7.6) de toutes ces parties conductrices. De telles parties doivent être reliées à la borne ou **connexion** de mise à la terre de protection du **dispositif de commande**.

Les exigences pour les éléments du **schéma TBTP** sont données dans l'Article P.3.

P.3 Mesures de protection pour le schéma TBTS et le schéma TBTP

P.3.1 Limitation de tension

La limitation de la tension doit assurer que la tension entre des parties accessibles simultanément ne dépasse pas les limites spécifiées en 3.1.5 et comme spécifié en 6.1.1.

P.3.2 Séparation de protection

La séparation de protection entre circuits dans des **schémas TBTS** ou des **schémas TBTP** et d'autres circuits actifs doit être assurée par les mesures suivantes

– une **isolation principale** et une **isolation supplémentaire**, chacune étant assignée pour la tension la plus élevée présente, c'est-à-dire **double isolation**, ou

– une **isolation renforcée** assignée pour la tension la plus élevée présente, ou

– une **protection par écran conducteur** selon P.3.3 avec l'**écran de protection conducteur** séparé de chaque circuit adjacent par une **isolation principale** assignée pour la tension la plus élevée du circuit adjacent (voir aussi P.2.1, dernier alinéa), ou

– une combinaison de ces dispositions.

Les conducteurs du circuit séparé, lorsqu'ils sont contenus ensemble avec les conducteurs d'autres circuits dans un câble multiconducteur ou dans un autre groupement de conducteurs, doivent être isolés, individuellement ou collectivement, pour la tension présente la plus élevée, de façon à réaliser une **double isolation** ou une **isolation renforcée**.

Si un des composants est raccordé entre des circuits séparés, ce composant doit satisfaire aux exigences d'**impédance de protection** spécifiées en 6.1.10.

Une **séparation de protection** ou un niveau de protection équivalent exigé entre des circuits **TBTS** ou **TBTP** et d'autres circuits est assuré par les sources suivantes:

– un transformateur de sécurité;

– une source de courant assurant un degré de sécurité équivalent à celui d'un transformateur de sécurité (par exemple groupe convertisseur); ou

– une source de courant électrochimique (par exemple batterie).

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NOTE Les limites de tension sont établies sur l'hypothèse d'un **transformateur de sécurité** alimenté à la limite supérieure de sa tension assignée.

Si un convertisseur est utilisé, et si le **dispositif de commande** est déclaré:

– IPX7 et IPX8 comme déclarés dans le Tableau 1, exigence 9, le **dispositif de commande** doit être déclaré comme devant être soumis à une analyse de deuxième **panne** (voir Tableau H.1, exigence H.10) pour les circuits et l'isolation entre les enroulements du convertisseur et, résultant de cette deuxième **panne**, la valeur **TBT** de 0 V ne doit pas être dépassée. Le courant entre les pôles de la sortie doit satisfaire à 6.1.9.

La conformité est vérifiée par examen, mesure et réalisation du ou des essais appropriés dans l'ordre du présent document.

P.3.3 Protection par écran conducteur

La **protection par écran conducteur** doit comprendre un écran conducteur inséré entre les **parties actives dangereuses** du **dispositif de commande**, de l'installation ou du **système** (réseau) et la partie protégée (par exemple un circuit **TBTS** ou un circuit **TBTP**). L'**écran de protection conducteur**:

– doit être raccordé en permanence et de façon sûre à la borne de mise à la terre de protection du **dispositif de commande** et la connexion doit satisfaire aux exigences de l'Article 7; et

– doit lui-même satisfaire aux exigences de l'Article 7.

P.3.4 Séparation simple

La **séparation simple** entre un circuit **TBTS** et d'autres **schémas TBTS** ou des **schémas TBTP** ou la terre doit satisfaire aux exigences de l'**isolation principale** dans leur totalité, assignées pour la tension présente la plus élevée.

Si un composant quelconque est raccordé entre les circuits séparés, ce composant doit supporter les contraintes électriques spécifiées pour l'isolation qu'il contourne et son impédance doit limiter le courant présumé à travers le composant aux valeurs de **courant de contact** en régime établi indiquées en 6.1.10 et en 9.2.5 pour l'**impédance de protection**.

P.3.5 Mise à la terre fonctionnelle

Le présent document admet l'utilisation des **parties conductrices accessibles** en tant que **conducteurs internes** d'un circuit **TBTP** interne pour la mise à la terre fonctionnelle, sous réserve des conditions spécifiées dans le présent document, et pour les applications particulières dans la Partie 2 applicable.

