

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Automatic electrical controls –  
Part 1: General requirements**

**Dispositifs de commande électrique automatiques –  
Partie 1: Exigences générales**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**AUTOMATIC ELECTRICAL CONTROLS –****Part 1: General requirements****FOREWORD**

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

This fifth edition cancels and replaces the fourth edition published in 2010. It constitutes a technical revision. The major changes with respect to the previous edition are as follows.

- modification of the title and scope;
- revisions to Clause H.26 based on changes in technology, applications, and to improve consistency and layout;
- modification to Table H.12 to align with CISPR 22;
- revisions to Annex J to correlate the fault modes of thermistors and to exempt thermistors used in conjunction with type 1 controls in SELV low power circuits from the tests specified in Annex J;
- new requirements covering battery-powered controls, and the use of batteries in controls;
- revision addressing the exclusion of relay faults;
- new/updated requirements in Clause 24, for switch mode power supplies;

- revisions covering the allowance of screwless-type clamping units complying with IEC 60999-1;
- new requirements addressing remotely actuated control functions;
- addition of a new/updated leakage current diagram to align the Annex E diagram with the diagram in IEC 60990;
- updated requirements for temperature sensing controls.

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

| FDIS        | Report on voting |
|-------------|------------------|
| 72/899/FDIS | 72/928/RVD       |

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

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 controls for household and similar use, 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” notes regarding differing national practices are contained in the following subclauses:

|                               |                               |                        |
|-------------------------------|-------------------------------|------------------------|
| 2.1.5                         | 11.11.1.2                     | 17.10.4                |
| 2.7.2                         | 11.11.1.3                     | 17.12.5                |
| 2.7.3                         | 11.11.1.4                     | 18.1.6                 |
| 2.14.2                        | 12.1.6                        | 18.1.6.1               |
| 4.2.1                         | 12.3                          | 18.1.6.2               |
| 6.6.1                         | Table 12 (13.2.1), footnote a | 18.1.6.3               |
| Table 1 (7.2), footnote d     | 13.3.4                        | 18.4                   |
| 7.4.3                         | 14.4                          | 19.2.4.1               |
| 7.4.3.2                       | Table 13 (14.7.4), footnote f | 19.2.5.1               |
| 8.1.1.1                       | 15.1                          | 21.1                   |
| 8.4                           | 16.2.1                        | 21.4                   |
| 9.3.2                         | 17.1.3.1                      | 27.2.3.1               |
| 9.3.4                         | 17.2.2                        | Annex C                |
| 9.5.2                         | 17.2.3                        | Annex D                |
| Table 3 (10.1.4), footnote b  | 17.2.3.1                      | H.26.10                |
| 10.1.4.1                      | Table 14 (17.2.5)             | Table H.18 (H.26.10.4) |
| 10.1.14                       | Table 15 (17.2.5)             | H.27.1.1.3             |
| 10.1.16                       | Table 16 (17.2.5)             | Table K.1, footnote b  |
| 10.1.16.1                     | 17.5.1                        | Table K.2, footnote b  |
| Table 6 (10.2.1), footnote b  | 17.7.7                        | T.3.2                  |
| 11.5                          | 17.8.4.1                      |                        |
| Table 10 (11.8.2), footnote b | 17.10                         |                        |

It is envisaged that in the next edition of this standard 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.

NOTE In this standard 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**.

Some table titles contain reference in brackets to table numbers in IEC 60730-1, edition 3 for ease of correlation between parts 2 and the Part 1.

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

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

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

The contents of the corrigendum of September 2014 have been included in this copy.

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

# AUTOMATIC ELECTRICAL CONTROLS –

## Part 1: General requirements

### 1 Scope and normative references

#### 1.1 Scope

In general, this part of IEC 60730 applies to automatic **electrical controls** for use in, on, or in association with equipment for household and similar use. The equipment may use electricity, gas, oil, solid fuel, solar thermal energy, etc., or a combination thereof.

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

EXAMPLE 1 **Controls** for appliances within the scope of IEC 60335.

This International Standard is applicable to **controls** for building automation within the scope of ISO 16484.

This standard also applies to automatic **electrical controls** for equipment that may be 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.

This standard is also applicable to individual **controls** utilized as part of a **control** system or **controls** which are mechanically integral with multifunctional **controls** having non-electrical outputs.

EXAMPLE 3 Independently mounted water valves, **controls** in smart grid systems and **controls** for building automation systems within the scope of ISO 16484-2.

This standard is also applicable to relays when used as **controls** for IEC 60335 appliances. Additional requirements for the safety and **operating values** of relays when used as **controls** for IEC 60335 appliances are contained in Annex U.

NOTE 2 These requirements are referred to in the scope of IEC 61810-1.

NOTE 3 This standard is intended to be used for the testing of any stand-alone relay which is intended to be used as a **control** of an appliance according to IEC 60335-1. It is not intended to be used for any other stand-alone relay, or to replace the IEC 61810 series of standards.

This standard does not apply to automatic **electrical controls** intended exclusively for industrial process applications unless explicitly mentioned in the relevant part 2 or the equipment standard.

**1.1.1** This International Standard applies to the inherent safety, to the **operating values**, **operating times**, and **operating sequences** where such are associated with equipment safety, and to the testing of automatic **electrical control** devices used in, or in association with, equipment.

This standard applies to **controls** using **thermistors**, see also Annex J.

This standard is also applicable to the **functional safety** of **low complexity safety related systems** and **controls**.

**1.1.2** This standard applies to automatic **electrical controls**, 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.

**1.1.3** This standard applies to starting relays, which are a specific type of automatic **electrical control**, intended to switch the starting winding of a motor. Such **controls** may be built into, or be separate from, the motor.

**1.1.4** This standard applies to **manual controls** when such are electrically and/or mechanically integral with **automatic controls**.

NOTE Requirements for manual switches not forming part of an **automatic control** are contained in IEC 61058-1.

**1.1.5** This standard applies to a.c. or d.c. powered **controls** with a rated voltage not exceeding 690 V a.c. or 600 V d.c.

**1.1.6** This standard does not 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 household equipment standard or as determined by the manufacturer shall apply.

**1.1.7** This standard applies also to **controls** incorporating **electronic devices**, requirements for which are contained in Annex H.

**1.1.8** This standard applies also to **controls** using NTC or PTC **thermistors**, requirements for which are contained in Annex J.

## **1.2 Normative references**

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038, *IEC standard voltages*

IEC 60065:2001, *Audio, video and similar electronic apparatus – Safety requirements*<sup>1</sup>

Amendment 1:2005

Amendment 2:2010

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, *Surge arresters – Part 1: Non-linear resistor type gapped arresters for a.c. systems*<sup>2</sup>

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*<sup>3</sup>

Amendment 1:2009

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<sup>1</sup> There exists a consolidated edition 7.2:2011 including IEC 60065:2001 and its Amendments 1:2005 and 2:2010.

<sup>2</sup> Withdrawn.

<sup>3</sup> There exists a consolidated edition 4.1:2009 including IEC 60112:2003 and its Amendment 1:2009.

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

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 60269-1, *Low-voltage fuses – Part 1: General requirements*

IEC 60335-1:2010, *Household and similar electrical appliances – Safety – Part 1: General requirements*

IEC 60364 (all parts), *Low-voltage electrical installations*

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*

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

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

IEC 60417 (all parts), *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)*<sup>4</sup>  
Amendment 1:1999

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

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

IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*  
Amendment 1:2010

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 60695-2-11:2000, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow-wire flammability test method for end-products*

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

<sup>4</sup> There exists a consolidated edition 2.1:2001 including IEC 60529:1989 and its Amendment 1:1999.

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

IEC 60738-1-1, *Thermistors – Directly heated positive step-function temperature coefficient – Part 1-1: Blank detail specification – Current limiting application – Assessment level EZ*

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*

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*

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<sup>2</sup> up to 35 mm<sup>2</sup> (included)*

IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*

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

IEC 61000-3-3:2008, *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 61000-4-2:2008, *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, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

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*

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*

Amendment 1:2009



IEC 61000-4-28, *Electromagnetic compatibility (EMC) – Part 4-28: Testing and measurements techniques – Variation of power frequency, immunity test*

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

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 similar products for supply voltages up to 1 100 V – Part 2-6: Particular requirements and tests for safety isolating transformers and power supply units incorporating safety isolating transformers*

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

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

IEC 62326 (all parts), *Printed boards*

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

CISPR 14-1:2005, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*<sup>5</sup>  
Amendment 1:2008

CISPR 22:2008, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

ISO 16484-2, *Building automation and control systems (BACS) – Part 2: Hardware*

## 2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

Where the terms "voltage" and "current" are used, they imply the r.m.s. values, unless otherwise specified.

### 2.1 Definitions relating to ratings, voltages, currents, frequencies, and wattages

#### 2.1.1

##### **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 voltage.

<sup>5</sup> There exists a consolidated edition 5.1:2009 including CISPR 14-1:2005 and its Amendment 1:2008.



### 2.1.2

#### **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

### 2.1.3

#### **working voltage**

highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

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

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

### 2.1.4

#### **extra-low voltage**

##### **ELV**

nominal voltage not exceeding 50 V between conductors and between conductors and earth, or for three-phase connection not exceeding 50 V between line conductors and 29 V between line conductors and neutral

Note 1 to entry: These values were derived from IEC 60335-1:2010, Definition 3.4.1.

Note 2 to entry: In this standard **ELV**-levels for use in a specific application as specified in the relevant application standard may be declared for **controls** used in or with such applications for environmental conditions as specified by the application standard.

### 2.1.5

#### **safety extra-low voltage**

##### **SELV**

nominal voltage for use in a **SELV system** or **PELV system** between conductors and between conductors and earth, not exceeding 42 V between conductors, or in the case of three-phase circuits, not exceeding 24 V between conductors and neutral, the no-load voltage of the circuit not exceeding 50 V and 29 V, respectively, and which is provided by a battery or when obtained from higher voltage is provided by a **safety isolating transformer** or a converter with separate windings

Note 1 to entry: The voltage limits are based on the assumption that the **safety isolating transformer** is supplied at its rated voltage.

Note 2 to entry: Converters with separate windings providing equivalent insulation are dealt with in IEC 61558-2-6 and IEC 61558-2-16.

Note 3 to entry: In Canada and the USA, the limit for **safety extra-low voltage** is 30 V.

Note 4 to entry: Also see 2.1.20 **SELV system** and 2.1.21 **PELV system**.

### 2.1.6

#### **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

### 2.1.7

#### **same polarity**

relationship between **live parts** such that an interconnection between them allows a flow of current through a load, and which current is thus limited by the load

## 2.1.8 Void

## 2.1.9

### **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

## 2.1.10

### **pilot duty**

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

## 2.1.11

### **transient overvoltage**

short duration overvoltage of few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

[SOURCE: IEC 60050-604:1987, 604-03-13]

## 2.1.12

### **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

## 2.1.13

### **overvoltage category**

numeral characterizing a **transient overvoltage** condition

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

## 2.1.14

### **exposed-conductive-part**

conductive part of equipment, which can be touched and which is not normally live, but which 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 60050-195:1998, 195-06-10, modified – Note 1 to entry has been added.]

## 2.1.15

### **(conductive) screen**

### **(conductive) shield (US)**

conductive part that encloses or separates electric circuits and/or conductors

[SOURCE: IEC 60050-195:1998, Amendment 1:2001, 195-02-38]

## 2.1.16

### **(electrically) protective screen**

### **(electrically) protective shield (US)**

**conductive screen** used to separate an electric circuit and/or conductors from hazardous-live-parts

[SOURCE: IEC 60050-195:1998, Amendment 1:2001, 195-06-17]

**2.1.17****(electrically) protective screening****(electrically) protective shielding** (US)

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 60050-195:1998, Amendment 1:2001, 195-06-18]

**2.1.18****simple separation**

separation between circuits or between a circuit and earth by means of **basic insulation**

[SOURCE: IEC 61140:2001, 3.23]

**2.1.19****(electrically) protective separation**

separation of one electric circuit from another by means of:

- **double insulation**, or
- **basic insulation** and **electrically protective screening** (**shielding**), or
- **reinforced insulation**

[SOURCE: IEC 60050-195:1998, Amendment 1:2001, 195-06-19]

**2.1.20****SELV system**

electrical system in which the voltage cannot exceed **ELV**:

- under normal conditions, and
- under single-**fault** conditions, including earth **faults** in other circuits

[SOURCE: IEC 61140:2001, 3.26.1]

**2.1.21****PELV system**

electrical system in which the voltage cannot exceed **ELV**:

- under normal conditions, and
- under single-**fault** conditions, except earth **faults** in other circuits

[SOURCE: IEC 61140:2001, 3.26.2]

**2.2 Definitions of types of control according to purpose****2.2.1****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.

**2.2.2****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

### 2.2.3

#### **automatic control**

**control** in which at least one aspect is non-manual

### 2.2.4

#### **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

### 2.2.5

#### **thermally operated control**

**automatic control** in which the **transmission** is by a thermal **prime mover**

### 2.2.6

#### **thermostat**

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

### 2.2.7

#### **temperature limiter**

temperature **sensing control** which is intended to keep a temperature below or above one particular value during normal operating conditions and which may 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.

### 2.2.8

#### **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: Normally a **thermal cut-out** will provide a **type 2 action**.

### 2.2.9 Void

### 2.2.10

#### **energy regulator**

self-cycling **control** which alters the energy to a load and which may 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.

### 2.2.11

#### **time-based control**

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

### 2.2.12

#### **electrically operated control**

**automatic control** in which the **transmission** is effected 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 testing authority and manufacturer.

### 2.2.13

#### **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.

### 2.2.14

#### **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.

### 2.2.15

#### **motor protector**

**automatic control** that is specifically intended to protect the windings of an electric motor from overheating

### 2.2.16

#### **thermal motor protector**

**automatic control**, built-in or on a motor, that is specifically intended to protect the motor against overheating due to running overload and failure to start

Note 1 to entry: The **control** carries motor current and is sensitive to motor temperature and current.

Note 2 to entry: The **control** is capable of being reset (either manually or automatically) when its temperature falls to the reset value.

### 2.2.17

#### **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

### 2.2.18

#### **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.

### 2.2.19

#### **operating control**

**control** which starts or regulates the equipment during normal **operation**

### 2.2.20

#### **protective control**

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

### 2.2.21

#### **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**.

### 2.2.22

#### **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.

### 2.2.23

#### **system**

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

## 2.3 Definitions relating to the function of controls

### 2.3.1

#### **initiation**

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

### 2.3.2

#### **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 **transmission**; or

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

### 2.3.3

#### **operation**

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

### 2.3.4

#### **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**

### 2.3.5

#### **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.

### 2.3.6

#### **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**

### 2.3.7

#### **actuation**

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

**2.3.8****located position**

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

**2.3.9****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

**2.3.10****activating quantity**

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

**2.3.11****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**

**2.3.12****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**

**2.3.13****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**.

**2.3.14****response value**

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

**2.3.15****trip-free**

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

**2.3.16****leakage current**

all currents, including capacitively coupled currents, which may be conveyed between exposed conductive surfaces of a device and earth or other exposed conductive surfaces of a device

**2.3.17****setting**

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

**2.3.18****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**



### 2.3.19

#### **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**

### 2.3.20

#### **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**

### 2.3.21

#### **setting by the user**

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

### 2.3.22

#### **set point**

value selected by **setting**

### 2.3.23

#### **adjustable set point**

multiple values, within a declared range of values, which can be selected by **setting**

### 2.3.24

#### **duty cycle**

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

### 2.3.25

#### **cycle of contact operation**

one contact make and one subsequent contact break action, or one contact break and one subsequent contact make action

### 2.3.26

#### **operating differential**

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

### 2.3.27

#### **adjustable differential**

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

### 2.3.28

#### **fixed differential**

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

### 2.3.29

#### **maximum working pressure**

#### **maximum rated pressure**

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

### 2.3.30

#### **maximum temperature**

$T_{\max}$

declared maximum continuous ambient temperature to which the **switch head** is intended to be exposed during normal **operation**

### 2.3.31

#### **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.

### 2.3.32

#### **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

## 2.4 Definitions relating to disconnection and interruption

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

### 2.4.1

#### **all-pole disconnection**

for single-phase a.c. appliances and for d.c. appliances, disconnection of both supply conductors by a single switching action or, for appliances to be connected to more than two supply conductors, disconnection of all supply conductors, except the earthed (grounded) conductor, by a single switching action

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

### 2.4.2

#### **full disconnection**

contact separation in all supply poles other than 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: See also Annex H.

### 2.4.3

#### **micro-disconnection**

adequate contact separation in at least one pole so as to provide functional security

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 requirement 36 of Table 1.

Note 3 to entry: See also Annex H.

### 2.4.4

#### **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: See also Annex H.

## 2.4.5

### **OFF position**

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

2.4.6 See Annex H.

## 2.5 Definitions of types of control according to construction

### 2.5.1

#### **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: The equipment may use electricity, gas, oil, solid fuel or a combination thereof.

Note 2 to entry: **Integrated control** also denotes a **control** which is part of a more complex **control** (electrical or non-electrical).

### 2.5.2

#### **incorporated control**

**control** intended for incorporation 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 may not be tested in an equipment as specified in 4.3.1.1.

Note 2 to entry: The equipment may use electricity, gas, oil, solid fuel or a combination thereof.

Note 3 to entry: **Incorporated control** also denotes a **control** intended for incorporation in or on a more complex **control** (electrical or non-electrical).

### 2.5.3

#### **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**.

### 2.5.4

#### **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.

### 2.5.5

#### **independently mounted control**

**control** intended for permanent connection to **fixed wiring**, but intended to be mounted away 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.

### 2.5.6

#### **pull-cord actuated control**

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

**2.5.7 to 2.5.10** See Annex H.

### **2.5.11**

#### **two-step actuation**

sequential performance of two distinct movements of the **actuating member**

## **2.6 Definitions of type of automatic action of a control according to test procedure**

### **2.6.1**

#### **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 standard

Note 1 to entry: A **type 1 action** is subclassified as specified in 6.4.

### **2.6.2**

#### **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 standard

Note 1 to entry: A **type 2 action** is subclassified as specified in 6.4.

## **2.7 Definitions relating to protection against electric shock**

### **2.7.1**

#### **live part**

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

#### **2.7.1.1**

##### **hazardous live part**

**live part** which, under certain conditions of external influences, can give an electric shock

### **2.7.2**

#### **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: In Austria, Belgium, Denmark, France, Germany, Italy, Norway, and the United Kingdom **class 0 controls** are not allowed.

Note 3 to entry: An earthing terminal is only allowed if it is for continuity or functional (as distinct from protective) purposes.

### **2.7.3**

#### **class 0I control**

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

Note 1 to entry: In Austria, Belgium, Denmark, France, Germany, Italy, Norway, and the United Kingdom **class 0I controls** are not allowed.

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

## 2.7.4

### 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; provided that it is fitted with a plug which cannot be introduced into a socket-outlet with earthing contact, the protection is then equivalent to that of class 0, but 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**.

## 2.7.5

### 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 2.7.5.1 to 2.7.5.3.

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

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.

### 2.7.5.1

#### 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**

### 2.7.5.2

#### 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

### 2.7.5.3

#### combination insulation-encased/metal-encased class II control

**control** which is a combination of the types described in 2.7.5.1 and 2.7.5.2

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.

## 2.7.6

### class III control

**control** relying on limitation of voltage to **ELV** 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 may appear or be generated exceeding **ELV** level; and
- not provided with a means of connection for a **protective conductor**

### 2.7.7

#### **detachable part**

part which can be removed or opened without the aid of a **tool** and which does not comply with the test of 11.11.1.5

### 2.7.8

#### **accessible part or accessible surface**

part or surface which can be touched by the test finger of Figure 2, when the **control** is mounted as in **normal use**, and after **detachable parts** have been removed

### 2.7.9

#### **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)

Note 1 to entry: In 2.7.9 through 2.7.12, the following abbreviations are used:

L **live part**;

A **accessible part** (either conductive or an insulating surface);

I intermediate part.

### 2.7.10

#### **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).

Note 2 to entry: This was formerly part of that insulation referred to as **functional insulation**.

### 2.7.11

#### **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).

### 2.7.12

#### **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 standard (L-(I)-A)

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

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**.