NOTE La mise à la terre fonctionnelle est le raccordement d'un circuit électrique local à la terre pour des raisons fonctionnelles par opposition à la mise à la terre de protection. Selon le type du **système** (réseau) d'installation, différentes exigences s'appliquent et sont données dans les normes de l'IEC pour l'installation des bâtiments. La mise à la terre fonctionnelle peut être nécessaire pour le matériel de télécommunications, pour lesquels les normes de produits de l'IEC s'appliquent.

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Annexe Q
(informative)

Différences régionales pertinentes pour les pays membres du CENELEC

NOTE La présente annexe fournit les différences régionales pertinentes pour les pays membres de Cenelec, sans les mentionner. Si certaines exigences, essais ou notes sont uniquement applicables à un ou plusieurs de ces pays, les pays concernés sont alors mentionnés. Les numéros de paragraphe de la présente annexe indiquent les ajouts/modifications apportés au même numéro de paragraphe que celui utilisé dans la partie principale du présent document, à l'exception de Q.30 et Q.31, qui concernent uniquement la présente Annexe Q. L'Annexe ZB (voir Q.30) dans la version CENELEC de la présente norme spécifie "Condition nationale particulière: Caractéristique ou pratique nationale qu'il n'est pas possible de modifier même sur une longue période, telle que, par exemple, des conditions climatiques ou des conditions électriques de mise à la terre." L'Annexe ZC (voir Q.31) dans la version CENELEC de la présente norme spécifie "Divergence A: divergence nationale due à des règlements dont la modification n'est pas dans l'immédiat de la compétence du membre national du CEN-CENELEC."

Q.3.7.3 Dispositif de commande de la classe 0 (voir 3.7.3)

NOTE Voir Annexe ZB.

Q.3.7.4 Dispositif de commande de la classe II (voir 3.7.4)

NOTE Voir Annexe ZB.

Q.3.7.6.3 Dispositif de commande de la classe II (voir 3.7.6.3)

NOTE Voir Annexe ZB.

Q.4.2 Exigences générales (voir 4.2)

Ajouter après le 1er alinéa:

La tension assignée des dispositifs de commande, disposant de bornes destinées à être directement raccordées au réseau d'alimentation monophasé, doit couvrir l'utilisation à 230 V et, pour le réseau d'alimentation multiphasé, à 400 V.

Q.4.3.4.3 Selon la protection contre les chocs électriques (voir 4.3.4.3.1)

Q.4.3.4.3.1 (voir 4.3.4.3.1)

NOTE Voir Annexe ZB.

Q.4.3.4.3.3 (voir 4.3.4.3.3)

NOTE Voir Annexe ZB.

Q.5.4.2 Marquage des bornes pour connexions externes (voir 5.4.2)

Q.5.4.2.2 (voir 5.4.2.2)

NOTE Voir Annexe ZB.

Q.5.4.2.4 (voir 5.4.2.4)

NOTE Voir Annexe ZB.

Q.7.1.1 (voir 7.1.1)

NOTE Voir Annexe ZB.

Q.7.5.2 Dispositif de commande incorporé (voir 7.5.2)

NOTE 7.5.2 ne s'applique pas.

Q.14.3 Le paragraphe 14.3 ne s'applique pas.

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Q.15.2 Rigidité diélectrique (voir 15.2, Tableau 16)

NOTE Voir Annexe ZB.

Q.15.3 Le paragraphe 15.3 ne s'applique pas.

Q.16 Heating (voir Article 16)

Ajouter après le Tableau 17:

Si la température maximale admise d'un enroulement ou des tôles de noyau dépasse la valeur spécifiée pour l'essai décrit en 16.1, six échantillons supplémentaires doivent être soumis aux essais suivants:

Les parties mobiles, le cas échéant, sont verrouillées et un courant circule individuellement dans chaque enroulement, ce courant étant tel que la température de l'enroulement concerné est égale à la température maximale mesurée dans les conditions spécifiées en 16.1. Cette température est augmentée d'une valeur quelconque choisie dans le Tableau Q.1. Le temps total pendant lequel le courant passe est indiqué dans le tableau pour l'augmentation de température choisie.

Tableau Q.1 – Paramètres supplémentaires de vieillissement pour les enroulements

Augmentation de la température	Durée totale
0 ± 3	p[a]
10 ± 3	0,5 p
20 ± 3	0,25 p
30 ± 3	0,125 p

[a] Généralement, p est égal à 8 000 pour les dispositifs de commande pour les applications relevant de l'EN 60335-1.

La durée totale est divisée en quatre périodes égales, chacune d'entre elles étant suivie d'une période de 48 h pendant laquelle le dispositif de commande est soumis à une épreuve hygroscopique comme spécifié en 14.2. Après l'épreuve hygroscopique finale, l'isolation doit résister à un essai de rigidité diélectrique comme spécifié à l'Article 15.2, la tension d'essai pour la rigidité diélectrique étant, cependant, réduite à 50 % des valeurs spécifiées dans le Tableau 16.