### 2.7.13

#### **double insulation**

insulation comprising both **basic insulation** and **supplementary insulation** (class II situation)

2.7.14 See Annex H.

### 2.7.15

#### **equipotential bonding**

provision of electric connections between conductive parts, intended to achieve equipotentiality

Note 1 to entry: The effectiveness of the **equipotential bonding** depends on the frequency of the current in the bonding.

**Equipotential bonding** is used to connect any conductive part of a building not forming part of the electrical installation and liable to introduce an electrical potential, generally the electric potential of the local earth (extraneous-conductive part) and any conductive part of **controls** or equipment or components in the installation which can be touched and which is not normally live but which can become live when **basic insulation** fails (**exposed-conductive-part**) to a main **equipotential bonding terminal** in the form of a bar, in order to bring these parts to the same potential. Parts to be connected to the **equipotential bonding system** include, for example, **protective conductors**, **PE** conductors, **PEN** conductors, earthing conductors, protective earthing terminals of **controls** or equipment, all conductive parts in a building, for example, metal tubing for water (drinking and waste), metallic bathtubs, the central heating system piping, any internal gas tubing (which is also required to be isolated from external gas tubing), earth connectors for antennas and telecommunication systems, all metal parts of the building used for construction like mats and iron, and conductors for lightning protection and depending on the installation system, the earth electrode. Requirements for **equipotential bonding** can be found in the IEC standards for the installation of buildings. These may be relevant for the installation of **controls** which consist of several component-parts (for example, sensors, actors, central **control** element, interface elements) connected in parallel to or via the fixed installation of the building.

[SOURCE: IEC 60050-195:1998, 195-01-10]

### 2.7.15.1

#### **protective-equipotential-bonding**

**equipotential bonding** for purposes of safety (protection against electric shock)

Note 1 to entry: Functional **equipotential bonding** is defined in [IEV 195-01-16].

[SOURCE: IEC 60050-195:1998, 195-01-15, modified – (protection against electric shock) has been added.]

## 2.8 Definitions relating to component parts of controls

### 2.8.1

#### **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

### 2.8.2

#### **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**.

**2.8.3****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**.

**2.8.4****actuating means**

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

**2.8.5****pull-cord**

flexible **actuating member** which is pulled to cause **actuation**

**2.8.6****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.

**2.8.7****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

**2.8.8****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.

**2.8.9****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.



## 2.9 Definitions of types of terminals and terminations of controls

### 2.9.1

#### **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 11).

### 2.9.2

#### **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 10).

### 2.9.3

#### **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 10).

### 2.9.4

#### **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.

### 2.9.5

#### **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

### 2.9.6

#### **receptacle**

female part of a **flat push-on connector** intended to be permanently attached to a core or conductor (see Figure 16)

### 2.9.7

#### **tab**

male part of a **flat push-on connector** (see Figures 14 and 15)

### 2.9.8

#### **in-line tab**

**tab** intended to be permanently attached to a core or conductor

### 2.9.9

#### **tab forming part of a control**

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

**2.9.10****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.

**2.9.11****solder termination**

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

**2.9.12****saddle terminal**

terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts (see Figure 13a)

**2.9.13****lug terminal**

**screw terminal** or **stud terminal**, intended to clamp a cable lug or bar by means of a screw or nut (see Figure 13b)

**2.9.14****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 12).

**2.9.15****equipotential bonding terminal**

terminal provided on equipment or on a device and intended for the electric connection with the **equipotential bonding system**

[SOURCE: IEC 60050-195:1998, 195-02-32]

**2.9.16****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.

**2.9.17****protective conductor****PE**

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

[SOURCE: IEC 60050-195:1998, 195-02-09 ]

**2.10 Definitions relating to the connections to controls****2.10.1****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**.

## 2.10.2

### **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.

## 2.10.3

### **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.

## 2.10.4

### **integrated conductor**

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

## 2.10.5

### **detachable cord**

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

## 2.10.6

### **non-detachable cord**

flexible **external conductor** connected to, or assembled to, a **control** according to one of the methods in 2.10.6.1 to 2.10.6.4

### 2.10.6.1

#### **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

### 2.10.6.2

#### **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.

### 2.10.6.3

#### **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

### 2.10.6.4

#### **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**

**2.10.7****flying lead  
pigtail**

wire or wires intended for the connection of the **control**, with one end permanently connected to the **control** by the **control manufacturer**

**2.10.8****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.

**2.10.9****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.

**2.11 Definitions relating to the performance of type 2 actions****2.11.1****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 15.

**2.11.2****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 standard

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 15.

**2.12 Definitions relating to the requirements for creepage distances and clearances****2.12.1****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 17.

**2.12.2****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 17.

**2.12.3 Void**

**2.12.4 Void**

**2.12.5 Void**

**2.12.6 Void**

**2.12.7 Void**

**2.12.8**

**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

**2.12.9 Environment**

**2.12.9.1**

**macro-environment**

**environment** of the room or other location in which the equipment is installed or used

**2.12.9.2**

**micro-environment**

immediate **environment** of the insulation which particularly influences the dimensioning of the **creepage distances**

**2.12.9.3**

**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 N.

**2.13 Miscellaneous definitions**

**2.13.1**

**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

**2.13.2**

**tool**

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

**2.13.3**

**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**.

**2.13.4**

**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.

### 2.13.5

#### **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**

### 2.13.6

#### **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.

### 2.13.7

#### **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**.

### 2.13.8

#### **failure**

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

[SOURCE: IEC 60050-191:1990, 191-04-01]

### 2.13.9

#### **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**.

[SOURCE: IEC 60050-191:1990, 191-05-01]

## 2.14 Definitions relating to manufacturer and user

### 2.14.1

#### **control manufacturer**

manufacturer of the **control**

### 2.14.2

#### **equipment manufacturer**

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

Note 1 to entry: In Canada and the USA, the **equipment manufacturer** is indicated as the OEM (original **equipment manufacturer**). The OEM receives **controls** from **control manufacturers** for integration or incorporation into equipment.

### 2.14.3

#### **installer**

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

#### **2.14.4**

##### **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.

#### **2.14.5**

##### **low complexity safety-related systems or controls**

safety related **system** or **control** in which

- the **failure** modes of each individual component are well defined;
- the behaviour of the **system** or **control** under **fault** conditions can be completely determined

#### **2.15 Definitions pertaining to thermistors**

See Annex J.

#### **2.16 Definitions relating to the structure of controls using software**

See Annex H.

#### **2.17 Definitions relating to error avoidance in controls using software**

See Annex H.

#### **2.18 Definitions relating to fault/error control techniques for controls using software**

See Annex H.

#### **2.19 Definitions relating to memory tests for controls using software**

See Annex H.

#### **2.20 Definitions of software terminology – General**

See Annex H.

#### **2.21 Void**

#### **2.22 Definitions relating to classes of control functions**

See Annex H.

#### **2.23 Definitions relating to functional safety**

See Annex H.

#### **2.24 Definitions related to access to data exchange**

See Annex H.

### **3 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 may occur in **normal use**.

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

## 4 General notes on tests

*Tests according to this standard are type tests.*

NOTE 1 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.

NOTE 2 See also Annex H. The requirements of Annex H are not applicable to non-electronic **controls**, unless specified in an appropriate part 2 of this standard.

### 4.1 Conditions of test

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

**4.1.2** *If the test results are influenced by the room temperature, this shall be maintained at  $(20 \pm 5) ^\circ\text{C}$ , except that in cases of doubt, it shall be maintained at  $(23 \pm 2) ^\circ\text{C}$ , unless otherwise specified in a particular clause.*

**4.1.3** ***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.*

**4.1.4** *Unless otherwise specified in this standard, the tests are carried out in the order of the clauses of this standard.*

*See also Annex H.*

**4.1.5** *During the tests of this standard, **actuation** may be performed by test equipment if so desired, except for the high-speed tests of 17.12.*

**4.1.6** *During and for the purpose of the tests of this standard, other than for the tests of 17.12, the **actuating means** can be used to actuate the **control**, if an **actuating member** is not supplied by the manufacturer.*

**4.1.7** *The rates of temperature change declared in 7.2 and used in Clause 17 (that is  $\alpha_1$ ,  $\beta_1$ ,  $\alpha_2$  and  $\beta_2$ ) shall have test tolerances of  $\pm 12$  K/h.*

*For other activating quantities, the minimum and/or maximum rates of change declared in requirement 37 of Table 1 and used in Clause 17 (that is  $\alpha_1$ ,  $\beta_1$ ,  $\alpha_2$  and  $\beta_2$ ) shall have test tolerances as specified in the appropriate part 2.*

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

**4.1.9 to 4.1.11** See Annex H.

### 4.2 Samples required

**4.2.1** *One sample is used for the tests in Clauses 5 to 11 and 18 to 27, including the relevant annexes. A set of three samples is subjected to the remaining tests.*



*If one sample does not comply with the tests of Clauses 12 to 17 inclusive, the test which caused the non-compliance, and those preceding which may have influenced the result of that test, are repeated on another set of identical samples, all of which shall then comply with the repeated tests.*

*The manufacturer may submit, together with the first set of samples, the additional set or sets which may be wanted should one sample not comply. The testing authority will then, without further request, test the additional samples, and will only reject if a further non-compliance occurs. If the additional sets of samples are not submitted at the same time, a non-compliance of one sample may entail a rejection.*

NOTE In Canada and the USA, only one sample is used for the tests of Clauses 12 to 17 inclusive and the sample tested must comply.

#### 4.2.2 Void

4.2.3 Additional samples may be required for some destructive tests of this standard.

4.2.4 **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 testing authority, 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.

### 4.3 Instructions for test

#### 4.3.1 According to submission

4.3.1.1 **Controls**, if submitted in or with an equipment, may either be tested in or with the equipment, in which case they are classified as for declared specific load or tested separately, in which case they may be classified as for declared specific load, resistive load or resistive and inductive load. In either of the latter two cases, the current in the appropriate circuit when the equipment is operating under normal load is regarded as the rated current of the circuit.

4.3.1.2 For all **controls** submitted, in, on or with an equipment, all other relevant information as required by 7.2 may be obtained by inspection and measurement of the submitted equipment.

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

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

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

#### 4.3.2 According to rating

4.3.2.1 **Controls** for a.c. only are tested with a.c. at rated frequency if declared; those for d.c. only are tested with d.c. and those for a.c./d.c. at the more unfavourable supply.

4.3.2.2 **Controls** for a.c. 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.

4.3.2.3 When testing **controls** intended for d.c. only, the possible influence of polarity on the operation of the **control** is taken into consideration.

**4.3.2.4** For **controls** with different a.c. and d.c. ratings, the tests for Clauses 12, 13, 14 and 17, are made on two sets of samples, one being tested according to the a.c. rating, and the other according to the d.c. rating.

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

**4.3.2.5** 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 4.3.2.7).

**4.3.2.6** For **controls** marked or declared for more than one rated voltage or rated current, the tests of Clause 17 are made on sets of samples for each combination of rated voltage and rated current.

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

**4.3.2.7** 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.

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

**4.3.2.9** A circuit for connection to the d.c. 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.

**4.3.2.10** **Controls** powered by rechargeable batteries are additionally tested in accordance with Annex V.

**4.3.2.11** See Annex J.

### **4.3.3 According to protection against shock**

**4.3.3.1** 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**.

**4.3.3.2** 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 9.1.1).

**4.3.3.3** 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 11.2.6.

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 11.2.6.

NOTE By definition (2.7.5) **class II controls** cannot use **PELV**-circuits.

#### 4.3.4 According to manufacturing variants

**4.3.4.1 Controls** which are otherwise identical but which may be set by the manufacturer, or which may, by the inclusion at the manufacturing stage of alternative components or parts produce various **operating values, operating times or operating sequences**, are for the purpose of this standard normally treated as a single submission. Normally, **controls** set to the most arduous condition will be sufficient. However, the testing authority 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.

**4.3.4.2** 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 may be applicable to different parts of the range.

#### 4.3.5 According to purpose

**4.3.5.1** Multi-purpose **controls** shall, according to 6.3, 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.

**4.3.5.2** Such **controls** without an appropriate section of Clause 17 shall be tested in a manner agreed between the manufacturer and the testing authority so that the essential intended **operating values, operating times and operating sequences** are tested.

**4.3.5.3** Any **control** with a purpose not classified in 6.3, or in the appropriate part 2, may be tested and approved to this standard, except for Clause 17. A test schedule for Clause 17 shall be based, wherever possible, on the intent of that clause and shall be agreed between the manufacturer and the testing authority.

**4.3.5.4** See Annex J.

### 5 Rating

#### 5.1 Maximum rated voltage

The maximum rated voltage is 690 V.

#### 5.2 Void

#### 5.3 Compliance

Compliance with 5.1 and 5.2 is checked by the information requirements in Clause 7.

### 6 Classification

A **control** is classified:

#### 6.1 According to nature of supply

##### 6.1.1 Control for a.c. only

NOTE 1 A **control** for a.c. only can be used on a d.c. circuit provided that the current does not exceed 10 % of the rated current for a.c., or 0,1 A, whichever is smaller.

NOTE 2 Additional tests can be required to establish the d.c. rating.

**6.1.2 Control** for d.c. only.

**6.1.3 Control** for a.c. and d.c.

**6.1.4 Control** for specific supplies or multiple supplies.

**6.1.5** Battery powered **control**.

## **6.2 According to type of load to be controlled by each circuit of the control**

A **control** having more than one circuit need not have the same classification for each circuit.

**6.2.1** Circuit for a substantially resistive load with a power factor not less than 0,95.

NOTE 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.

**6.2.2** 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.

NOTE 1 An example is a circuit in a fan-heater which incorporates both a heating element and a motor.

NOTE 2 Circuits intended for inductive loads only can either be classified under 6.2.2 by declaring that the resistive load is equal to the inductive load, or may be classified as for a declared specific load.

**6.2.3** Circuit for declared specific load.

NOTE Examples are circuits for tungsten filament or fluorescent lamp loads, highly inductive loads with a power factor of less than 0,6, capacitive loads, and contacts intended to be operated off load.

**6.2.4** Circuit for a current less than 20 mA.

NOTE Examples are circuits for neon indicators and other signal lamps.

**6.2.5** Circuit for a.c. motor load whose characteristics are defined by the **control** manufacturer's declaration.

**6.2.6** Circuit for pilot load.

## **6.3 According to their purpose**

A **control** may be classified for more than one purpose, in which case it is referred to as a multi-purpose **control**.

NOTE Any **manual action** of an **automatic control** or a separate **manual action** being integral with an **automatic control** is not classified according to 6.3.

**6.3.1** – **thermostat**;

**6.3.2** – **temperature limiter**;

**6.3.3** – **thermal cut-out**;

**6.3.4** Void

**6.3.5** – **energy regulator**;

**6.3.6** – **timer**;

- 6.3.7 – **time switch**;
- 6.3.8 – **manual control**;
- 6.3.9 – **sensing control** (other than one covered by 6.3.1 through 6.3.4);
- 6.3.10 – **electrically operated control**;
- 6.3.11 – **motor protector**;
- 6.3.11.1 – **thermal motor protector**;
- 6.3.12 – **electrically operated valve**;
- 6.3.13 – **electrically operated mechanism**;
- 6.3.14 – **protective control**;
- 6.3.15 – **operating control**.

NOTE Further classification can be found in the appropriate part 2.

#### 6.4 According to features of automatic action

- 6.4.1 – **Type 1 action**;
- 6.4.2 – **Type 2 action**.

**6.4.3 Type 1 actions and type 2 actions** are further classified according to one or more of the following constructional or operational features:

NOTE 1 These further classifications are only applicable if the relevant declarations have been made and any appropriate tests completed.

NOTE 2 An action providing more than one feature may be classified by a combination of the appropriate letters, for example, type 1.C.L. or type 2.A.E.

NOTE 3 A **manual action** is not classified according to 6.4.3.

- 6.4.3.1 – **full disconnection on operation** (type 1.A or 2.A);
- 6.4.3.2 – **micro-disconnection on operation** (type 1.B or 2.B);
- 6.4.3.3 – **micro-interruption on operation** (type 1.C or 2.C);
- 6.4.3.4 – a **trip-free** mechanism which cannot even momentarily be reclosed against the **fault** (type 1.D or 2.D);
- 6.4.3.5 – a **trip-free** mechanism in which the contacts cannot be prevented from opening or maintained closed against a continuation of the **fault** (type 1.E or 2.E);

NOTE An example is a current-**sensing control** which has to be reclosed or can be reclosed momentarily to detect that the excess current **fault** still exists.

- 6.4.3.6 – an action which can only be reset by the use of a **tool** (type 1.F or 2.F);
- 6.4.3.7 – an action which is not intended to be reset under electrically loaded conditions (type 1.G or 2.G);

- 6.4.3.8** – a **trip-free** mechanism in which the contacts cannot be prevented from opening and which may automatically be reset to the "closed" position after normal **operation** conditions have been restored if the reset means is held in the "reset" position (type 1.H or 2.H);
- 6.4.3.9** – 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 (type 1.J or 2.J);
- 6.4.3.10** – 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** (type 1.K or 2.K);
- 6.4.3.11** – an action that does not require any external auxiliary energy source of electrical supply for its intended **operation** (type 1.L or 2.L);
- 6.4.3.12** – an action which operates after a declared ageing period (type 1.M or 2.M).
- 6.4.3.13** See Annex H.

## 6.5 According to the degree of protection and control pollution degree

**6.5.1** According to degrees of protection provided by enclosures against ingress of solid objects and dust (see IEC 60529):

IP0X, IP1X, IP2X, IP3X, IP4X, IP5X, IP6X.

**6.5.2** According to degree of protection provided by enclosures against harmful ingress of water (see IEC 60529):

IPX0, IPX1, IPX2, IPX3, IPX4, IPX5, IPX6, IPX7, IPX8.

NOTE 1 A **control** intended for use in a particular **environment** can be used for a different **environment** if the appropriate provisions, if any, are made in the equipment.

NOTE 2 Preferred combinations of degrees of protection are according to 6.5.1 and 6.5.2:

| First characteristic numeral<br>Protection against ingress of foreign bodies | Second characteristic numeral<br>Protection against ingress of water |      |   |      |      |      |   |      |      |
|------------------------------------------------------------------------------|----------------------------------------------------------------------|------|---|------|------|------|---|------|------|
|                                                                              | 0                                                                    | 1    | 2 | 3    | 4    | 5    | 6 | 7    | 8    |
| 0                                                                            | IP00                                                                 |      |   |      |      |      |   |      |      |
| 1                                                                            |                                                                      |      |   |      |      |      |   |      |      |
| 2                                                                            | IP20                                                                 | IP21 |   |      |      |      |   |      |      |
| 3                                                                            |                                                                      |      |   |      |      |      |   |      |      |
| 4                                                                            |                                                                      | IP41 |   | IP43 | IP44 |      |   |      |      |
| 5                                                                            |                                                                      |      |   |      | IP54 | IP55 |   |      |      |
| 6                                                                            |                                                                      |      |   |      |      | IP65 |   | IP67 | IP68 |

**6.5.3** According to the **pollution degree** or **pollution degrees** for which the **control** is declared. See Annex N.

NOTE It is possible that when a **control** is mounted in accordance with the manufacturer's declaration, different parts of the **control** can be in **macro-environments** having different **pollution degrees**.

## 6.6 According to method of connection

### 6.6.1 Control with at least one terminal intended for the connection of **fixed wiring**.

NOTE In Canada and the USA, **flying leads** are allowed.

### 6.6.2 Control with at least one terminal intended for the connection of a flexible cord.

A **control** may be classified under both 6.6.1 and 6.6.2.

### 6.6.3 Control without any terminals intended for the connection of an **external conductor**.

This type of **control** is intended for the connection of only integrated or **internal conductors**.

### 6.6.4 Control intended for the connection of a **primary battery**.

### 6.6.5 Control intended for the connection of a **secondary battery (rechargeable cell)**.

## 6.7 According to ambient temperature limits of the switch head

### 6.7.1 Control with a **switch head** for use in an ambient temperature between a minimum value ( $T_{\min}$ ) of 0 °C, and a maximum value ( $T_{\max}$ ) of 55 °C.

### 6.7.2 Control with a **switch head** intended to be used in an ambient temperature having a maximum value ( $T_{\max}$ ) other than 55 °C but no less than 30 °C, or a minimum value ( $T_{\min}$ ) lower than 0 °C, or both.

NOTE Preferred values of  $T_{\max}$  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.

Values differing from these preferred values are possible.

## 6.8 According to protection against electric shock

### 6.8.1 For an **integrated control**:

NOTE An **integrated control** is not classified but takes the classification of the equipment with which it is integrated.

### 6.8.2 For an **incorporated control** for use in:

6.8.2.1 – class 0 equipment;

6.8.2.2 – class 0I equipment;

6.8.2.3 – class I equipment;

6.8.2.4 – class II equipment;

6.8.2.5 – class III equipment.

NOTE 1 For coordination of electrical equipment class 0, class I, class II and class III, see IEC 61140, and for protective provisions within an electrical installation, see IEC 60364.

NOTE 2 A **control** intended for incorporation in a particular class of equipment may be used for a different class if appropriate provisions are made in the equipment.

### 6.8.3 For an **in-line cord control**, a **freestanding control**, or an **independently mounted control**:

- 6.8.3.1 – of class 0;
- 6.8.3.2 – of class 0I;
- 6.8.3.3 – of class I;
- 6.8.3.4 – of class II;
- 6.8.3.5 – of class III.

NOTE 1 For coordination of electrical equipment class 0, class I, class II and class III, see IEC 61140, and for protective provisions within an electrical installation, see IEC 60364.

NOTE 2 A **control** intended for incorporation in a particular class of equipment may be used for a different class if appropriate provisions are made in the equipment.

#### 6.8.4 Controls using SELV or PELV for protection against electric shock

6.8.4.1 Controls using SELV-circuit(s), and if applicable, the information declared in Table 1, requirement 86

6.8.4.2 Controls using PELV-circuit(s), and if applicable, the information declared in Table 1, requirement 86

#### 6.9 According to circuit disconnection or interruption:

- 6.9.1 – full disconnection;
- 6.9.2 – micro-disconnection;
- 6.9.3 – micro-interruption;
- 6.9.4 – all-pole disconnection;
- 6.9.5 – See Annex H.

NOTE 1 Some equipment standards require **full disconnection**, others permit either **full disconnection** or **micro-disconnection**; some only require **micro-interruption**.

NOTE 2 Different actions of a **control** can provide different circuit disconnections or interruptions.

#### 6.10 According to number of cycles of actuation (M) of each manual action

Preferred values are:

- 6.10.1 – 100 000 cycles;
- 6.10.2 – 30 000 cycles;
- 6.10.3 – 10 000 cycles;
- 6.10.4 – 6 000 cycles;
- 6.10.5 – 3 000 cycles <sup>1)</sup>;
- 6.10.6 – 300 cycles <sup>1)</sup>;
- 6.10.7 – 30 cycles <sup>1)</sup>.

<sup>1)</sup> 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.

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.



### 6.11 According to number of automatic cycles (A) of each automatic action

Preferred values are:

- 6.11.1 – 300 000 cycles;
- 6.11.2 – 200 000 cycles;
- 6.11.3 – 100 000 cycles;
- 6.11.4 – 30 000 cycles;
- 6.11.5 – 20 000 cycles;
- 6.11.6 – 10 000 cycles;
- 6.11.7 – 6 000 cycles;
- 6.11.8 – 3 000 cycles<sup>1)</sup>;
- 6.11.9 – 1 000 cycles<sup>1)</sup>;
- 6.11.10 – 300 cycles<sup>2)</sup>;
- 6.11.11 – 30 cycles<sup>2)4)</sup>;
- 6.11.12 – 1 cycle<sup>3)</sup>.

<sup>1)</sup> Not applicable to **thermostats** or to other fast cycling actions.

<sup>2)</sup> Applicable only to manual reset.

<sup>3)</sup> Applicable only to actions which require the replacement of a part after each **operation**.

<sup>4)</sup> Can only be reset during **manufacturer servicing**.

NOTE For **controls** having more than one **automatic action**, a different value can be declared for each.

### 6.12 According to temperature limits of the mounting surface of the control

**6.12.1 Control** suitable for mounting on a surface which is not more than 20 K above the ambient temperature classified in 6.7.

**6.12.2 Control** suitable for mounting on a surface which is more than 20 K above the ambient temperature classified in 6.7.

NOTE An example of such a **control** is one mounted on a compressor unit in a refrigerator, where the mounting surface can be 150 °C, although the **sensing element** is at a temperature of –10 °C, and the ambient temperature is only 30 °C.

### 6.13 According to value of proof tracking index (PTI) for the insulation material used

- 6.13.1 – material of material group IIIb with a PTI of 100 and up to but excluding 175;
- 6.13.2 – material of material group IIIa with a PTI of 175 and up to but excluding 400;
- 6.13.3 – material of material group II with a PTI of 400 and up to but excluding 600;
- 6.13.4 – material of material group I with a PTI of 600 and over.

**6.14 According to period of electrical stress across insulating parts supporting live parts and between live parts and earthed metal**

**6.14.1** – short period;

**6.14.2** – long period.

NOTE Long periods of electrical stress are considered to exist if the **control** is used in equipment for continuous use; and also for the supply side of a **control** in any other equipment unlikely to be disconnected from the supply by the removal of a plug or by the **operation** of a **control** providing **full disconnection**.

**6.15 According to construction:**

**6.15.1** – integrated control;

**6.15.2** – incorporated control;

**6.15.3** – in-line cord control;

**6.15.4** – free-standing control;

**6.15.5** – independently mounted control for:

**6.15.5.1** – surface mounting;

**6.15.5.2** – flush mounting;

**6.15.5.3** – panel mounting.

**6.15.6** See Annex J.

**6.16 According to ageing requirements (Y) of the equipment in which, or with which, the control is intended to be used**

**6.16.1** – 60 000 h;

**6.16.2** – 30 000 h;

**6.16.3** – 10 000 h;

**6.16.4** – 3 000 h;

**6.16.5** – 300 h;

**6.16.6** – 15 h.

NOTE **Controls** which operate during the heating or endurance tests of the equipment standard are not classified according to 6.16.6.

**6.17 According to use of the thermistor**

See Annex J.

**6.18 According to classes of control functions**

See Annex H.

## 7 Information

### 7.1 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 standard; and
- that the relevant tests can be performed to determine compliance with this standard.

### 7.2 Methods of providing information

**7.2.1** 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 indicated in Table 1.

NOTE 1 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**.

NOTE 2 Information provided by marking (C) can also be included in documentation (D).

- By documentation (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 standard 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 may be replaced by a leaflet, letter or drawing, etc. It is not necessary for each **control** to be accompanied by such a document.

- By declaration (X) – this information shall be provided for the testing authority for purposes of test and in a manner agreed between testing authority and manufacturer. It may, 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.

**7.2.2** Information which is indicated as being required by marking (C) or by documentation (D) shall also be provided for the testing authority in an agreed manner if so requested by the testing authority.

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

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

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

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

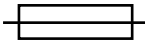
**7.2.6** Except as indicated in 7.4, for **integrated controls** all information is provided by means of declaration (X). Unless otherwise indicated in a part 2, for **incorporated controls**, the only marking required is the manufacturer's name or trade mark and the **unique type**

**reference**, if other required marking is provided by documentation (D). For **incorporated controls** declared under item 50, see the explanation of documentation (D) contained in 7.2.1.

**7.2.7** 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).

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

**7.2.9** 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<br>(2002-10)                                                                                                                                                                                     |
| Alternating current (three-phase) .....                  | 3~                                                                                                                                                                                                                |
| Alternating current (three-phase with neutral) .....     | 3N~                                                                                                                                                                                                               |
| Direct current .....                                     | — — — IEC 60417-5031<br>(2002-10)                                                                                                                                                                                 |
| Class II construction .....                              |  IEC 60417-5172<br>(2003-02)                                                                                                 |
| <b>Class III control</b> .....                           |  IEC 60417-5180<br>(2003-02)                                                                                                 |
| Ambient temperature limits of <b>switch head</b> ..... 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 $T_{max}$ other than 55 °C.) |
| Rated current of the appropriate fuse in amperes .....   |  IEC 60417-5016 (2002-10)                                                                                                    |
| Frequency .....                                          | Hz                                                                                                                                                                                                                |
| Earthing terminal .....                                  |  IEC 60417-5019<br>(2006-08)                                                                                                 |
| Functional earthing .....                                |  IEC 60417-5018<br>(2011-07)                                                                                                 |

For identification of the degree of protection provided by enclosures, the symbols shown in 6.5 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:

$$16 (3) \text{ A } 250 \text{ V } \sim \text{ or } 16 (3) / 250 \sim \text{ or } \frac{16 (3)}{250} \sim$$

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".

**Table 1 (7.2 of edition 3) – Required information and methods of providing information (1 of 4)**

| Information                                                                                                                                                                                  | Clause or subclause           | Method |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|--------|
| 1 Manufacturer's name or trade mark                                                                                                                                                          | 7.2.6                         | C      |
| 2 <b>Unique type reference</b> <sup>a</sup>                                                                                                                                                  | 2.11.1, 2.13.1, 7.2.6         | C      |
| 3 Rated voltage or rated voltage range in volts (V)                                                                                                                                          | 2.1.2, 4.3.2, 14.4,           | C      |
| 4 Nature of supply unless the <b>control</b> is for both a.c. and d.c., or unless the rating is the same for a.c. and d.c.                                                                   | 4.3.2, 6.1                    | C      |
| 5 Frequency if other than for range 50 Hz to 60 Hz inclusive                                                                                                                                 | 4.3.2                         | C      |
| 6 Purpose of <b>control</b>                                                                                                                                                                  | 2.2, 4.2.4, 4.3.5, 6.3, 17.16 | D      |
| 6a Construction of <b>control</b> and whether the <b>control</b> is electronic                                                                                                               | 6.15, Annex H, H.2.5.7        | D      |
| 7 The type of load controlled by each circuit <sup>b</sup>                                                                                                                                   | 6.2, 14, 17, 23.1.1           | C      |
| 15 Degree of protection provided by enclosure <sup>c</sup>                                                                                                                                   | 6.5.1, 6.5.2, 11.5            | C      |
| 17 Which of the terminals are suitable for the connection of <b>external conductors</b> , and if they are suitable for line or neutral conductors, or both                                   | 6.6, 7.4.2, 7.4.3             | C      |
| 18 Which of the terminals for <b>external conductors</b> are for a wider range of conductor sizes than those indicated in Table 3.                                                           | 10.1                          | D      |
| 19 For <b>screwless terminals</b> , the method of connection and disconnection <sup>d</sup>                                                                                                  | 10                            | D      |
| 20 Details of any special conductors which are intended to be connected to the terminals for <b>internal conductors</b>                                                                      | 10.2.1                        | D      |
| 21 Maximum temperature of terminals for <b>internal conductors</b> and terminals for <b>external conductors</b> of <b>incorporated</b> and <b>integrated controls</b> , if higher than 85 °C | 14                            | X      |
| 22 Temperature limits of the <b>switch head</b> , if $T_{\min}$ lower than 0 °C or $T_{\max}$ other than 55 °C                                                                               | 6.7, 14.5, 14.7, 17.3         | C      |
| 23 Temperature limits of mounting surfaces ( $T_s$ )                                                                                                                                         | 6.12.2, 14.1, 17.3            | C      |
| 24 Classification of <b>control</b> according to protection against electric shock                                                                                                           | 6.8                           | X      |
| 25 For <b>class II controls</b> , the symbol for Class II construction                                                                                                                       | 7.3                           | C      |
| 26 Number of cycles of <b>actuation</b> (M) for each <b>manual action</b>                                                                                                                    | 6.10, 17.10, 17.11            | X      |
| 27 Number of automatic cycles (A) for each <b>automatic action</b>                                                                                                                           | 6.11, 17.8, 17.9              | X      |
| 28 Ageing period (Y) for <b>controls</b> with type 1M or 2M action                                                                                                                           | 6.16, 17.6                    | X      |

Table 1 (2 of 4)

| Information                                                                                                                                                                                                                                                         | Clause or subclause                                      | Method |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|--------|
| 29 Type of disconnection or interruption provided by each circuit                                                                                                                                                                                                   | 2.4.1, 2.4.2, 2.4.3, 2.4.4, 6.9                          | X      |
| 30 PTI of materials used for insulation                                                                                                                                                                                                                             | 6.13, Table 23, Footnote b, Table 24, Footnote d, 21.2.7 | X      |
| 31 Method of mounting <b>control</b> <sup>e</sup>                                                                                                                                                                                                                   | 11.6                                                     | D      |
| 31a Method of providing earthing of <b>control</b>                                                                                                                                                                                                                  | 7.4.3, 9, 9.1.1, 9.1.2                                   | D      |
| 32 Method of attachment for <b>non-detachable cords</b> <sup>f</sup>                                                                                                                                                                                                | 10.1, 11.7                                               | D      |
| 33 Intended transportation condition of <b>control</b> <sup>g</sup>                                                                                                                                                                                                 | 16.1                                                     | X      |
| 34 Details of any limitation of <b>operating time</b> <sup>h</sup>                                                                                                                                                                                                  | 14, 17                                                   | D      |
| 35 Period of electric stress across insulating parts                                                                                                                                                                                                                | 6.14                                                     | X      |
| 36 Limits of <b>activating quantity</b> for any <b>sensing element</b> over which <b>micro-disconnection</b> is secure (see also Clause H.7, item 36)                                                                                                               | 11.3.2                                                   | X      |
| 37 Minimum and/or maximum rates of change of actuating quantity, or minimum and/or maximum cycling rates for a <b>sensing control</b> <sup>i</sup>                                                                                                                  | 4.1.7, 15, 17                                            | X      |
| 38 Values of overshoot of <b>activating quantity</b> for <b>sensing controls</b> which are necessary for correct action, or which can be used for test purposes                                                                                                     | 17                                                       | X      |
| 39 <b>Type 1 action</b> or <b>type 2 action</b>                                                                                                                                                                                                                     | 6.4                                                      | D      |
| 40 Additional features of <b>type 1 action</b> or <b>type 2 actions</b>                                                                                                                                                                                             | 6.4.3, 11.4                                              | D      |
| 41 <b>Manufacturing deviation</b> and condition of test appropriate to deviation                                                                                                                                                                                    | 2.11.1, 11.4.3, 15, 17.14                                | X      |
| 42 <b>Drift</b>                                                                                                                                                                                                                                                     | 2.11.2, 11.4.3, 15, 16.2.4                               | X      |
| 43 Reset characteristics for cut-out action <sup>j</sup>                                                                                                                                                                                                            | 6.4                                                      | D      |
| 44 If a <b>control</b> is either to be hand-held or is intended for a hand-held equipment                                                                                                                                                                           |                                                          | X      |
| 45 Any limitation to the number or distribution of flat push-on <b>receptacles</b> which can be fitted                                                                                                                                                              | 10.2.4.4                                                 | D      |
| 46 Any <b>type 2 action</b> shall be so designed that the <b>manufacturing deviation</b> and <b>drift</b> of its <b>operating value</b> , <b>operating time</b> or <b>operating sequence</b> is within the limit declared in requirements 41, 42, and 46 of Table 1 | 11.4.3                                                   | D      |
| 47 Extent of any <b>sensing element</b>                                                                                                                                                                                                                             | 2.8.1                                                    | D      |
| 48 <b>Operating value</b> (or values) or <b>operating time</b>                                                                                                                                                                                                      | 2.3.11, 2.3.12, 6.4.3.10, 11, 14, 15.6, 17               | D      |
| 49 <b>Control pollution degree</b>                                                                                                                                                                                                                                  | 6.5.3                                                    | D      |
| 50 <b>Control</b> intended to be delivered exclusively to the <b>equipment manufacturer</b>                                                                                                                                                                         | 7.2.1, 7.2.6                                             | X      |
| 51 Glow wire test temperatures                                                                                                                                                                                                                                      | 21.2.1, 21.2.2, 21.2.3, and 21.2.4                       | X      |
| 52 to 60 See Annex H                                                                                                                                                                                                                                                |                                                          |        |
| 61 to 65 See Annex J                                                                                                                                                                                                                                                |                                                          |        |
| 66 to 74 See Annex H                                                                                                                                                                                                                                                |                                                          |        |

**Table 1 (3 of 4)**

| Information                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Clause or subclause               | Method |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|--------|
| 75 <b>Rated impulse voltage</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 2.1.12, 20.1                      | D      |
| 76 Type of printed circuit board coating                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Annex P or Annex Q                | X      |
| 77 Temperature for the ball pressure test                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 21.2.1, 21.2.2, 21.2.3 and 21.2.4 | D      |
| 78 Maximum declared torque on single bush mounting using thermoplastic material                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Table 20, Footnote a              | D      |
| 79 <b>Pollution degree</b> in the <b>micro-environment</b> of the <b>creepage distance</b> or <b>clearance</b> if cleaner than that of the <b>control</b> , and how this is designed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Table H.24                        | D      |
| 80 <b>Rated impulse voltage</b> for the <b>creepage distance</b> or <b>clearance</b> if different from that of the <b>control</b> , and how this is ensured                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Table H.24                        | D      |
| 81 The values designed for tolerances of distances for which the exclusion from <b>fault</b> mode "short" is claimed                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Table H.24                        | D      |
| 82 See Annex J                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                   |        |
| 85 For <b>class III controls</b> , the symbol for Class III construction                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 7.4.6                             | C      |
| 86 For <b>SELV</b> or <b>PELV</b> circuits, the <b>ELV</b> limits realized                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 2.1.5, T.3.2                      | D      |
| 87 Value of accessible voltage of <b>SELV/PELV</b> circuit, if different from 8.1.1, product standard referred to for the application of the <b>control</b> , in which standard(s) the accessible <b>SELV/PELV</b> level(s) is (are) given                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 2.1.4, 6.8.4.1, 6.8.4.2, 8.1.1    | D      |
| 88 See Annex U                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                   |        |
| 89 Emission tests and groups as declared according to CISPR 11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | 23.2, H.23.1.2                    | X      |
| 90 Immunity tests for <b>protective controls</b> for use in accordance with IEC 60335 appliances                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Table H.13                        | X      |
| 91 to 94 See Annex H                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                   |        |
| 95 Maximum short circuit current as declared                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 11.3.5.2.1 b)                     | D      |
| <p><sup>a</sup> The <b>unique type reference</b> shall be such that, when it is quoted in full, the manufacturer of the <b>control</b> can supply a replacement which will be fully interchangeable with the original electrically, mechanically, dimensionally, and functionally.</p> <p>It may comprise a series type reference with other marking, such as voltage rating or an ambient temperature marking, which together provide a <b>unique type reference</b>.</p> <p><sup>b</sup> For <b>controls</b> 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 17.2.</p> <p><sup>c</sup> The marking (C) requirement does not apply to <b>controls</b> or parts thereof classified as IP00, IP10, IP20, IP30 and IP40.</p> <p><sup>d</sup> In Canada and the USA, marking (C) is required for the method of connection and disconnection of <b>screwless terminals</b> for field wiring.</p> |                                   |        |

Table 1 (4 of 4)

- <sup>e</sup> 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 standard 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 13, the instruction sheet shall also state that the **control** shall be connected by means of conductors having the appropriate T rating (see Footnote a of Table 13).

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.

- <sup>f</sup> **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).

- <sup>g</sup> The method of packaging does not have to be declared.

- <sup>h</sup> For **in-line cord, free-standing and independently mounted controls**, this information shall be provided by method C.

- <sup>i</sup>  $\alpha_1$  = minimum rising rate

$\beta_1$  = minimum falling rate

The rate of change ( $\alpha_1$  and  $\beta_1$ ), of the **activating quantity** are those applicable to **normal use**.

$\alpha_2$  = maximum rising rate (for **type 2 actions** only)

$\beta_2$  = maximum falling rate (for **type 2 actions** only)

For test purposes,  $\alpha_1$  and  $\beta_1$  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  $\alpha_2$  and  $\beta_2$  are for test purposes only, and may alternatively be declared as a maximum cycling rate. The rates of change for the purpose of this standard 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 <sup>2</sup>              |
| Liquid level        | mm/s                           |
| Current             | A/s                            |
| Humidity            | %/s                            |
| Air flow            | m <sup>3</sup> /s <sup>2</sup> |

\* When using other activating quantities, the units shall be expressed in SI-units.

- <sup>j</sup> The manufacturer may declare a time before which, or a specific value of **activating quantity** above which, manual reset shall not occur.

- <sup>k</sup> Void

- <sup>l</sup> Void

- <sup>m</sup> to <sup>t</sup> See Annex H.