L'échec d'un seul des six échantillons pendant la première des quatre périodes de l'essai est ignoré. Si l'un des six échantillons échoue au cours de la deuxième, troisième ou quatrième période de l'essai, les cinq échantillons restants sont soumis à une cinquième période supplémentaire de passage de courant et d'épreuve hygroscopique, suivie d'un essai de rigidité diélectrique et d'un essai de résistance d'isolement comme spécifié précédemment.

L'échec de l'un des cinq dispositifs de commande restants entraîne un rejet.

Les dispositifs de commande sont alors soumis à l'essai de 19.8, mais uniquement pour la moitié du nombre de cycles spécifié dans ce paragraphe. Tous les dispositifs de commande doivent satisfaire à l'essai de rigidité diélectrique comme spécifié précédemment.

NOTE Les deux cas où la classification du **système** d'isolation d'un enroulement peut être mise en doute sont ceux où des matériaux isolants bien connus sont utilisés de manière non conventionnelle, où des combinaisons de matériaux de différentes classes de température sont utilisées à une température supérieure à celle autorisée pour la classe la plus basse utilisée ou encore où des matériaux sont utilisés pour lesquels il n'y a pas d'expérience suffisante, comme cela peut être le cas pour l'isolation intégrale du conducteur.

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S'il est souhaité d'établir que l'isolation unique appartient à la classe de température déclarée par le fabricant, la température d'enroulement doit être égale à la limite de température de la classe d'isolation déclarée, augmentée de l'augmentation de température choisie dans le tableau.

Il convient que l'augmentation de température choisie dans le tableau fasse l'objet d'un accord avec le fabricant.

Q.18.2.1 L'effet de la température (voir 18.2.1) est vérifié de la manière suivante:

NOTE Voir Annexe ZB.

Q.19.3.1 Les exigences suivantes doivent s'appliquer à toutes les parties du **dispositif de commande** à l'exception d'un **élément thermosensible** (voir 19.3.1):

Ajouter ce qui suit comme une sous-partie du 3e tiret:

– Dispositifs de commande avec une **action de type 1** – Articles 18 et 19;
– Dispositifs de commande avec une **action de type 2** – Articles 15, 18 et 19.

Un échantillon supplémentaire exigé.

Q.19.7 Essai de surtension ou essai de surcharge dans tous les pays qui utilisent un essai de surcharge pour action automatique accélérée (voir 19.7)

Seul l'essai de surtension s'applique.

Q.19.10 Essai de surtension ou essai de surcharge dans tous les pays qui utilisent un essai de surcharge pour action automatique accélérée (voir 19.10)

Seul l'essai de surtension s'applique.

Q.21.3.1 (voir 21.3.1)

Ajouter ce qui suit comme 2e alinéa:

Pour les parties qui maintiennent ou retiennent en position les connexions électriques, l'essai au fil incandescent doit être effectué à une température de 850 °C.

Q.25 Exigences de compatibilité électromagnétique (CEM) – Immunité (voir Article 25)

Q.25.1 Généralités

Ajouter l'exigence suivante avant le Tableau 25:

Le Tableau 25 s'applique avec les modifications suivantes. Pour tous les dispositifs de commande séparés, à montage indépendant et intercalés dans un câble souple de classe A, les essais de 25.5 à 25.10 s'appliquent, ce qui signifie que la Note [a] du Tableau 25 ne s'applique pas.

Q.30 – Annexe ZB (normative) – Conditions nationales particulières

Condition nationale particulière Caractéristique ou pratique nationale qu'il n'est pas possible de modifier même sur une longue période, telle que, par exemple, des conditions climatiques ou des conditions électriques de mise à la terre.

NOTE Si elle affecte l'harmonisation, elle fait partie intégrante de la Norme européenne.

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Pour les pays pour lesquels la condition nationale particulière est applicable, ces dispositions sont normatives, pour les autres pays, elles sont informatives.

Q.30.3.7.3 Les dispositifs de commande de la classe 0 tels que décrits en 3.7.3 ne sont pas admis en Autriche, en Belgique, au Danemark, en France, en Allemagne, en Italie, en Norvège et au Royaume-Uni.

Q.30.3.7.4 Les dispositifs de commande de la classe 0I tels que décrits en 3.7.4 ne sont pas admis en Autriche, en Belgique, au Danemark, en France, en Allemagne, en Italie, en Norvège et au Royaume-Uni.