### 7.3 Class II symbol

**7.3.1** The symbol for class II construction shall be used only for **controls** classified according to 6.8.3.4.

**7.3.2** 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.

**7.3.2.1** 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 may be reduced but the length of the sides of its outer square shall be not less than 3 mm.

**7.3.2.2 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**.

### 7.4 Additional requirements for marking

**7.4.1** Required marking on a **control** shall preferably be on the main body of the **control** but may be placed on non-**detachable parts**.

Required markings shall be legible and durable.

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

**7.4.2** 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.*

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

NOTE In the United Kingdom, terminals intended exclusively for a live **external conductor** shall be indicated by the letter "L".

**7.4.3.1** Earthing terminals for external 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 earth, IEC 60417-5018 (2011-07).

**7.4.3.2** 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.*

NOTE 1 In Canada and the USA, a terminal intended for connection of a grounded supply conductor shall be finished to show a white or natural grey colour and shall be distinguishable from the other parts.

NOTE 2 In Canada and the USA, a wire-binding screw intended for the connection of an equipment earthing conductor shall have a slotted or hexagonal green-coloured head. A pressure wire connector intended for connection of such a conductor shall be identified by being marked GROUND, GROUNDING, EARTH or by a marking on a wiring diagram provided on the **control**. The wire-binding screw or pressure wire connector shall be so located that it is unlikely to be removed during **servicing** of the **control**.

NOTE 3 With respect to 7.4.2 to 7.4.3.2 inclusive, in Canada and the USA, additional or alternative markings are required in the wiring rules.

NOTE 4 In the United Kingdom, the letter "L" shall not be used except as indicated in 7.4.3, above.

**7.4.4 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**.

**7.4.5** 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**.

**7.4.6 Controls** intended to be connected only to **SELV 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 earthing continuity for functional purposes shall not be marked with the symbol for class III construction, IEC 60417-5180 (2003-02).

**7.4.7** 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**

**7.4.8** 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.

**7.4.9** 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.

**7.4.10** See Annex V.

## 8 Protection against electric shock

### 8.1 General requirements

**8.1.1 Controls** shall be so constructed that there is adequate protection against accidental contact with **live parts**, in any unfavourable position which may 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, **SELV**-circuits or **PELV**-circuits supplied at a voltage not exceeding 24 V are not considered to be **hazardous live parts**.

If **SELV**- or **PELV**-circuits supplied at higher than 24 V are accessible, the current between the **accessible part(s)** and either pole of the supply source of the **SELV/PELV** circuits shall comply with H.8.1.10.1.

**8.1.1.1** The value of the voltage of **SELV/PELV** circuits considered to be not hazardous may be specified at a different value

- 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

- if 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 (Table 1, requirement 86).

NOTE In Canada and the USA, parts connected to **ELV** supplied from a **safety isolating transformer** at a voltage not exceeding 42,4 V peak or 30 V r.m.s. when dry, or 21,2 V peak or 15 V r.m.s. when wet contact is likely to occur are not considered to be **hazardous live parts**.

**8.1.2** For **class II controls** and **controls** for class II equipment, this requirement applies also with regard to accidental contact with metal parts separated from **hazardous live parts** by **basic insulation** only.

**8.1.3** 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**.

NOTE Sealing compounds of the self-hardening types can be touched.

**8.1.4** 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**.

**8.1.5** 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.

**8.1.6** For **integrated and incorporated controls**, the tests of 8.1.9 to 8.1.9.5 inclusive is only applied to those parts of the **control** which are accessible when it is mounted in any position in accordance with the manufacturer's declarations and after removal of **detachable parts**.

**8.1.7** For **in-line cord** and **free-standing controls**, the tests of 8.1.9 to 8.1.9.5 inclusive, are made when the **control** is fitted with flexible cords either of the smallest, or of the largest nominal cross-sectional area used in 10.1.4, whichever is more unfavourable. **Detachable parts** are removed, and hinged **covers** which can be opened without the use of a **tool** are opened.

**8.1.8** 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 10.1.4, 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.

**8.1.9** Compliance with 8.1.1 to 8.1.8 inclusive is checked by inspection and by the following tests:

The standard test finger shown in Figure 2 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 finger shown in Figure 2 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 2 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.

**8.1.9.1** The standard test finger 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.

**8.1.9.2** In addition, openings in insulating material and in unearthed metal shall be tested by applying the test pin shown in Figure 1 without force in every possible position.

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

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

**8.1.9.5** 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** 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**.

**8.1.10** See Annex H.

**8.1.11** 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.

**8.1.12** A **live part** shall be considered to be hazardous if it exceeds the values specified in 8.1.1 and it is not separated from the source by **protective impedance** complying with H.8.1.10 and is not a PEN conductor or a part of the **equipotential bonding system**.

**8.1.13 Controls** having battery compartments that can be opened without the aid of a **tool**, or that according to the instructions for use may 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.

## **8.2 Actuating members and actuating means**

**8.2.1** An **actuating member** shall not be live.

**8.2.2** An **actuating means** shall not be live, 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 8.2.1 and 8.2.2 is checked by inspection and by the tests of 8.1.*

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.

**8.2.3** 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 fixings by **supplementary insulation**, if such 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 an earthing terminal or earthing contact; or
- shielded from **hazardous live parts** by earthed metal.

*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**.

## **8.3 Capacitors**

**8.3.1** For class II **in-line cord controls** and **independently mounted controls**, capacitors shall not be connected to accessible metal parts. For **controls** for 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. Metal casings of capacitors shall be separated by **supplementary insulation** from accessible metal parts, and from other metal parts likely to be connected to accessible metal, when the **control** is mounted in accordance with the manufacturer's declarations.

*Compliance is checked by inspection and by the requirements for **supplementary insulation** in Clauses 13 and 20.*

**8.3.2 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.

*Compliance is checked by the test of 8.3.2.1 to 8.3.2.4 inclusive, which is made 10 times.*

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

**8.3.2.2** 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.

**8.3.2.3** One second after disconnection, the voltage between the pins of the plug is measured.

**8.3.2.4** The voltage shall not exceed 34 V peak. The test is only performed if the capacitor exceeds 0,1  $\mu$ F.

## **8.4 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 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.*

NOTE 1 In Canada and the USA, **hazardous live parts** are required to be so arranged, and the **cover** so located, that persons are not likely to be exposed to shock **hazard** while removing and replacing the **cover**.

NOTE 2 In Canada and the USA, **hazardous live parts** or hazardous moving parts are required to be so located, guarded or enclosed so as to reduce the likelihood of contact of such parts by persons while changing lamps, electron tubes or fuses; lubricating parts, or during other **operations** carried out during **user maintenance** or **servicing**.

**8.5** See Annex V.

## **9 Provision for protective earthing**

### **9.1 General requirements**

**9.1.1** Accessible metal parts, other than **actuating members**, of **in-line cord**, **free-standing** and **independently mounted controls** of class 0I and class I which may 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.

NOTE 1 The phrase "permanently and reliably connected to an earthing terminal" is synonymous with the term "bonded".

NOTE 2 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 3 Requirements for **actuating members** are specified in 8.2.3.

**9.1.2** Accessible metal parts, other than **actuating members**, of integrated and **incorporated controls** for class 0I and class I equipment which may become live in the event of an insulation **fault** shall have provision for earthing.



NOTE 1 **Integrated controls** and **incorporated controls** may 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.

NOTE 2 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 3 Requirements for **actuating members** are specified in 8.2.3.

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

*Compliance with 9.1.1 to 9.1.3 inclusive is checked by inspection.*

## **9.2 Class II and class III controls**

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

*Compliance is checked by inspection.*

## **9.3 Adequacy of earth connections**

### **9.3.1 General requirements**

The connection between an earthing terminal, earthing **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 a.c. 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  $\Omega$ . The test is continued until steady conditions have been established.

NOTE 1 Care is taken that the contact resistance between the tip of the measuring probe and the metal part under test 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.

### **9.3.2 Fixed wiring and methods X and M**

Earthing terminals for the connection of **fixed wiring** or for **non-detachable cords** using methods X and M shall comply with the requirements of 10.1.

NOTE 1 In Canada and the USA, a quick connect terminal having the dimensions indicated in Table 2 may be employed as a non-accessible earthing terminal provided it has additional means for preventing displacement in use and it is used on a circuit having a protective device as specified in the table.

NOTE 2 In Canada, China and the USA, an earthing conductor in **fixed wiring** or in a supply cord shall not be terminated by means of a quick-connect terminal.

**Table 2 (9.3.2 of edition 3) – Quick connect terminal dimensions (Canada and USA)**

| Nominal sizes<br>mm |           |        | Rating of circuit<br>protective device<br>A |
|---------------------|-----------|--------|---------------------------------------------|
| Width               | Thickness | Length |                                             |
| 4,8                 | 0,5       | 6,4    | 20 or less                                  |
| 4,8                 | 0,8       | 6,4    | 20 or less                                  |
| 5,2                 | 0,8       | 6,4    | 20 or less                                  |
| 6,3                 | 0,8       | 8,0    | 60 or less                                  |

### 9.3.3 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.

### 9.3.4 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<sup>2</sup> to 6 mm<sup>2</sup> inclusive and it shall not be possible to loosen them without the aid of a **tool**.

NOTE In Canada and the USA, conductors of other nominal cross-sectional area are permitted.

### 9.3.5 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.

### 9.3.6 Locking of earthing terminals

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

*Compliance with 9.3.2 to 9.3.6 inclusive is checked by inspection, by manual test and by the appropriate tests of 10.1.*

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.

## 9.4 Corrosion resistance

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.

### 9.4.1 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.



### 9.4.2 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 resulting from contact between copper and aluminium or its alloys.

*Compliance with 9.4, 9.4.1, and 9.4.2 is checked by inspection, and in cases of doubt by an analysis of the materials and their coatings.*

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

## 9.5 Other requirements

### 9.5.1 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.*

### 9.5.2 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 1 Refrigerator temperature **sensing controls** and defrost **controls** are examples.

NOTE 2 In the countries members of CENELEC, 9.5.2 does not apply.

## 10 Terminals and terminations

See also Clause 20, third paragraph.

### 10.1 Terminals and terminations for external copper conductors

**10.1.1** Terminals for **fixed wiring** and for **non-detachable cords** using **type X attachment** and **type M attachment**, except as specified in 10.1.3, 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.

**10.1.1.1** 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 may require the use of **special purpose tools** for connection or disconnection.

*Compliance with 10.1.1 and 10.1.1.1 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.

**10.1.2** 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 may also clamp **internal conductors** if these are so arranged that they are unlikely to be displaced when fitting the **external conductors**.

*Compliance is checked by inspection.*

NOTE 1 Provisionally, SI, BA and Unified threads are deemed to be of equal effectiveness to metric ISO thread.

NOTE 2 A test for equivalent effectiveness is under consideration. Pending agreement to such a test, all torque values for threads other than ISO, SI, BA and Unified are increased by 20 %.

### **10.1.3 Soldered, welded, crimped or similar terminations**

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 10.2.2 and 10.2.3.

*Compliance is checked by inspection.*

NOTE In general, the standards for equipment restrict the use of such connections.

**10.1.4** 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 3.

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

**Table 3 (10.1.4 of edition 3) – Minimum cross-sectional area of conductors**

| Current carried by terminal <sup>a</sup><br>A                                                                                                                                                                                                                                                                                    | Nominal cross-sectional area <sup>b</sup><br>mm <sup>2</sup> |                         |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|-------------------------|
|                                                                                                                                                                                                                                                                                                                                  | Flexible cord conductor                                      | Fixed wiring conductors |
| Up to 6 and including <sup>c</sup>                                                                                                                                                                                                                                                                                               | 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                |
| <sup>a</sup> Requirements for applications greater than 63 A are under consideration.<br><sup>b</sup> In the USA, other sizes of conductors apply.<br><sup>c</sup> The nominal cross-sectional areas specified do not apply to terminals in <b>SELV</b> -circuits or <b>PELV</b> -circuits carrying a current not exceeding 3 A. |                                                              |                         |

**10.1.4.1** 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 3, then this shall be declared.

NOTE 1 In Canada and the USA, **creepage distances** and **clearances** between terminals declared for **external conductors** for **fixed wiring** and between such terminals, other than earthing terminals, and adjacent metal parts shall meet the requirements of Clause 20, and in addition, when measured in accordance with Note 2 of 10.1.4.1, shall be at least:

- 6,4 mm for rated voltages not exceeding 250 V;
- 8,0 mm for rated voltages exceeding 250 V and up to 400 V;
- 9,6 mm for rated voltages exceeding 400 V.

NOTE 2 In Canada and the USA, the measurements of **creepage distance** and **clearances** at terminals are made twice, once with conductors of the largest cross-sectional area to be used and once without conductors fitted.

**10.1.5** 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 20.

*Compliance is checked by inspection and by measurement after fastening and loosening a conductor of the largest cross-sectional area used in 10.1.4 10 times, the conductor being moved each time it is loosened. For threaded parts, the full torque applied is either that shown in Table 20, or the torque specified in the relevant figure (see Figures 10 to 13), 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.*

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 standard.

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 standard.

**10.1.6** 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 may be of non-metallic material.

*Compliance is checked by inspection of the terminal and of the conductors after the test of 10.1.5.*

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

**10.1.7** 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.

**10.1.7.1** Terminals for **type X attachment** may 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.

**10.1.8** 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.

**10.1.8.1** *Compliance is checked by the following test.*

**10.1.8.2** *Terminals are fitted with conductors according to the use of the terminal, in accordance with Table 4. The wires of **fixed wiring** conductors are straightened before inserting into the terminal.*

**10.1.8.3** *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 20.*

**10.1.8.4** *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.*

**Table 4 (10.1.8 of edition 3) – Terminal conductors**

| Current carried by terminal <sup>a</sup><br>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                    |
| <sup>a</sup> Requirements for applications greater than 63 A are under consideration. |                         |                                                                                           |                             |

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

*Compliance is checked by the following test.*

**10.1.9.1** *The terminals are fitted with conductors of the smallest and largest nominal cross-sectional areas used in 10.1.4, 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 20. Each conductor is subjected to a pull of the value shown in Table 5. The pull is applied without jerks for 1 min, in the direction of the axis of the conductor space.*

**10.1.9.2** 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.

**10.1.9.3** During the test the conductor shall not move appreciably in the terminal.

**Table 5 (10.1.9 of edition 3) – Conductor pull test values**

| Current carried by terminal <sup>a</sup><br>A                                                                                                         | Pull<br>N                              |                                       |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|---------------------------------------|
|                                                                                                                                                       | Terminals for flexible cord conductors | Terminals for fixed wiring conductors |
| Up to and including 3                                                                                                                                 | 20 <sup>b</sup>                        | 20 <sup>b</sup>                       |
| 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                                   |
| <sup>a</sup> Requirements for applications greater than 63 A are under consideration.                                                                 |                                        |                                       |
| <sup>b</sup> Applicable only to <b>SELV</b> -circuits or <b>PELV</b> -circuits, and other applications where particular conductors are not specified. |                                        |                                       |

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

*Compliance is checked during the heating tests of Clause 14.*

**10.1.11** 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.*

**10.1.12** 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 10.1.4. 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**.*

**10.1.13** 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 17.*

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

**10.1.14** Screws and threaded parts of terminals shall be of metal.

*Compliance is checked by inspection.*

NOTE In Canada and the USA, national standards require that when screws are used for conductors of 2,5 mm or smaller diameter, the connection shall consist of clamps or binding screws with terminal plates having upturned lugs, or equivalent, to hold the wires in position. Terminal plate thicknesses are 1,27 mm (0,050 in) for wire size of more than 1,6 mm diameter (# 14 AWG); and 0,76 mm thickness minimum (0,030 in) for wire sizes of 1,6 mm or smaller diameter. The terminal screws shall not be smaller than # 8 Unified, except that # 6 Unified screw may be used for connection of a 1,29 mm (# 16) wire or a 1,02 mm (# 18) wire or a single 1,6 mm (# 14) wire.

**10.1.15** 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 11 and for **mantle terminals** by the minimum distance specified in Figure 12.*

NOTE In the U.S.A. and Canada, Subclauses 10.1.16 and 10.1.16.1 apply:

#### **10.1.16 Flying leads (pig tails)**

In Canada and the U.S.A., where **flying leads (pig tails)** may be used for wiring connections of **independently mounted controls**, the lead wires shall not be smaller than 0,82 mm<sup>2</sup>. The insulation shall be at least 0,8 mm thick, if thermoplastic, or at least 0,8 mm thick rubber, with a braid of 0,8 mm thick thermoplastic.

The leads shall have a minimum length of 150 mm and shall be arranged so that they are inaccessible when installed in accordance with national wiring practices. Additionally, the **control** end connection of such a lead, if located in the same wiring compartment, shall not be to a threaded terminal construction unless the means of connection is rendered unusable for connection of an **external conductor**.

The threaded terminal construction need not be rendered unusable if the lead is insulated at the connection end, and a marking on the device clearly indicates the intended use of the lead.

Compliance is checked by inspection.

**10.1.16.1** In Canada and the U.S.A., **flying leads** shall be provided with strain relief to prevent mechanical stress from being transmitted to terminal, splices (for example, twist-on connections) or internal wiring.

Compliance is checked by inspection and by applying a pull of 44 N on the leads for 1 min.

During this test, the lead shall not be damaged and shall not be displaced longitudinally by more than 2 mm.

## 10.2 Terminals and terminations for internal conductors

### 10.2.1 Connection of conductors

Terminals and **terminations** shall allow the connection of conductors having nominal cross-sectional areas as shown in Table 6.

**Table 6 (10.2.1 of edition 3) – Nominal cross-sectional areas of conductors**

| Current carried by terminal or terminations <sup>a</sup><br>A                                               | Minimum nominal <sup>b</sup> cross-sectional area of conductor<br>mm <sup>2</sup> |
|-------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Up to and including 3                                                                                       | – <sup>c</sup>                                                                    |
| 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                                                                                |
| <sup>a</sup> Requirements for applications greater than 63 A are under consideration.                       |                                                                                   |
| <sup>b</sup> In the USA, other sizes of conductors apply.                                                   |                                                                                   |
| <sup>c</sup> No minimum specified, but the manufacturer shall declare the conductor size for test purposes. |                                                                                   |

NOTE The requirements of 10.2.1 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. An example is a **thermostat** intended for use within the fabric of an electric blanket.

### 10.2.2 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.*

### 10.2.3 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 20 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.

### 10.2.4 Flat push-on connectors

**10.2.4.1 Tabs** forming part of a **control** shall comply with the dimensional requirements of Figure 14 or 15.



*Compliance is checked by measurement.*

**Tabs** with dimensions other than those shown in Figure 14 or 15 can be used, if the dimensions and shapes are so different as to prevent any possible mismatching with a standard **receptacle** (see Figure 16).

For the dimensions of Figures 14, 15 and 16, the physical dimensions of IEC 61210 may alternatively be used. The performance requirements of IEC 61210 do not apply.

**Tabs** allowing the polarized acceptance of **receptacles** can be used (see Figure 16).

**10.2.4.2 Tabs** forming part of a **control** shall consist of material and plating appropriate to the maximum temperature of the **tabs** as indicated in Table 7. Materials or coatings other than those specified in the table can be used provided their electrical and mechanical characteristics are no less reliable, particularly with regard to resistance to corrosion and mechanical strength.

**Table 7 (10.2.4.2 of edition 3) – Material and plating for tabs**

| Material and plating of tabs           | Maximum temperature of the tab<br>°C |
|----------------------------------------|--------------------------------------|
| Bare copper                            | 155                                  |
| Bare brass                             | 210                                  |
| Tin plated copper and copper alloys    | 160                                  |
| Nickel plated copper and copper alloys | 185                                  |
| Silver plated copper and copper alloys | 205                                  |
| Nickel plated steel                    | 400                                  |
| Stainless steel                        | 400                                  |

*Compliance is checked by measuring the temperatures attained during the tests of Clause 14.*

NOTE The temperatures specified are those for continuous use. Higher transient temperatures are possible, for example, during temperature overshoot of a temperature **sensing control**.

**10.2.4.3 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 standard.

*Compliance is checked by applying, without jerks, axial forces equal to those shown in Table 8. No significant displacement or damage shall occur.*

**Table 8 (10.2.4.3 of edition 3) – Axial force values for tab insertion and withdrawal**

| Tab size<br>(see Figure 16)                                                                                                                  | Push <sup>a</sup><br>N | Pull <sup>a</sup><br>N |
|----------------------------------------------------------------------------------------------------------------------------------------------|------------------------|------------------------|
| 2,8                                                                                                                                          | 50                     | 40                     |
| 4,8                                                                                                                                          | 60                     | 50                     |
| 6,3                                                                                                                                          | 80                     | 70                     |
| 9,5                                                                                                                                          | 100                    | 100                    |
| <sup>a</sup> The values in the table are the maximum allowed for the insertion and the withdrawal of a <b>receptacle</b> from a <b>tab</b> . |                        |                        |



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

For the dimensions of Figures 14, 15 and 16, the physical dimensions of IEC 61210 may 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 20.*

NOTE For **tabs** complying with Figure 14 or 15, the appropriate **receptacle** is shown in Figure 16.

### 10.3 Terminals and terminations for integrated conductors

There are no specific requirements or tests for terminals or terminations for **integrated conductors** under Clause 10, but the relevant requirements of the other clauses may apply.

## 11 Constructional requirements

### 11.1 Materials

#### 11.1.1 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.

#### 11.1.2 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 and by analysis of the material.*

#### 11.1.3 Non-detachable cords

**11.1.3.1 Non-detachable cords of class I controls** shall have a green/yellow conductor insulation 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.

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

*Compliance with 11.1.3.1 and 11.1.3.2 is checked by inspection.*

### 11.2 Protection against electric shock

#### 11.2.1 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.

**11.2.1.1** 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.*

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

## **11.2.2 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 20. 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 20.

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

*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 17 and 18 are deemed to comply;*
- *wires connected by soldering are considered to be not adequately fixed unless they are held 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.*

## **11.2.3 Integrated conductors**

**11.2.3.1 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 20.

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

*Compliance with 11.2.3.1 and 11.2.3.2 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 13, the conductor is considered to be a bare conductor.

## **11.2.4 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.*

### 11.2.5 Protective impedance

See Annex H.

### 11.2.6 Protection against electric shock by use of SELV or PELV

See Annex T.

### 11.2.7 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.*

## 11.3 Actuation and operation

### 11.3.1 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 20. The contact separation may 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 substantially together.

*Compliance is checked by inspection and by the tests of Clauses 13 and 20, where necessary.*

### 11.3.2 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 13 but no **clearance** dimension is specified. The contact separation may be obtained by **automatic action** or by **manual action**, but any subsequent change of **activating quantity** between the limits declared in Table 1, requirement 36, or at any **switch head** temperature between the limits declared in Table 1, requirement 22, shall not cause an **operation** which would reduce the contact separation such that the requirements of Clause 13 are no longer met.

*Compliance is checked by inspection and, where necessary, by the tests of Clause 13 carried out at the temperature limits declared.*

### 11.3.3 Reset buttons

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

*Compliance is checked by inspection.*

NOTE 1 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**.

NOTE 2 This requirement does not apply to manual reset **controls** with **trip-free** actions.

### 11.3.4 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.*

### 11.3.5 Contacts – General

**11.3.5.1** Contacts with a d.c. 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 11.3.7.

**11.3.5.2** **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.

#### 11.3.5.2.1 Measures 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 H.27.1.1.2 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 95) short-circuit current.*

**11.3.5.2.1.1** *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 if there is no current flow through the switch.*

*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.*

**11.3.5.2.1.2** *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 H.27.1.1.3 and Clause 15.*

*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.*

### **11.3.6 Contacts for full disconnection and micro-disconnection**

Contacts for **full disconnection** and contacts for **micro-disconnection**, having either a d.c. rating not greater than 0,1 A, or an a.c. 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 14, and for open position by the requirements of Clause 13, 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 13 and 20, as specified for **full disconnection**, are made for this **intermediate position**.*

### **11.3.7 Exclusions for 11.3.5 and 11.3.6**

The requirements of 11.3.5 and 11.3.6 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**.

**11.3.7.1** *Compliance is checked by inspection, and if necessary by the test of 11.3.7.2.*

**11.3.7.2** *A d.c. 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.*

### **11.3.8 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**.

### 11.3.9 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.*

NOTE 1 **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 2 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 may be given.

## 11.4 Actions

### 11.4.1 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.*

### 11.4.2 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.*

### 11.4.3 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 requirements 41 and 42 of Table 1.

*Compliance is checked by the tests of Clauses 15 to 17 inclusive.*

### 11.4.4 Type 1.A or 2.A action

A 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 13 and the relevant requirements of Clause 20.*

### 11.4.5 Type 1.B or 2.B action

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 13 and the relevant requirements of Clause 20.*

#### **11.4.6 Type 1.C or 2.C action**

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 20.*

#### **11.4.7 Type 1.D or 2.D action**

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.*

#### **11.4.8 Type 1.E or 2.E action**

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.

*Compliance is checked by inspection and by test.*

#### **11.4.9 Type 1.F or 2.F action**

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 and by test.*

NOTE Mounting within an equipment such that a **tool** is required to gain access to the **control** is deemed to satisfy this requirement.

#### **11.4.10 Type 1.G or 2.G action**

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.*

#### **11.4.11 Type 1.H or 2.H action**

A Type 1.H or 2.H action shall be so designed that the contacts cannot be prevented from opening and which may 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.*

#### **11.4.12 Type 1.J or 2.J action**

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 –35 °C.

*Compliance is checked by inspection and by test.*



#### 11.4.13 Type 1.K or 2.K action

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.

#### 11.4.14 Type 1.L or 2.L action

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.

#### 11.4.15 Type 1.M or 2.M action

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 17.6.*

11.4.16 See Annex H.

11.4.17 See Annex J.

### 11.5 Openings in enclosures

Drain holes, if any, shall have a minimum area of 20 mm<sup>2</sup>, a maximum area of 40 mm<sup>2</sup> and minimum dimension of 3 mm.

*Compliance is checked by inspection.*

NOTE 1 Additional requirements for moisture resistance are contained in Clause 12.

NOTE 2 **Controls** classified as IPX7 can have a facility for opening a drain hole.

NOTE 3 In the USA, there are additional requirements for openings in enclosures provided for ventilation, drainage, mounting of components, or clearance around a dial, knob, lever, handle, capillary tube or the like.

### 11.6 Mounting of controls

11.6.1 **Controls** shall be so designed that the methods of mounting in accordance with the manufacturer's declaration do not adversely affect compliance with this standard.

11.6.2 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 standard. If removal or partial removal is necessary for correct use of the **control**, then the requirements of Clauses 8, 13 and 20 shall be satisfied before and after removal.

*Compliance with 11.6.1 and 11.6.2 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.

### 11.6.3 Mounting of independently mounted controls

**11.6.3.1 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.

**11.6.3.2** 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.

**11.6.3.3 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.

**11.6.3.4 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.

**11.6.3.5 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.

**11.6.3.6 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**.

**11.6.3.7** 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.

*Compliance with 11.6.3.1 to 11.6.3.7, 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.

## 11.7 Attachment of cords

### 11.7.1 Flexing

**11.7.1.1** 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.

**11.7.1.2** *Compliance is checked by subjecting the **control**, fitted with the flexible cord or range of flexible cords for which it is designed, to the following test.*

**11.7.1.2.1** The **control** is mounted in the flexing apparatus shown in Figure 9. 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.

**11.7.1.2.2** After the test, the sample shall show no damage within the meaning of this standard. 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.

**11.7.1.2.3** Not more than 10 % of the total number of conductors of the flexible cord shall have been broken.

## **11.7.2 Cord anchorages**

**11.7.2.1 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.

**11.7.2.2** 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**.

**11.7.2.3** 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 11.7.1.

**11.7.2.4** 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 may be connected;
- for **type X attachment**, the design and location make replacement of the flexible cord easily possible.

**11.7.2.5** 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.

**11.7.2.6** 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.

**11.7.2.7** 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.

**11.7.2.8** Compliance with 11.7.2.1 to 11.7.2.7, inclusive, is checked by inspection and by the tests of 11.7.2.9 to 11.7.2.15 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.

**11.7.2.9** 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 19.1.

**11.7.2.10** 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 standard.

**11.7.2.11** The cord is then subjected to pulls of the value and number shown in Table 9. The pulls are applied in the most unfavourable direction, without jerks, each time for 1 s.

**11.7.2.12** Immediately afterwards, the cord is subjected for 1 min to a torque of the value shown in Table 9.

**Table 9 (11.7.2 of edition 3) – Pull and torque values**

| Control                                                              | Pull <sup>a</sup><br>N | Torque <sup>a</sup><br>Nm | Number of pulls <sup>a</sup> |
|----------------------------------------------------------------------|------------------------|---------------------------|------------------------------|
| <b>Free-standing controls and independently mounted controls:</b>    |                        |                           |                              |
| 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                           |
| <b>In-line cord controls</b> (other than free-standing controls)     | 90                     | 0,25                      | 100                          |
| <sup>a</sup> Some equipment standards may require a different value. |                        |                           |                              |

**11.7.2.13** 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 10.1.4, 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.

**11.7.2.14** 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 20.

**11.7.2.15** 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.

## 11.8 Size of cords – non-detachable

**11.8.1 Non-detachable cords** shall not be lighter than 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 lighter flexible cord is permissible if allowed in a particular equipment standard or for connection to external **SELV** devices (sensors/units).

*Compliance is checked by inspection.*

**11.8.2 Controls** fitted with **non-detachable cords** shall have a cord with conductors of a size not less than that shown in Table 10.

**Table 10 (11.8.2 of edition 3) – Minimum cord conductor sizes**

| Current in relevant circuit <sup>a</sup><br>A | Nominal cross-sectional area <sup>b</sup><br>mm <sup>2</sup> |
|-----------------------------------------------|--------------------------------------------------------------|
| Up to and including 6 <sup>c</sup>            | 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                                                           |

<sup>a</sup> Requirements for applications greater than 63 A are under consideration.

<sup>b</sup> In the USA, other sizes of conductors apply.

<sup>c</sup> Lower values than 0,75 mm<sup>2</sup> are permitted for **class III controls** or if permitted in a particular equipment or installation standard.

*Compliance is checked by inspection.*

**11.8.3** 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 10.1.4.*

## 11.9 Inlet openings

**11.9.1** 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.

**11.9.1.1** 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 20.

*Compliance is checked by inspection.*

**11.9.2** If an inlet bushing is not provided, then the inlet opening shall be of insulating material.

**11.9.3** 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.

**11.9.4** 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 0I control** or **class I control**, rubber is allowed if the bushing is integral with the sheath of a cord of rubber.

*Compliance with 11.9.1 to 11.9.4, inclusive, is checked by inspection and manual test.*

**11.9.5** 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.

## **11.10 Equipment inlets and socket-outlets**

**11.10.1** 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.*

**11.10.2 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.*

**11.10.3 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.

If **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 27.5.

The plug and socket outlet part of the **control** shall comply with the appropriate standard for the plug and socket system. The **control** part shall comply with this standard.

NOTE This clause is not applicable in Canada and the USA.

*Compliance is checked by inspection and by carrying out tests based on those prescribed for the socket-outlet system.*

## 11.11 Requirements during mounting, maintenance and servicing

### 11.11.1 Covers and their fixing

**11.11.1.1** 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 standard.

**11.11.1.2** 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 standard. 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 11.11.1.1 and 11.11.1.2 is checked by inspection.*

NOTE 1 In Canada and the USA, a screwless fixed **cover** which gives access to bare **live parts** and which does not require a **tool** for its removal shall withstand the following tests:

A **cover** shall not become disengaged from the case when a direct pull of 60 N is applied. For this test, the **cover** is to be gripped at any two convenient points. The test shall be performed before and after 10 removal and replacement **operations**.

A **cover** shall be capable of withstanding an impact of 1,35 Nm applied to the accessible faces of the **cover** (one blow per face) without being displaced, and there shall be no damage to internal parts nor malfunction of the **control** as a result of this test. The radius of the ball used for this test shall be not less than 25,4 mm.

NOTE 2 In Canada and the USA, the continuity of the earthing means for a screwless fixed **cover** shall comply with the requirements of 9.3 and 9.5.

### 11.11.1.3 Covers of enclosures

NOTE In Canada and the U.S.A., there are additional requirements for doors or **covers** of enclosures giving access to fuses or any overload protective device, the normal functioning of which requires renewal, or if it is necessary to open the **cover** in connection with the normal **operation** of the overload protective device.

### 11.11.1.4 Glass covering an opening

NOTE In Canada and the U.S.A., there are additional requirements for glass or glass-like material covering an observation opening.

### 11.11.1.5 Non-detachable parts

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 11.11.1.5.1 to 11.11.1.5.3.*

**11.11.1.5.1** *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.

**11.11.1.5.2** *For the tests of 11.11.1.5.3, the **control** shall be at room temperature. However, in cases where compliance may be affected by temperature, the test is also carried out immediately after the **control** has been operated under the conditions specified in Clause 14.*



**11.11.1.5.3** 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 2.

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 3 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.

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 3 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 of 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.

**11.11.1.5.4** During and after the tests of 11.11.1.5.3, parts shall not become detached and they shall remain in the locked position, otherwise they are deemed to be **detachable parts**.

**11.11.1.6** 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**.

## 11.11.2 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 19.1.5.

### 11.11.3 Actuating member

**11.11.3.1** A **control** shall not be damaged when its **actuating member** is mounted or removed in the intended manner.

**11.11.3.2** 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**.

**11.11.3.3** 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 11.11.3.1 to 11.11.3.3 inclusive is checked by inspection and, for actuating members which do not require a tool for their removal, by the test of 18.9.*

NOTE Standards for equipment may require that an **actuating member** used to indicate the condition of a **control** not be capable of being fixed in an incorrect position.

### 11.11.4 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.

### 11.11.5 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.

### 11.11.6 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.*

### 11.11.7 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.*

## 11.12 Controls using software

See Annex H.



## 11.13 Protective controls and components of protective control systems

### 11.13.1 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.

**Operating controls** shall not be used as **protective controls**.

*Compliance is checked by carrying out the relevant tests specified in this standard and the appropriate part 2.*

### 11.13.2 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.

### 11.13.3 Temperature monitoring devices

These devices shall have an adequate response time on safety grounds, consistent with measurement function.

### 11.13.4 Batteries

**11.13.4.1 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**.

**11.13.4.2** 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 (see Annex V); and
- for non-rechargeable batteries, discharging at a rate exceeding the battery manufacturer's recommendations, and unintentional charging, are prevented; and
- for rechargeable batteries (see Annex V), 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 2); or
  - be inherently protected to avoid creating a **hazard** within the meaning of the standard.

NOTE Reversed charging of a rechargeable battery occurs when the polarity of the charging circuit is reversed, aiding the discharge of the battery.

**11.13.4.3** 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.

NOTE An example of a battery construction where leakage of the electrolyte is considered to be unlikely is the sealed **cell** valve-regulated type.

**11.13.4.3.1** 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**.

**11.13.4.4** Compliance with 11.13.4.1 to 11.13.4.3.1 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 11.13.4.4.1 to 11.13.4.4.4 and 11.13.4.5. 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. The battery used for the following tests is a new non-rechargeable battery or as provided with, or recommended by the manufacturer for use with, the **control**.*

**11.13.4.4.1** 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.

**11.13.4.4.2** Excessive discharging rate. 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.

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.

**11.13.4.4.3** See Annex V.

**11.13.4.4.4** These tests 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
- 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.

**11.13.4.5** After completion of the tests, the equipment is subjected to the electric strength tests of 13.2.

## 12 Moisture and dust resistance

### 12.1 Protection against ingress of water and dust

**12.1.1 Controls** shall provide the degree of protection against ingress of water and dust appropriate to their IP classification when mounted and used in the declared manner.

**12.1.2 Compliance** is checked by first preparing the **control** as described in 12.1.3 to 12.1.6 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 13.2, and inspection shall show that any water which may have entered the **control** has not impaired compliance with this standard: 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 20.

**12.1.3 Controls** are allowed to stand in normal test room atmosphere for 24 h before being subjected to the appropriate test.

**12.1.4 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 smallest cross-sectional area specified in 10.1.4; **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.

**12.1.5 Detachable parts** are removed and subjected, if necessary, to the tests with the main part.

**12.1.6 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  $(70 \pm 2) ^\circ\text{C}$ , for 10 days (240 h).

NOTE In the USA, there are additional requirements for gaskets, glands and sealing compounds employed to prevent harmful ingress of water and to adhesives used for securement of such gaskets to an enclosure or **cover** in **controls** to be installed where exposed to rain and operating at or below  $60 ^\circ\text{C}$ .

**12.1.6.1 Void**

**12.1.6.2 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 20.

### 12.2 Protection against humid conditions

**12.2.1 All controls** shall withstand humid conditions which may occur in **normal use**.

See also Annex J.

**12.2.2 Compliance** is checked by the test sequence described in 12.2.3, after the humidity treatment of 12.2.5 to 12.2.9, inclusive.

**12.2.3** For *in-line cord, free-standing, independently mounted controls*, the test of 13.2 is conducted immediately after the humidity treatment. For integrated and **incorporated controls**, the test of 13.2 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.

**12.2.4** The **control** shall show no damage so as to impair compliance with this standard.

**12.2.5** Cable inlet openings, if any, and drain holes are left open. If a drain hole is provided for an **IPX7 control**, it is opened.

**12.2.6** **Detachable parts** are removed and subjected, if necessary, to the humidity treatment with the main part.

**12.2.7** Before being placed in the humidity cabinet, the sample is brought to a temperature between  $t$  and  $(t + 4)$  °C. 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**.

**12.2.8** 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 1 K of any convenient value ( $t$ ) between 20 °C and 30 °C.

**12.2.9** After this treatment, the tests of Clause 13 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 detached parts.

NOTE 1 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.

NOTE 2 A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate ( $\text{Na}_2\text{SO}_4$ ) or potassium nitrate ( $\text{KNO}_3$ ) in water having a sufficiently large contact surface with the air. It is important that care be taken such that the test sample is not subjected to condensate or other contaminants from the salt solution or from any part of the test equipment.

NOTE 3 In order to achieve the specified conditions within the cabinet, it is necessary to provide constant circulation of the air within and, in general, to use a cabinet which is thermally insulated.

**12.3** For *in-line cord* and **free-standing controls**, one sample is subjected to the test of 12.3.1 to 12.3.7 inclusive prior to the other tests of Clause 12.

**Class III controls** are not tested under these subclauses.

NOTE In the countries members of CENELEC, 12.3 does not apply.

**12.3.1** 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.

**12.3.2** The **leakage current** is measured between parts as indicated in 13.3.1.

**12.3.3** 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 250 V, or three-phase **control** used as a single-phase control, if a **class II control**, see Figure 25; if other than a **class II control**, see Figure 26;
- for a single-phase **control** having a rated voltage exceeding 250 V, or a three-phase **control** not suitable for use as a single-phase **control**, if a **class II control**, see Figure 27; if other than a **class II control**, see Figure 28;
- for a two-phase **control** having a rating not exceeding 250 V, other than **class II control**, see Figure 29 or 30, depending upon usage.

**Controls** for single-phase equipment having a rated voltage exceeding 250 V shall be connected to two of the phase conductors, the remaining phase conductor not being used.

A suitable measuring circuit is shown in Annex E.

**12.3.4** During measurement, all **control** circuits shall be closed. However, **controls** tested according to Figures 26, 29 and 30 shall have **leakage currents** checked with switch S1 in the open and the closed position.

It is permissible to short circuit contact points to simulate closed circuits.

**12.3.5** The measuring circuit shall have a total impedance of  $(1\,750 \pm 250) \, \Omega$  and be shunted by a capacitor such that the time constant of the circuit is  $(225 \pm 15) \, \mu\text{s}$ .

**12.3.6** The measurement circuit shall not have an error of more than 5 % at an indicated 0,75 mA of leakage and shall have an accuracy of within 5 % for all frequencies in the range of 20 Hz to 5 kHz.

**12.3.7** The maximum **leakage current**, after the temperature of the **control** has stabilized, shall not exceed the values given in 13.3.4.

## 13 Electric strength and insulation resistance

### 13.1 Insulation resistance

The insulation resistance of **in-line cord**, **free standing** and **independently mounted controls** shall be adequate.

**13.1.1** Compliance is checked by the test of 13.1.2 to 13.1.4 inclusive. This test is made when specified in Clause 12.

**13.1.2** 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.

**13.1.3** The insulation resistance is measured with a d.c. voltage of approximately 500 V applied, the measurement being made 1 min after application of the voltage.