Q.30.3.7.6.3 Les dispositifs de commande de la classe II tels que décrits en 3.7.6.3 ne sont pas admis en Autriche, en Belgique, au Danemark, en France, en Allemagne, en Italie, en Norvège et au Royaume-Uni.

Q.30.4.3.4.3.1 Les dispositifs de commande de la classe 0 et de la classe 0I tels que décrits en 4.3.4.3.1 ne sont pas admis en Autriche, en Belgique, au Danemark, en France, en Allemagne, en Italie, en Norvège et au Royaume-Uni.

Q.30.4.3.4.3.3 Les dispositifs de commande de la classe 0 et de la classe 0I tels que décrits en 4.3.4.3.3 ne sont pas admis en Autriche, en Belgique, au Danemark, en France, en Allemagne, en Italie, en Norvège et au Royaume-Uni.

Q.30.5.4.2.2 Royaume-Uni

Ajouter à l'exigence de 5.4.2.2: les bornes à relier exclusivement à un conducteur externe doivent être signalées par la lettre "L".

Q.30.5.4.2.4 Royaume-Uni

Ajouter à l'exigence de 5.4.2.4:

La lettre "L" ne doit pas être utilisée sauf comme indiqué ci-dessus.

Q.30.7.1.1 Les dispositifs de commande de la classe 0I tels que décrits en 7.1.1 ne sont pas admis en Autriche, en Belgique, au Danemark, en France, en Allemagne, en Italie, en Norvège et au Royaume-Uni.

Q.30.15.2 Les dispositifs de commande de la classe 0I tels que décrits dans le Tableau 16, Note [c], ne sont pas admis en Autriche, en Belgique, au Danemark, en France, en Allemagne, en Italie, en Norvège et au Royaume-Uni.

Q.30.18.2.1 Pour la Finlande, la Norvège et la Suède.

Dans le premier tiret de 18.2.1, remplacer "(–10 ± 2) °C" par "(–25 ± 2) °C".

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Q.31 – Annexe ZC (informative) – Divergences A

Divergence A: Divergence nationale due à des règlements dont la modification n'est pas dans l'immédiat de la compétence du membre national du CEN-CENELEC.

La présente Norme européenne relève du domaine des directives DBT (2014/35/UE), CEM (2014/30/UE) et RED (2014/53/UE).

NOTE (CEN/CENELEC RI Partie 2:2011, 2.17) Lorsqu'une norme relève du domaine de directives de l'UE, la Commission des Communautés européennes estime (voir JO no C 59, 1982-03-09) que la conséquence de la décision de la Cour de justice dans le cas 815/79 Cremonini/Vrankovich (Rapports de la Cour européenne 1980, p. 3583) est que la conformité aux divergences A n'est plus obligatoire et que la libre circulation des produits conformes à une telle norme ne peut être restreinte que par la procédure de sauvegarde prévue dans la directive correspondante.

Les **divergences A** dans un pays de l'AELE remplacent les dispositions de la Norme européenne dans le pays correspondant du CEN-CENELEC jusqu'à ce qu'elles aient été supprimées.

Alinéa	Divergence
Q.31.9.1.3	**Royaume-Uni** (décret 1768:1994)
	Ajouter à l'exigence:
	Ces réglementations s'appliquent à toutes les fiches pour utilisation domestique à une tension supérieure ou égale à 200 V et en général admettent uniquement le montage de fiches conformes à la BS 1363.

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Annexe R
(informative)

Différences nationales applicables aux Etats-Unis

NOTE La présente annexe est informative dans le présent document, mais normative dans l'UL 60730-1. Voir UL 60730-1, Différences nationales pour les exigences spécifiques aux Etats-Unis.

R.2 Références normatives

Voir UL 60730-1 pour les exigences spécifiques aux Etats-Unis.

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Annexe S
(informative)

Différences nationales applicables au Japon

NOTE La présente annexe est informative dans le présent document, mais normative dans la JIS C 9730-1. Voir JIS C 9730-1, Annexe JA, pour les exigences spécifiques au Japon.

S.2 Références normatives

Voir JIS C 9730-1, Annexe JA, pour les exigences spécifiques au Japon.

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Annexe T
(informative)

Différences nationales applicables au Canada

NOTE La présente annexe est informative dans le présent document, mais normative dans la CAN/CSA-E60730-1. Voir CAN/CSA-E60730-1, Différences nationales pour les exigences spécifiques au Canada.

T.2 Références normatives

Voir CAN/CSA-E60730-1 pour les exigences spécifiques au Canada.

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ISO/IEC 9796 (toutes les parties), *Technologies de l'information – Techniques de sécurité – Schémas de signature numérique rétablissant le message*

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