**13.1.4** The insulation resistance shall not be less than that shown in Table 11.

**Table 11 (13.1 of edition 3) – Minimum insulation resistance**

| Insulation to be tested  | Insulation resistance<br>MΩ |
|--------------------------|-----------------------------|
| Functional insulation    | –                           |
| Basic insulation         | 2                           |
| Supplementary insulation | 5                           |
| Reinforced insulation    | 7                           |

## 13.2 Electric strength

The electric strength of all **controls** shall be adequate.

**13.2.1** Compliance is checked by the following test of 13.2.2 to 13.2.4 inclusive, using insulation or disconnection test voltages as shown in Table 12. This test is made when specified in Clause 12 and Clause 17.

**Table 12 (13.2 of edition 3) – Insulation or disconnection test voltages <sup>a</sup> (1 of 2)**

| Insulation or disconnection<br>to be tested <sup>c d e</sup> | Test voltage for working voltages <sup>b</sup> |                                                                 |                                                           |                                                            |                                                            |                                                            |
|--------------------------------------------------------------|------------------------------------------------|-----------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|
|                                                              | Up to<br>50 V <sup>f</sup><br>(Class III)      | Up to<br>50 V <sup>f or g</sup><br>(Other<br>than<br>Class III) | Over 50 V<br>up to and<br>including<br>130 V <sup>g</sup> | Over 130 V<br>up to and<br>including<br>250 V <sup>g</sup> | Over 250 V<br>up to and<br>including<br>440 V <sup>g</sup> | Over 440 V<br>up to and<br>including<br>690 V <sup>g</sup> |
| Functional insulation <sup>h</sup>                           | 100                                            | 100                                                             | 260                                                       | 500                                                        | 880                                                        | 1 380                                                      |
| Basic insulation <sup>i j</sup>                              | 500                                            | 1 250                                                           | 1 330                                                     | 1 450                                                      | 1 640                                                      | 1 890                                                      |
| Supplementary insulation <sup>i j k l</sup>                  | –                                              | 1 250                                                           | 1 330                                                     | 1 450                                                      | 1 640                                                      | 1 890                                                      |
| Reinforced insulation <sup>i j k l m</sup>                   | –                                              | 2 500                                                           | 2 660                                                     | 2 900                                                      | 3 280                                                      | 3 780                                                      |
| Electronic disconnection <sup>n o</sup>                      | 100                                            | 100                                                             | 260                                                       | 500                                                        | 880                                                        | 1 380                                                      |
| Micro-disconnection <sup>p</sup>                             | 100                                            | 100                                                             | 260                                                       | 500                                                        | 880                                                        | 1 380                                                      |
| Full disconnection <sup>p</sup>                              | 500                                            | 1 250                                                           | 1 330                                                     | 1 450                                                      | 1 640                                                      | 1 890                                                      |
| Micro-interruption <sup>q</sup>                              | –                                              | –                                                               | –                                                         | –                                                          | –                                                          | –                                                          |

**Table 12 (2 of 2)**

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <sup>a</sup> | In Canada and the USA, other values are applicable.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <sup>b</sup> | The high-voltage transformer used for the test must 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 must not trip when the output current is less than 100 mA. Care shall be taken that the r.m.s. value of the test voltage is measured within $\pm 3\%$ . See also Annex H.                                                                                                               |
| <sup>c</sup> | 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 <b>functional insulation</b> when one pole is disconnected. Where such a proceeding is not practical, the tests of Clauses 15 to 17 inclusive are considered to be sufficient.                                                                                        |
| <sup>d</sup> | For class I and <b>class 0I controls</b> and <b>controls</b> for class I situations, care must be taken that adequate <b>clearance</b> is maintained between metal foil and accessible metal to avoid over-stressing of insulation between <b>live parts</b> and earthed metal parts.                                                                                                                                                                                                                                                      |
| <sup>e</sup> | Care should be taken when carrying out the tests to avoid overstressing the components of <b>electronic controls</b> .                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <sup>f</sup> | No requirement up to 24 V a.c. r.m.s. if the circuit is insulated from the mains by <b>double insulation</b> or <b>reinforced insulation</b> (may be earthed).                                                                                                                                                                                                                                                                                                                                                                             |
| <sup>g</sup> | Applies to <b>controls</b> galvanically connected to mains.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <sup>h</sup> | <b>Functional insulation</b> on printed wiring boards submitted in <b>normal use</b> to a voltage up to 50 V is not subjected to the tests of this clause.                                                                                                                                                                                                                                                                                                                                                                                 |
| <sup>i</sup> | See 13.3.1.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <sup>j</sup> | Any metal in contact with accessible metal is also regarded as accessible.                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <sup>k</sup> | For the tests of <b>supplementary insulation</b> and <b>reinforced insulation</b> , the metal foil is applied in such a way that sealing compound, if any, is effectively tested to accessible insulating surfaces.                                                                                                                                                                                                                                                                                                                        |
| <sup>l</sup> | For <b>accessible parts</b> which are protected by means of <b>protective impedance</b> , the tests are carried out with the components disconnected, the mid-point of the two impedances being regarded as an intermediate metal part.                                                                                                                                                                                                                                                                                                    |
| <sup>m</sup> | For <b>controls</b> incorporating <b>reinforced insulation</b> as well as <b>double insulation</b> , care should be taken that the voltage applied to the <b>reinforced insulation</b> does not over-stress the <b>basic insulation</b> or the supplementary parts of the <b>double insulation</b> .                                                                                                                                                                                                                                       |
| <sup>n</sup> | The device which actually performs the disconnection is first removed from the circuit. If necessary, any <b>control</b> input is connected such that the device is providing the disconnection. The test voltage is then applied to the terminals and <b>terminations</b> of the device which carry the load current.                                                                                                                                                                                                                     |
| <sup>o</sup> | See Clause H.28.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <sup>p</sup> | For the test of <b>full disconnection</b> and <b>micro-disconnection</b> , 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.<br><br>In the case of temperature <b>sensing controls</b> , 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. |
| <sup>q</sup> | There are no electric strength requirements for <b>micro-interruption</b> , since the satisfactory completion of the tests of Clauses 15 to 17 inclusive are considered to be sufficient. Furthermore, for a <b>control</b> which has no <b>micro-disconnection</b> in one position of its <b>actuating means</b> and <b>micro-interruption</b> in other positions, there are no requirements for electric strength for those positions corresponding to <b>micro-interruption</b> .                                                       |

**13.2.2** 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.

**13.2.3** The insulation is subjected to a voltage of substantially sine-wave form, having frequency of 50 Hz or 60 Hz. Voltage is applied for 1 min across the insulation or disconnection indicated in Table 12 and has the value shown in the table.

**13.2.4** 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.



### 13.3 Additional tests for in-line cord and free-standing controls

For **in-line cord** and **free-standing controls**, after the tests of 13.1 or 13.2, as appropriate, the sample that was subjected to the tests of 12.3 shall be subjected to the tests of 13.3.1 to 13.3.4 inclusive.

**Class III controls** are not tested under these subclauses.

**13.3.1** A test voltage, d.c. for **controls** for d.c. only and a.c. 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 a grounding pin or conductor, the grounding conductor is to be disconnected at the supply source.

**13.3.2** The test voltage is

- 1,06 times rated voltage, or 1,06 times the upper limit of the rated voltage range, for **controls** for d.c. 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 250 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**.

**13.3.3** The **leakage current** is measured within 5 s after the application of the test voltage.

**13.3.4** The maximum **leakage 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.

NOTE In Canada and the USA, the values for **controls** using 250 V or less supply are as follows:

- for **class 0 control**, **class 01 control** and **class I control** 0,5 mA;
- for **class II controls** 0,25 mA.

## 14 Heating

**14.1 Controls** and their supporting surfaces shall not attain excessive temperatures in normal use.

**14.1.1** Compliance is checked by the test of 14.2 to 14.7 inclusive.

**14.1.2** During this test, the temperatures shall not exceed the values specified in Table 13, and the **controls** shall not undergo any change so as to impair compliance with this standard and in particular with Clauses 8, 13 and 20.

**14.2** 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 10.1.4.

**14.2.1** 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.

**14.2.2** If a terminal is suitable for both flexible cords and for fixed conductors, then the appropriate flexible cord is used.

**14.2.3** Terminals not intended for the connection of **external conductors** shall be fitted with conductors of the minimum cross-sectional area, as specified in 10.2.1, or with a special conductor if declared in 7.2.

**14.3** **In-line cord controls** are stood or rested on a dull black painted plywood surface.

**14.3.1** **Independently mounted controls** are mounted as in **normal use**.

**14.4** **Controls** shall be connected to a supply having the most unfavourable voltage between  $0,94 V_R$  and  $1,06 V_R$ . Circuits which are not voltage sensitive may be connected to a lower voltage (but not less than 10 % of  $V_R$  and loaded such that the most unfavourable current between 0,94 and 1,06 times the rated current flows in the circuit).

NOTE In the USA, the test is conducted at the voltages specified in 17.2.3.1 and 17.2.3.2.

**14.4.1** Circuits and contacts not intended for external loads shall be specified by the manufacturer.

**14.4.2** **Actuating members** are placed in the most unfavourable position.

**14.4.3** 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.

**14.4.3.1** 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 ( $5 \pm 1$ ) K such that the contacts are then in the closed position.

**14.4.3.2** 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.

**14.4.3.3** 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.

**14.4.3.4** For other **automatic controls**, the most arduous **operating sequence** or segment of the **operating sequence** shall be selected.

**14.4.4** If the **control** starts to operate during this test, the **control** is reset so that the contacts will remain closed.

**14.4.4.1** 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**.

**14.5 Controls** are tested in an appropriate heating and/or refrigerating apparatus such that the conditions in 14.5.1 and 14.5.2 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.

**14.5.1** The temperature of the **switch head** is maintained between  $T_{\max}$  and either  $(T_{\max} + 5) ^\circ\text{C}$  or 1,05 times  $T_{\max}$ , whichever is greater. The temperature of any mounting surface is maintained between  $T_{s \max}$  and either  $(T_{s \max} + 5) ^\circ\text{C}$  or 1,05 times  $T_{s \max}$  whichever is the greater if  $T_{s \max}$  is different from  $T_{\max}$ .

**14.5.2 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  $15 ^\circ\text{C}$  to  $30 ^\circ\text{C}$ , the resulting measured temperature being corrected to a  $25 ^\circ\text{C}$  reference value.

**14.6** The temperatures specified for the **switch head**, the mounting surfaces and **sensing element** shall be attained in approximately 1 h.

**14.6.1** The electrical and thermal conditions are maintained for 4 h, or for 1 h after steady state, whichever occurs first.

**14.6.2** For **controls** designed for short-time or intermittent **operation**, the resting time(s) declared in Table 1, requirement 34, shall be included in the 4 h.

**14.7** 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**.

**14.7.1** The temperature of the parts and surfaces indicated in Table 13 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.

**14.7.2** 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.

**14.7.3** 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.

**14.7.4** 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 20.

**Table 13 (14.1 of edition 3) – Maximum heating temperatures (1 of 3)**

| Parts                                                                                                                                    | Maximum temperature permitted<br>°C |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| Pins of appliance inlets and plug-in devices <sup>a</sup> :                                                                              |                                     |
| – for very hot conditions                                                                                                                | 155                                 |
| – for hot conditions                                                                                                                     | 120                                 |
| – for cold conditions                                                                                                                    | 65                                  |
| Windings <sup>b c d e</sup> 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 <sup>a f g</sup>                                                                      | 85                                  |
| Other terminals and terminations <sup>a h</sup>                                                                                          | 85                                  |
| Rubber or polyvinyl chloride insulation of conductors: <sup>a</sup>                                                                      |                                     |
| – 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 <sup>i</sup>                                                                                | 60                                  |
| Rubber other than synthetic when used for gaskets or other parts, the deterioration of which could impair compliance with this standard: |                                     |
| – when used as supplementary insulation or as reinforced insulation                                                                      | 65                                  |
| – in other cases                                                                                                                         | 75                                  |
| Materials used as insulation other than for wires <sup>i j k</sup> :                                                                     |                                     |
| – 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 <sup>j</sup>                                                                                                              |                                     |
| 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 <sup>l</sup>                                                               | –                                   |
| All accessible surfaces except those of actuating members, handles, knobs, grips and the like                                            | 85                                  |

Table 13 (2 of 3)

| Parts                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Maximum temperature permitted<br>°C |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
| <b>Accessible surfaces</b> of handles, knobs, grips and the like used for carrying and transporting the <b>control</b> : <ul style="list-style-type: none"> <li>– of metal</li> <li>– of porcelain or vitreous material</li> <li>– of moulded material, rubber or wood</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 55<br>65<br>75                      |
| <b>Accessible surface of actuating members</b> , or of other handles, grips or the like which are held for short periods only: <ul style="list-style-type: none"> <li>– of metal</li> <li>– of porcelain or vitreous material</li> <li>– of moulded material, rubber or wood</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 60<br>70<br>85                      |
| Wood in general                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 90                                  |
| Supported painted plywood surface                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 85                                  |
| Current-carrying parts made of copper or brass <sup>a m n</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 230                                 |
| Current-carrying parts made of steel <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 400                                 |
| Other current-carrying parts <sup>a m</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | –                                   |
| <p><sup>a</sup> For these parts, the tests of 14.7 are repeated after Clause 17.</p> <p><sup>b</sup> The classification is in accordance with IEC 60085.</p> <p>Examples of class A material are: impregnated cotton, silk, artificial silk and paper; enamels based on oleo- or polyamide resins.</p> <p>Examples of class B material are: glass fibre, melamine and phenol formaldehyde resins.</p> <p>Examples of class E material are:</p> <ul style="list-style-type: none"> <li>– mouldings with cellulose fillers, cotton fabric laminates and paper laminates, bonded with melamine- formaldehyde, phenol-furfural resins;</li> <li>– cross-linked polyester resins, cellulose triacetate films, polyethylene terephthalate films;</li> <li>– varnished polyethylene terephthalate textile bonded with oil modified alkyd resin varnish;</li> <li>– enamels based on polyvinylformal, polyurethane or epoxy resins.</li> </ul> <p>More extensive accelerated temperature tests and, in addition, compatibility testing is required for insulation systems of class B and higher temperature classes.</p> <p>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.</p> <p><sup>c</sup> 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 a.c. motors, the figures without square brackets apply in both cases.</p> |                                     |

**Table 13 (3 of 3)**

- <sup>d</sup> The value of the temperature rise of a copper winding is calculated from the formula:

$$\Delta t = \frac{R_2 - R_1}{R_1} \cdot 234,5 \cdot t_1 - t_2 - t_1$$

where

$\Delta t$  is the temperature rise;

$R_1$  is the resistance at the beginning of the test;

$R_2$  is the resistance at the end of the test;

$t_1$  is the working ambient temperature at the beginning of the test, to be set at  $T_{\max}$ ;

$t_2$  is the working ambient temperature at the end of the test;

At the beginning of the test, the windings are to be at  $T_{\max}$ .

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 14 is derived by adding the temperature rise to  $T_{\max}$ .

- <sup>e</sup> 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 |

- <sup>f</sup> For **controls** submitted in or on equipment, only the temperatures of terminals for fixed conductors are verified, as such equipment are 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.

In the USA, the maximum temperature permitted is 75 °C. Higher temperatures are permitted if the **control** is marked with the required T rating for the **external conductors**.

- <sup>g</sup> 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 21.

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.

- <sup>h</sup> The temperature measured shall not exceed 85 °C unless a higher value has been declared by the manufacturer.

- <sup>i</sup> 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.

- <sup>j</sup> 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.

- <sup>k</sup> 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.

- <sup>l</sup> 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.

- <sup>m</sup> The maximum permissible temperature shall not exceed those which have been shown to be acceptable in service for these materials.

- <sup>n</sup> 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.

## 15 Manufacturing deviation and drift

**15.1** 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**.

NOTE In Canada and the USA, **manufacturing deviation** and **drift** are expressed as separate tolerances to the declared **operating value**. For some **controls** with **type 2 action**, allowable values of **manufacturing deviation** and **drift** are specified. The consistency is then determined, using prescribed apparatus, by measurement of the **operating value** of the sample and comparison to the declared **operating value**.

**15.2** *Compliance is checked by the appropriate tests of this clause.*

**15.3** *For those **controls** which are completely or partially destroyed during their normal operation, the tests of the appropriate subclauses of Clause 17 are deemed to be sufficient.*

**15.4** *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,  $\pm 10$  K or  $\pm 5$  K,  $-10$  K).*

**15.5** *The consistency shall be determined as follows:*

**15.5.1** *Test apparatus used shall be such that the **control** is mounted in the manner declared by the manufacturer.*

**15.5.2** *For **sensing controls**, the apparatus shall preferably be such that the normal operation of the **control** is used to **control** the apparatus.*

**15.5.3** *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.*

**15.5.4** *The electrical conditions of the test shall normally be  $V_{R \max}$  and  $I_{R \max}$  unless different conditions have been declared in requirement 41 of Table 1.*

*However, the **operation** of the **control** shall be sensed by a suitable device with a sensing current not exceeding 0,05 A.*

**15.5.5** *For **sensing controls**, the rate of change of **activating quantity** shall be any suitable value unless specific values have been declared in requirement 37 of Table 1.*

**15.5.6** *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**.*

**15.5.7** *The recorded values are also used as reference values for each sample, so that the repeat tests after the environmental tests of Clause 16 and the endurance test of Clause 17 will enable **drift** to be determined.*

**15.6** *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:*



**15.6.1** 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** may be made.

**15.6.2** 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.

**15.6.3** Test apparatus shall be such as to simulate the most arduous conditions of **normal use** declared.

**15.6.4** If a **drift** value has been declared separately in requirement 42 of Table 1, the measured values for each sample shall be recorded as a reference value, so that the repeat tests after the environmental tests of Clause 16 and the endurance tests of Clause 17 will enable the **drift** to be determined.

**15.7** See Annex J.

**15.8** See Annex J.

## **16 Environmental stress**

### **16.1 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.

**16.1.1** Compliance is checked by the appropriate tests of 16.2, 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.

### **16.2 Environmental stress of temperature**

**16.2.1** The effect of temperature is tested as follows:

- The entire **control** shall be maintained at a temperature of  $(-10 \pm 2) ^\circ\text{C}$  for a period of 24 h.
- The entire **control** shall then be maintained at a temperature of  $(60 \pm 5) ^\circ\text{C}$  for a period of 4 h.

NOTE In Finland, Norway, and Sweden, different values of temperature and time may apply.

**16.2.2** The **control** is not energized during either test.

**16.2.3** 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**.

**16.2.4** In addition, for **controls** with **type 2 actions**, the appropriate test of Clause 15 shall be repeated after each of the above tests. The value measured in these tests shall not differ from the value recorded in Clause 15 for the same sample, by an amount greater than the **drift** declared in requirement 42 of Table 1.

## 17 Endurance

### 17.1 General requirements

**17.1.1 Controls**, including those submitted in or with an equipment, shall withstand the mechanical, electrical and thermal stresses that occur in **normal use**.

**17.1.2 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**.

**17.1.2.1** Compliance with 17.1.1 and 17.1.2 is checked by the tests of 17.1.3 as indicated in 17.16.

### 17.1.3 Test sequence and conditions

**17.1.3.1** In general, the sequence of tests is:

- an ageing test specified in 17.6 (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 17.7. (In the USA and Canada and all countries using an overload test, this test is replaced by an overload test);
- a test of **automatic action** at accelerated rate specified in 17.8;
- a test of **automatic action** at slow rate specified in 17.9 (this test applies only to **slow-make slow-break automatic actions**);
- an overvoltage test of **manual action** at accelerated speed specified in 17.10. (In the USA and Canada and all countries using an overload test, this test is replaced by an overload test);
- a test of **manual action** at slow speed specified in 17.11;
- a test of **manual action** at high speed specified in 17.12 (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 17.13.

**17.1.3.2** The electrical, thermal and mechanical conditions of test shall in general be those specified in 17.2, 17.3 and 17.4. The general test requirements are given in 17.6 to 17.14 inclusive. The particular test requirements are given in the appropriate part 2.

**17.1.3.3** 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 17.10 to 17.13 inclusive apply to such **manual actions**.

**17.1.3.4** After all the tests specified the samples shall meet the requirements of 17.14, unless otherwise specified in the appropriate part 2.

**17.1.4** See Annex H.

### 17.2 Electrical conditions for the tests

**17.2.1** 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.

**17.2.2** *In all countries which use an overvoltage test, the electrical loads to be used are those specified in Table 14 at rated voltage  $V_R$ , with this voltage then being increased to  $1,15 V_R$  for the overvoltage test of 17.7 and 17.10. Canada, and the USA do not use the overvoltage test.*

**17.2.3** *In Canada, the USA, and all countries which use an overload test, the conditions specified in Table 15 and Table 16 apply. The overload tests are performed on a single pole or throw at a time, with all other poles or throws at normal load.*

**17.2.3.1** *In Canada, the USA, and all countries using an overload test, test voltages ( $V_T$ ) are:*

- 120 V for **controls** rated at any voltage between 110 V to 120 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.

**17.2.3.2** *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.*

**17.2.4** *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.*

**17.2.5** *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.*

**Table 14 (17.2.1 of edition 3) – Electrical conditions for the overvoltage test**  
(this table applies in all countries except Canada, and the USA)

| Type of circuit<br>as classified in 6.2          | Operation              | AC circuit |                                                           |                                      | DC circuit |                                                           |                          |
|--------------------------------------------------|------------------------|------------|-----------------------------------------------------------|--------------------------------------|------------|-----------------------------------------------------------|--------------------------|
|                                                  |                        | V          | A                                                         | Power factor<br>(±0,05) <sup>a</sup> | V          | A                                                         | Time constant<br>(±1 ms) |
| Substantially<br>resistive<br>(classified 6.2.1) | Making and<br>breaking | $I'_R$     | $I_R$                                                     | 0,95                                 | $I'_R$     | $I_R$                                                     | Non-inductive            |
| Resistive<br>or inductive<br>(classified 6.2.2)  | Making <sup>b</sup>    | $I'_R$     | $6,0 I_X$<br>or $I_R$<br>if arithmetically<br>the greater | 0,6<br>0,95                          | $I'_R$     | $2,5 I_X$<br>or $I_R$<br>if arithmetically<br>the greater | 7,5                      |
|                                                  | Breaking               | $I'_R$     | $I_X$<br>or $I_R$<br>if arithmetically<br>the greater     | 0,95                                 |            | $I_X$<br>or $I_R$<br>if arithmetically<br>the greater     | Non-inductive            |
| Declared specific<br>load<br>(classified 6.2.3)  | Making and<br>breaking | $I'_R$     | As determined by load                                     |                                      | $I'_R$     | As determined by load                                     |                          |
| 20 mA load<br>(classified 6.2.4)                 | Making and<br>breaking | $I'_R$     | 20 mA                                                     | 0,95                                 | $I'_R$     | 20 mA                                                     | Non-inductive            |
| Declared motor<br>load<br>(classified 6.2.5)     | Making and<br>breaking | $I'_R$     | As declared                                               |                                      | $I'_R$     | As declared                                               |                          |
| Pilot duty load<br>(classified 6.2.6)            | Making <sup>b</sup>    | $I'_R$     | $10 VA / I'_R$<br>$VA / I'_R$                             | 0,35                                 |            | c                                                         |                          |
|                                                  | Breaking               | $I'_R$     |                                                           | 0,95                                 |            |                                                           |                          |

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> These values are not applicable.

**Table 15 (17.2.2 of edition 3) – Electrical conditions for the overload tests of 17.7 and 17.10**  
(this table applies in Canada, USA, and all countries which use an overload test)

| Type of circuit                               | Operation           | AC circuit |                                  | DC circuit |                            |
|-----------------------------------------------|---------------------|------------|----------------------------------|------------|----------------------------|
|                                               |                     | V          | A                                | V          | A                          |
| Substantially resistive<br>(classified 6.2.1) | Making and breaking | $I_T$      | $1,5 I_R$                        | $I_T$      | $1,5 I_R$                  |
| Inductive<br>(non-motor)                      | Making and breaking | $I_T$      | $1,5 I_X$                        | $I_T$      | $1,5 I_X$                  |
| Declared motor load<br>(classified 6.2.5)     | Making and breaking | $I_T$      | $6 I_m$<br>or as declared        | $I_T$      | $10 I_m$<br>or as declared |
| Pilot duty load<br>(classified 6.2.6)         | Making              | $1,1 I_T$  | $11 VA / I_T$                    |            |                            |
|                                               | Breaking            | $1,1 I_T$  | $1,1 VA / I_T$<br>or as declared |            | As declared                |

The following abbreviations are used:

$I_R$  is the rated voltage,  $I_T$  is the test voltage (see 17.2.3.1). A circuit in which the closed-circuit voltage is 100 % to 110 % of  $I_T$  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

- for Table 15:

a) 100 %  $I_T$  for a.c. and 0,5  $I_T$  for d.c. for 1,5 rated current

b) 100 %  $I_T$  for locked-rotor current (make only)

- for Table 16:

100 %  $I_T$  for a.c. and 0,5  $I_T$  for d.c.

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 17.7 for a locked-rotor test.

For a switch intended for d.c. **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.

**Table 16 (17.2.3 of edition 3) – Electrical conditions for the overload tests of 17.8, 17.9, 17.11, 17.12 and 17.13**  
(this table applies in Canada, USA, and all countries which use an overload test)

| Type of circuit                               | Operation           | AC circuit |                                   |                            | DC circuit |             |
|-----------------------------------------------|---------------------|------------|-----------------------------------|----------------------------|------------|-------------|
|                                               |                     | V          | A                                 | Power factor               | V          | A           |
| Substantially resistive<br>(classified 6.2.1) | Making and breaking | $I_T$      | $I_R$                             | 1                          | $I_T$      | $I_R$       |
| Inductive<br>(non-motor)                      | Making and breaking | $I_T$      | $I_X$                             | 0,75-0,8                   | $I_T$      | $I_X$       |
| Declared motor load<br>(classified 6.2.5)     | Making and breaking | $I_T$      | $I_m$<br>or as determined by load | 0,75-0,8<br>or as declared | $I_T$      | $I_m$       |
| Pilot duty load<br>(classified 6.2.6)         | Making              | 1,1 $I_T$  | 10 VA/ $I_T$                      | 0,35 maximum               |            |             |
|                                               | Breaking            | 1,1 $I_T$  | VA/ $I_T$ or as declared          | or as declared             |            | As declared |

The following abbreviations are used:

$I_R$  is the rated voltage,  $I_T$  is the test voltage (see 17.2.3.1).

$I_m$  is the rated current for motor load,  $I_X$  is the rated current for induction load.

NOTE 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.

### 17.3 Thermal conditions for the tests

**17.3.1** 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 4.1);
- the mounting surface of the control shall be maintained between  $T_{s\ max}$ , and either  $(T_{s\ max} + 5) ^\circ\text{C}$ , or 1,05 times  $T_{s\ max}$ , whichever is greater;
- the remainder of the **switch head** shall be maintained between  $T_{\max}$  and either  $(T_{\max} + 5) ^\circ\text{C}$  or 1,05 times  $T_{\max}$ , whichever is greater. If  $T_{\min}$  is less than  $0 ^\circ\text{C}$ , additional tests shall be carried out with the **switch head** maintained between  $T_{\min}$  and  $(T_{\min} - 5) ^\circ\text{C}$ .

**17.3.2** During the tests of 17.8 and 17.13, the temperatures of 17.3.1 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  $T_{\min}$ ).

### 17.4 Manual and mechanical conditions for the tests

**17.4.1** 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**.

**17.4.2** The speed of movement of the **actuating member** shall be:

- for slow speed:
  - $(9 \pm 1) ^\circ$  per s for rotary actions;
  - $(5 \pm 0,5)$  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 testing authority for the purpose of this test;
- for accelerated speed:
  - $(45 \pm 5) ^\circ$  per s for rotary actions;
  - $(25 \pm 2,5)$  mm/s for linear actions.

**17.4.3** During the slow speed test of 17.4.2:

care is taken that the test apparatus drives the **actuating member** positively, without significant backlash between the apparatus and the **actuating member**.

**17.4.4** During the accelerated speed test of 17.4.2:

- care is taken to determine that the test apparatus allows the **actuating member** to operate freely, so that it does not interfere with the normal action of the mechanism;
- 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.

**17.4.5** Additional lubrication shall not be applied during these tests.

## **17.5 Dielectric strength requirements**

**17.5.1** After all the tests of this clause, the requirements of 13.2 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 13.2.

NOTE In Canada and the USA, the test voltage shall be that given in 13.2.

## **17.6 Ageing test**

**17.6.1** During this test, the **sensing element** shall be maintained at that value of the **activating quantity** determined and used in Clause 14. Other parts shall be maintained as specified in 17.3. **Controls** are electrically loaded as specified in 17.2 for the appropriate breaking condition. The duration of the test is  $(100 + 0,02 y)$  h where "y" is the value declared in 7.2. The test applies to **controls** with actions classified as type 1.M or 2.M.

**17.6.2** 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 may be repeated as many times as is necessary to complete the test, or until, when repeating the appropriate procedure of Clause 15, the **drift** limits declared in 7.2 are exceeded. The value of "x" is given in the appropriate part 2.

## **17.7 Overvoltage test (or overload test in Canada, the USA, and all countries using an overload test) of automatic action at accelerated rate**

**17.7.1** The electrical conditions shall be those specified for overvoltage (or overload conditions) in 17.2.

**17.7.2** The thermal conditions shall be those specified in 17.3.

**17.7.3** 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 testing authority 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, or so that the rates of change of **activating quantity** do not exceed  $\alpha_2$  and  $\beta_2$  declared in the same subclause.

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.

- *Type 2 **controls** are tested at the most unfavourable **operating value** declared in Table 1, requirement 48.*

NOTE 2 For temperature and pressure operated **controls**, this is normally the maximum value.

**17.7.4** *For type 2 sensing actions, overshoot at each **operation** shall be between the values declared in 7.2.*

**17.7.5** *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.*

**17.7.6** *The number of automatic cycles for the test is either one tenth of the number declared in 7.2, or 200, whichever is the smaller.*

**17.7.7** *During the test, **actuating members** are placed in their most unfavourable position.*

NOTE In Canada and the USA where the overload test applies, the number of cycles is 50.

## **17.8 Test of automatic action at accelerated rate**

**17.8.1** *The electrical conditions shall be those specified in 17.2.*

**17.8.2** *The thermal conditions shall be those specified in 17.3.*

**17.8.3** *The method and rate of **operation** shall be as used during the test of 17.7.3.*

**17.8.4** *The number of automatic cycles (except as shown below for **slow-make slow-break automatic actions**) shall be that declared in 7.2 less the number of cycles actually made during the test of 17.7. 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 referred to in 7.2 can be completed.*

**17.8.4.1** *For **slow-make slow-break automatic actions**, only 75 % of the number of automatic cycles referred to in 17.8.4 shall be carried out during this test. The remaining 25 % are carried out as specified in 17.9.*

NOTE In Canada and the USA, the number of cycles is specified for **type 2 actions** and some **type 1 actions**.

## **17.9 Test of automatic action at slow rate**

**17.9.1** ***Slow-make slow-break automatic actions** shall be tested for the 25 % remainder of the number of automatic cycles specified in 17.8.*

**17.9.2** *The electrical and thermal conditions shall be as specified in 17.2 and 17.3.*

**17.9.3** *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  $\alpha_1$  and  $\beta_1$  as declared in 7.2. 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 7.2. During this test for a **type 2 action**, continuous monitoring is essential to provide a record of **operating value**, overshoots or **operating sequences**.

**17.9.3.1** Such monitoring is also recommended for other **controls** to determine consistency of testing.

**17.9.4** If only the make or the break is a slow **automatic action**, then it may, by agreement between the testing authority and the manufacturer, be possible to accelerate the rest of the action, to which the details of 17.8 apply.

**17.10 Overvoltage test (or overload test in Canada USA and all countries that use the overload test) of manual action at accelerated speed**

**17.10.1** The electrical conditions shall be those specified for overvoltage (or overload) in 17.2.

**17.10.2** The thermal conditions shall be those specified in 17.3.

**17.10.3** The method of **operation** shall be that specified in 17.4 for accelerated speed. The number of cycles of **actuation** shall be either one tenth of the number declared in 7.2 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**.

**17.10.4** In Canada and the USA where the overload test applies, the number of cycles is 50.

**17.11 Test of manual action at slow speed**

**17.11.1** The electrical conditions shall be those specified in 17.2.

**17.11.2** The thermal conditions shall be those specified in 17.3.

**17.11.3** The method of **operation** shall be that specified in 17.4 for slow speed.

**17.11.4** The number of cycles of **actuactions** shall be either one tenth of the number declared in 7.2 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**.

**17.12 Test of manual action at high speed**

NOTE This test applies only to actions which have more than one pole, and where polarity reversal occurs during the action.

**17.12.1** The electrical conditions are those specified in 17.2.

**17.12.2** The thermal conditions are those specified in 17.3.

**17.12.3** The method of **operation** is that specified in 17.4 for high speed.

**17.12.4** 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**.

**17.12.5** In Canada and the USA where the overload test applies, the number of cycles is 50.

### 17.13 Test of manual action at accelerated speed

**17.13.1** The electrical conditions are those specified in 17.2.

**17.13.2** The thermal conditions are those specified in 17.3.

**17.13.3** The method of **operation** is that specified in 17.4 for accelerated speed.

**17.13.4** The number of cycles of **actuation** is that number declared in 7.2 less the number actually made during the tests of 17.10, 17.11 and 17.12. 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**.

**17.13.5** During the test, the **failure** of any component part of a **type 1 action** other than a **protective control** 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.

### 17.14 Evaluation of compliance

After all the appropriate tests of 17.6 to 17.13 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 standard;
- the requirements of Clause 14 with regard to those items designated by Footnote a of Table 13, that is, terminals, current-carrying parts and supporting surfaces, are still met;
- the requirements of Clause 8, 17.5 and Clause 20 are still met. For the tests of 17.5 and Clause 20, **controls** for which special samples were submitted for Clause 13, are tested at an appropriate condition to ensure that the contacts are open;
- for **type 2 actions**, the appropriate test of Clause 15 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 that any transient **fault** between **live parts** and earthed metal, accessible metal parts or **actuating members** has occurred.

See also Annex H.

### 17.15 Void

### 17.16 Test for particular purpose controls

The tests for particular purpose **controls** are specified in the appropriate Part 2s.

**17.17 to 17.18** See Annex J.

## 18 Mechanical strength

### 18.1 General requirements

**18.1.1 Controls** shall be so constructed as to withstand the mechanical stress that occurs in normal use.

**18.1.2 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.

**18.1.3 Integrated controls and incorporated controls** are not tested as in 18.2 as their impact resistance will be tested by the equipment standard.

**18.1.4 Compliance is checked by the tests of the appropriate Subclauses 18.2 to 18.8 inclusive, carried out sequentially on one sample.**

**18.1.5 After the appropriate tests, the control shall show no damage to impair compliance with this standard and in particular with Clauses 8, 13, and 20. 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 13.*

*Damage to the finish, small dents which do not reduce creepage distances or clearances below the values specified in Clause 20, 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.*

**18.1.6** In Canada and the USA, if threads for the connection of metal conduit are tapped all the way through a hole in an enclosure wall or if an equivalent construction is employed, there shall not be any sharp edges, not less than three nor more than five full threads in the metal and the construction of the device shall be such that a suitable conduit bushing can be properly attached.

**18.1.6.1** In Canada and the USA, if threads for the connection of metal conduit are not tapped all the way through a hole in an enclosure wall, conduit hub or the like, there shall not be less than 3,5 full threads in the metal with a conduit stop, and a smooth well-rounded inlet hole having an internal diameter approximately the same as that of the corresponding size of rigid metal conduit, which shall afford protection to the conductors equivalent to that provided by a standard conduit bushing.

**18.1.6.2** In the USA, an enclosure threaded for support by rigid metal conduit shall provide at least five full threads for engaging the conduit.

*Compliance with 18.1.6, 18.1.6.1 and 18.1.6.2 is checked by inspection.*

**18.1.6.3** In Canada and the USA, a conduit hub or nipple attached to the enclosure by swaging, staking or similar means shall withstand without pulling apart the following tests:

- a direct pull of 890 N for 5 min. For this test, the device is to be supported by a rigid conduit in the intended manner and is to support a suspended weight of 90,8 kg;
- the device is to be rigidly supported by means other than the conduit fittings. A bending force of 67,8 Nm is to be applied for 5 min to the conduit at right angles to its axis and the lever arm is measured from the wall of the enclosure in which the hub is located to the point of application of the bending force;
- a torque of 67,8 Nm is to be applied to the conduit for 5 min in a direction tending to tighten the connection and the lever arm is to be measured from the centre of the conduit.

Some distortion of the enclosure under test may result. Such distortion does not constitute a **failure**.

## 18.2 Impact resistance

**18.2.1** *In-line cord, free-standing and independently mounted controls, except as provided in 18.4, are checked by applying blows to the sample by means of the apparatus in IEC 60068-2-75.*

**18.2.2** *All surfaces which are accessible when the **control** is mounted as in **normal use** are tested with the apparatus.*

**18.2.3** *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.*

**18.2.4** *Blows are applied to all **accessible surfaces**, including **actuating members**, at any angle, the test apparatus being calibrated to deliver an energy of  $(0,5 \pm 0,04)$  Nm.*

**18.2.4.1** *Foot actuated **controls** shall be subject to the same test, but using a test apparatus calibrated to deliver an energy of  $(1,0 \pm 0,05)$  Nm.*

**18.2.5** *For all such surfaces, three blows are applied to every point that is likely to be weak.*

**18.2.5.1** *Care must be taken that the results from one series of three blows does not influence subsequent series.*

**18.2.5.2** *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.*

**18.2.6** *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 cm<sup>2</sup>, unless they form part of an **actuating member**, in which case they shall be tested in the same manner as an **actuating member**.*

## 18.3 Void

## 18.4 Alternate compliance – Impact resistance

NOTE In Canada and the USA, the minimum thicknesses of sheet metal or case metal shown in Tables 17 and 18 are considered to meet the requirements of 18.2 and the tests specified are not required.



**Table 17 (18.4.1 of edition 3) – Minimum thickness of sheet metal for enclosures made of carbon steel or stainless steel**

| Without supporting frame <sup>a</sup>        |                                               | With supporting frame or equivalent reinforcing <sup>a</sup> |                                               | Minimum thickness in inches (mm) |                           |
|----------------------------------------------|-----------------------------------------------|--------------------------------------------------------------|-----------------------------------------------|----------------------------------|---------------------------|
| Maximum width <sup>b</sup><br>in inches (cm) | Maximum length <sup>c</sup><br>in inches (cm) | Maximum width <sup>b</sup><br>in inches (cm)                 | Maximum length <sup>c</sup><br>in inches (cm) | Uncoated                         | Metal coated              |
| 4,0 (10,2)                                   | Not limited                                   | 6,25 (15,9)                                                  | Not limited                                   | 0,020 <sup>d</sup> (0,51)        | 0,023 <sup>d</sup> (0,58) |
| 4,75 (12,1)                                  | 5,75 (14,6)                                   | 6,75 (17,1)                                                  | 8,25 (21,0)                                   |                                  |                           |
| 6,0 (15,2)                                   | Not limited                                   | 9,5 (24,1)                                                   | Not limited                                   | 0,026 <sup>d</sup> (0,66)        | 0,029 <sup>d</sup> (0,74) |
| 7,0 (17,8)                                   | 8,75 (22,2)                                   | 10,0 (25,4)                                                  | 12,5 (31,8)                                   |                                  |                           |
| 8,0 (20,3)                                   | Not limited                                   | 12,0 (30,5)                                                  | Not limited                                   | 0,032 (0,81)                     | 0,034 (0,86)              |
| 9,0 (22,9)                                   | 11,5 (29,2)                                   | 13,0 (33,0)                                                  | 16,0 (40,6)                                   |                                  |                           |
| 12,5 (31,8)                                  | Not limited                                   | 19,5 (49,5)                                                  | Not limited                                   | 0,042 (1,07)                     | 0,045 (1,14)              |
| 14,0 (35,6)                                  | 18,0 (45,7)                                   | 21,0 (53,3)                                                  | 25,0 (63,5)                                   |                                  |                           |
| 18,0 (45,7)                                  | Not limited                                   | 27,0 (68,6)                                                  | Not limited                                   | 0,053 (1,35)                     | 0,056 (1,42)              |
| 20,0 (50,8)                                  | 25,0 (63,5)                                   | 29,0 (73,7)                                                  | 36,0 (91,4)                                   |                                  |                           |
| 22,0 (55,9)                                  | Not limited                                   | 33,0 (83,8)                                                  | Not limited                                   | 0,060 (1,52)                     | 0,063 (1,60)              |
| 25,0 (63,5)                                  | 31,0 (78,7)                                   | 35,0 (88,9)                                                  | 43,0 (109,2)                                  |                                  |                           |
| 25,0 (63,5)                                  | Not limited                                   | 39,0 (99,1)                                                  | Not limited                                   | 0,067 (1,70)                     | 0,070 (1,78)              |
| 29,0 (73,7)                                  | 36,0 (91,4)                                   | 41,0 (104,1)                                                 | 51,0 (129,5)                                  |                                  |                           |
| 33,0 (83,8)                                  | Not limited                                   | 51,0 (129,5)                                                 | Not limited                                   | 0,080 (2,03)                     | 0,084 (2,13)              |
| 38,0 (96,5)                                  | 47,0 (119,4)                                  | 54,0 (137,2)                                                 | 66,0 (167,6)                                  |                                  |                           |
| 42,0 (106,7)                                 | Not limited                                   | 64,0 (162,6)                                                 | Not limited                                   | 0,093 (2,36)                     | 0,097 (2,46)              |
| 47,0 (119,4)                                 | 59,0 (149,9)                                  | 68,0 (172,7)                                                 | 84,0 (213,4)                                  |                                  |                           |
| 52,0 (132,1)                                 | Not limited                                   | 80,0 (203,2)                                                 | Not limited                                   | 0,108 (2,74)                     | 0,111 (2,82)              |
| 60,0 (152,4)                                 | 74,0 (188,0)                                  | 84,0 (213,4)                                                 | 103,0 (261,6)                                 |                                  |                           |
| 63,0 (160,0)                                 | Not limited                                   | 97,0 (246,4)                                                 | Not limited                                   | 0,123 (3,12)                     | 0,126 (3,20)              |
| 73,0 (185,4)                                 | 90,0 (228,6)                                  | 103,0 (261,6)                                                | 127,0 (322,6)                                 |                                  |                           |

<sup>a</sup> With reference to Tables 17 and 18, a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface, and that has sufficient torsional rigidity to resist the bending moments that may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes: a) single sheet with single formed flanges or formed edges, b) a single sheet that is corrugated or ribbed, c) an enclosure surface loosely attached to a frame, for example, with spring clips.

<sup>b</sup> The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

<sup>c</sup> "Not limited" applies only if the edge of the surface is flanged at least 0,5 in (12,7 mm) or fastened to adjacent surfaces not normally removed in use.

<sup>d</sup> Sheet metal for an enclosure intended for outdoor use shall be not less than 0,034 in (0,86 mm) thick if zinc coated and not less than 0,032 in (0,81 mm) thick if uncoated.



**Table 18 (18.4.2 of edition 3) – Minimum thickness of sheet metal for enclosures of aluminium, copper or brass**

| Without supporting frame <sup>a</sup>        |                                               | With supporting frame or equivalent reinforcing <sup>a</sup> |                                               |                                     |
|----------------------------------------------|-----------------------------------------------|--------------------------------------------------------------|-----------------------------------------------|-------------------------------------|
| Maximum width <sup>b</sup><br>in inches (cm) | Maximum length <sup>c</sup><br>in inches (cm) | Maximum width <sup>b</sup><br>in inches (cm)                 | Maximum length <sup>c</sup><br>in inches (cm) | Maximum thickness<br>in inches (mm) |
| 3,0 (7,6)                                    | Not limited                                   | 7,0 (17,8)                                                   | Not limited                                   | 0,023 <sup>d</sup> (0,58)           |
| 3,5 (8,9)                                    | 4,0 (10,2)                                    | 8,5 (21,6)                                                   | 9,5 (24,1)                                    |                                     |
| 4,0 (10,2)                                   | Not limited                                   | 10,0 (25,4)                                                  | Not limited                                   | 0,029 (0,74)                        |
| 5,0 (12,7)                                   | 6,0 (15,2)                                    | 10,5 (26,7)                                                  | 13,5 (34,3)                                   |                                     |
| 6,0 (15,2)                                   | Not limited                                   | 14,0 (35,6)                                                  | Not limited                                   | 0,036 (0,91)                        |
| 6,5 (16,5)                                   | 8,0 (20,3)                                    | 15,0 (38,1)                                                  | 18,0 (45,7)                                   |                                     |
| 8,0 (20,3)                                   | Not limited                                   | 19,0 (48,3)                                                  | Not limited                                   | 0,045 (1,14)                        |
| 9,5 (24,1)                                   | 11,5 (29,2)                                   | 21,0 (53,3)                                                  | 25,0 (63,5)                                   |                                     |
| 12,0 (30,5)                                  | Not limited                                   | 28,0 (71,1)                                                  | Not limited                                   | 0,058 (1,47)                        |
| 14,0 (35,6)                                  | 16,0 (40,6)                                   | 30,0 (76,2)                                                  | 37,0 (94,0)                                   |                                     |
| 18,0 (45,7)                                  | Not limited                                   | 42,0 (106,7)                                                 | Not limited                                   | 0,075 (1,91)                        |
| 20,0 (50,8)                                  | 25,0 (63,4)                                   | 45,0 (114,3)                                                 | 55,0 (139,7)                                  |                                     |
| 25,0 (63,5)                                  | Not limited                                   | 60,0 (152,4)                                                 | Not limited                                   | 0,095 (2,41)                        |
| 29,0 (73,7)                                  | 36,0 (91,4)                                   | 64,0 (162,6)                                                 | 70,0 (178,1)                                  |                                     |
| 37,0 (94,0)                                  | Not limited                                   | 87,0 (221,0)                                                 | Not limited                                   | 0,122 (3,10)                        |
| 42,0 (106,7)                                 | 53,0 (134,6)                                  | 93,0 (236,2)                                                 | 114,0 (289,6)                                 |                                     |
| 52,0 (132,1)                                 | Not limited                                   | 123,0 (312,4)                                                | Not limited                                   | 0,153 (3,89)                        |
| 60,0 (152,4)                                 | 74,0 (188,0)                                  | 130,0 (330,2)                                                | 160,0 (406,4)                                 |                                     |

<sup>a</sup> With reference to Tables 17 and 18, a supporting frame is a structure of angle or channel or a folded rigid section of sheet metal that is rigidly attached to and has essentially the same outside dimensions as the enclosure surface, and that has sufficient torsional rigidity to resist the bending moments that may be applied via the enclosure surface when it is deflected. Construction that is considered to have equivalent reinforcing may be accomplished by designs that will produce a structure that is as rigid as one built with a frame of angles or channels. Construction considered to be without supporting frame includes: a) single sheet with single formed flanges or formed edges, b) a single sheet that is corrugated or ribbed, c) an enclosure surface loosely attached to a frame, for example, with spring clips.

<sup>b</sup> The width is the smaller dimension of a rectangular piece of sheet metal that is part of an enclosure. Adjacent surfaces of an enclosure may have supports in common and be made of a single sheet.

<sup>c</sup> "Not limited" applies only if the edge of the surface is flanged at least 0,5 in (12,7 mm) or fastened to adjacent surfaces not normally removed in use.

<sup>d</sup> Sheet copper, brass, or aluminium for an enclosure intended for outdoor use (raintight or rainproof) shall be not less than 0,029 in (0,74 mm) thick.

**18.4.1** Cast metal shall be not less than 3 mm thick but not more than 6 mm thick at threaded holes for conduit; except that, other than at plain or threaded holes for conduit, die-cast metal may be not less than 1,6 mm thick for an area not greater than 150 cm<sup>2</sup>, and having no dimension greater than 150 mm, and may be not less than 2,4 mm thick for larger areas.

## 18.5 Free-standing controls

**18.5.1** *Free-standing controls shall be additionally checked by the test of 18.5.2 and 18.5.3 using the apparatus shown in Figure 4.*

**18.5.2** *Two metres of flexible cord of the lightest type used in 10.1.4 shall be connected to the input terminals and secured as intended. Controls intended for use with a flexible cored connected to the output terminals shall have 2 m of the lightest intended type similarly connected and arranged as shown in Figure 4.*

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 9. 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.

**18.5.3** After the test, the sample shall be evaluated as in 18.1.5.

## **18.6 In-line cord controls**

**18.6.1 In-line cord controls** other than **free-standing controls** shall be additionally tested in a tumbling barrel as shown in Figure 5. 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 18.6.2.

**18.6.2 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 10.1.4 and a free length of approximately 50 mm. Terminal screws are tightened with two-thirds of the torque specified in 19.1. **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**.

**18.6.3** 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.

**18.6.4 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 18.5.

**18.6.5** The barrel is turned at a rate of five revolutions per min, 10 falls per min thus taking place.

**18.6.6** After this test, the **control** shall be evaluated as in 18.1.5. Special attention is paid to the connection of flexible cord or cords.

## **18.7 Pull-cord actuated controls**

**18.7.1 Pull-cord actuated controls** shall be additionally tested as in 18.7.2 and 18.7.3.

**18.7.2** 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.

**18.7.3** The values of the force are shown in Table 19.

**Table 19 (18.7 of edition 3) – Pull-cord force test values**

| Rated current<br>A    | Force<br>N          |                                |
|-----------------------|---------------------|--------------------------------|
|                       | Normal<br>direction | Most unfavourable<br>direction |
| Up to and including 4 | 50                  | 25                             |
| Over 4                | 100                 | 50                             |

**18.7.4** After this test, the **control** shall be evaluated as in 18.1.5.

## **18.8 Foot actuated controls**

**18.8.1** **Controls** actuated by foot shall be additionally tested as follows:

**18.8.2** 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.

**18.8.3** 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.

**18.8.4** After the test, the **control** shall be evaluated as in 18.1.5.

## **18.9 Actuating member and actuating means**

**18.9.1** **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**.

**18.9.2** 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.

**18.9.3** 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 standard.

## 19 Threaded parts and connections

### 19.1 Threaded parts moved during mounting or servicing

**19.1.1** 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.

**19.1.2** 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.

**19.1.3** Such threaded parts shall have a metric ISO thread or a thread of equivalent effectiveness.

NOTE Provisionally SI, BA and Unified threads are deemed to be of equivalent effectiveness to a metric ISO thread. A test for equivalent effectiveness is under consideration. Pending agreement to a test, all torque values for threads other than ISO, BA, SI or Unified are increased by 20 %.

**19.1.4** 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 may be of the thread forming (swaging) type. There is no requirement for the type of thread so produced.

**19.1.5** Such screws may 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.

**19.1.6** Such threaded parts shall not be of non-metallic material if their replacement by a dimensionally similar metal screw could impair compliance with Clause 13 or 20.

**19.1.7** 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**.

**19.1.8** 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.

**19.1.9** Such threaded parts, when used for **in-line cord controls**, if they are transmitting contact pressure and if they have 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.

**19.1.10** *Compliance with 19.1.1 to 19.1.9 inclusive is checked by inspection and by the test of 19.1.11 to 19.1.15, inclusive.*

**19.1.11 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.

**19.1.12 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 10.1.4 or of the minimum cross-sectional area specified in 10.2.1 is placed in the terminal.**

**19.1.13 The shape of the screwdriver should suit the head of the screw to be tested.**

**19.1.14 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.**

**19.1.15 The test is made by means of a suitable test screwdriver, spanner or key, applying a torque, without jerks, as shown in Table 20.**

**Table 20 (19.1 of edition 3) – Threaded parts torque test values**

| Nominal diameter of thread<br>mm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Torque<br>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 <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 0,8          | 2,0 | 1,0  |
| Over 5,3 <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | –            | 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: <ul style="list-style-type: none"> <li>• with a cylindrical head and a socket for a <b>special purpose tool</b>, the socket having a cross-corner dimension exceeding the overall thread diameter;</li> <li>• with a head having a slot or slots, the length of which exceeds 1,5 times the overall thread diameter.</li> </ul> – 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.                                                                                                                                                                                                                                                                                                                                                                                                                                                               |              |     |      |
| <sup>a</sup> 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 <b>controls</b> for single-bush mounting using thermoplastic materials and where there is no torque effected on the mounting for <b>setting</b> or resetting (i.e. for <b>thermal cut-outs</b> ), 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.              |              |     |      |

## 19.2 Current-carrying connections

**19.2.1** Current-carrying connections 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**.

**19.2.2** 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 13 or 20.

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 standard.

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**.

**19.2.3** 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**.

**19.2.4** 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.

**19.2.4.1** Space threaded screws may be used to provide earthing continuity if at least two such screws are used for each connection.

NOTE In Canada and the USA, to provide earthing continuity (bonding), the use of one screw is permitted if at least two full threads are engaged. If two screws are used, each screw shall engage at least one full thread.

**19.2.5** Such current-carrying connections may make use of thread cutting screws if these produce a full-form standard machine screw thread.

**19.2.5.1** Thread cutting screws may be used to provide earthing continuity if at least two such screws are used for each connection.

NOTE In Canada and the USA, to provide earthing continuity (bonding), the use of one screw is permitted if at least two full threads are engaged. If two screws are used, each screw shall engage at least one full thread.

**19.2.6** 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 may 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 may be achieved by plating or a similar process.

**19.2.7** Compliance with 19.2.1 to 19.2.6 inclusive is checked by inspection. In addition, compliance with 19.2.3 and 19.2.6 is checked by an inspection of the metallic resilient parts after the tests of Clause 17 have been completed.

## 20 Creepage distances, clearances and distances through solid insulation

**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 coating as specified in IEC 60664-3 shall comply with the minimum requirements of 20.3 for solid insulation. The spacing between the conductors before the protection is applied shall not be less than the values as specified in Table 1 of IEC 60664-3:2003. See also Annex Q.

**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 20 are absolute minimum values that must be maintained for all manufacturing conditions and through the lifetime of the equipment.

*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 A **creepage distance** cannot be less than the associated **clearance**. The shortest **creepage distance** possible is equal to the required **clearance**.

NOTE 3 See Annex S for guidance.

### 20.1 Clearances

**Clearances** shall not be less than the values shown in Table 22 for case A, taking into account the **pollution degree** and the **rated impulse voltage** required to serve the overvoltage categories of Table 21, except that, for **basic insulation** and **functional insulation**, smaller distances may be used if the **control** meets the impulse withstand test of 20.1.12 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 for case B.

*Compliance is checked by inspection, by measurement and, if necessary, by the test of 20.1.12.*

NOTE 1 **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 L provides guidance.

NOTE 2 **Controls** which are constructed in accordance with the minimum dimensions of Table 22, for case A, need not be subjected to the impulse test of 20.1.12. For further information on case A and case B, see 5.1.3.2 and 5.1.3.3 of IEC 60664-1:2007.

**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 2. Apertures are assumed to be covered by a piece of flat metal.

NOTE **Clearances** are measured as specified in Annex B.

**Table 21 (20.1 of edition 3) – Rated impulse voltage for equipment energized directly from the supply mains (from IEC 60664-1:2007, Table F.1)**

| Nominal voltage of the supply<br>based on IEC 60038 <sup>a b</sup><br>V |                                      | Voltage line-to-neutral derived<br>from nominal<br>voltages a.c. or<br>d.c. up to and<br>including<br>V | Rated impulse voltage required<br>according to overvoltage category <sup>c</sup><br>V |       |       |       |
|-------------------------------------------------------------------------|--------------------------------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-------|-------|-------|
| Three-phase<br>four-wire<br>systems <sup>a</sup>                        | Single-phase <sup>d</sup><br>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<br>277/480                                                      |                                      | 300                                                                                                     | 1 500                                                                                 | 2 500 | 4 000 | 6 000 |
| 400/690                                                                 |                                      | 600                                                                                                     | 2 500                                                                                 | 4 000 | 6 000 | 8 000 |

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> See Annex L for an explanation of **overvoltage categories** and Annex M for application guidance. **Overtvoltage category** may be specified in a part 2 or in the final equipment standard.

<sup>d</sup> See Annex K 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).

**Table 22 (20.2 of edition 3) – Clearances for insulation co-ordination  
(from IEC 60664-1:2007, Table F.2)**

| Rated impulse voltage from Table 21 <sup>a</sup><br>kV | Clearances in air up to 2 000 m above sea-level <sup>b</sup><br>mm |      |     |     |                                                 |     |     |     |
|--------------------------------------------------------|--------------------------------------------------------------------|------|-----|-----|-------------------------------------------------|-----|-----|-----|
|                                                        | Case A                                                             |      |     |     | Case B<br>(impulse test required – see 20.1.12) |     |     |     |
|                                                        | Pollution degree <sup>c</sup>                                      |      |     |     | Pollution degree <sup>c</sup>                   |     |     |     |
|                                                        | 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.

<sup>a</sup> For **functional insulation**, the **rated impulse voltage** is derived from the value in column 3 of Table 21 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**.

<sup>b</sup> 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.

<sup>c</sup> An explanation of **pollution degree** is given in Annex N.

**20.1.1** 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 22, case A apply except as permitted by 20.1.7.

*Compliance is checked by measurement.*

**20.1.1.1** 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.

**20.1.2** For **functional insulation**, Table 22, case A applies

– except as permitted by 20.1.7;

or

– except that **clearances** for **electronic controls** are not specified if the requirements of H.27.1.1.3 are met with the **clearances** short-circuited.

**20.1.3** *Compliance with 20.1 is checked by measurement using the methods of measurement as given in Annex B and Figure 17.*

**20.1.3.1** 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.

**20.1.3.2** 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 10.1.4 fitted, and once without conductors fitted.

**20.1.3.3** 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 10.2.1 fitted, and once without conductors fitted.

**20.1.4** 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 standard test finger shown in Figure 2, but is not pressed into openings.

**20.1.5** The standard test finger is applied to apertures as specified in 8.1, the distance through insulation between **live parts** and the metal foil shall then not be reduced below the values specified.

**20.1.6** 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.

**20.1.6.1** The force is applied by means of the standard test finger 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.

**20.1.7** For **basic insulation** and **functional insulation**, smaller distances may be permitted if the **control** meets the impulse withstand test of 20.1.12 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 20.1.12.

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.

**20.1.7.1** For **micro-disconnection** and interruption, there is no specified minimum distance for the **clearance** between the contacts. For other parts separated by the action of the contacts, **clearances** may be smaller than those of Table 22, but shall not be less than the distance between the contacts.

**20.1.7.2** For **full disconnection**, the values specified in Table 22, case A apply to parts separated by the switching element including the contacts, when the contacts are in the fully open position.

**20.1.8** **Clearances of supplementary insulation** shall be not less than those specified for **basic insulation** in Table 22, case A.

Compliance is checked by measurement.

**20.1.9 Clearances of reinforced insulation** shall be not less than those in Table 22, 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**.

*Compliance is checked by measurement.*

**20.1.10** 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 21.

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 21 based on the primary voltage for step-down transformers, and based on the maximum measured r.m.s. value of the secondary voltage for step-up transformers.

Part 2s may 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 impulse withstand voltages.

NOTE 2 See also references in Clause 24.

*Compliance is checked by measurement or test if necessary.*

**20.1.11** For circuits having **ELV** levels which are derived from the supply by means of **protective impedance**, **clearances of functional insulation** are determined from Table 21 based on the maximum measured value of the **working voltage** in the **ELV** circuit.

**20.1.12** The impulse voltage test, when required, is applied in accordance with 6.1.2.2.1 of IEC 60664-1:2007.

Part 2s may 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.

**20.1.13** 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 22 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 rated voltage for Table 21.

**20.1.14** See Annex J.

**20.1.15** See Annex H.

## **20.2 Creepage distances**

**20.2.1 Controls** shall be constructed so that **creepage distances** for **basic insulation** are not less than those specified in Table 23 for the rated voltage, taking into account the material group and the **pollution degree**.

**Creepage distances** are not specified for **electronic controls** if the requirements of H.27.1.1.3 are met with the **creepage distance** short-circuited.

*Compliance is checked by inspection and measurement.*

**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 2. Apertures are assumed to be covered by a piece of flat metal.

NOTE **Creepage distances** are measured as specified in Annex B.

**20.2.2 Controls** shall be constructed so that **creepage distances** for **functional insulation** are not less than those specified in Table 24 for **working voltage**, taking into account the material group and the **pollution degree**.

Part 2s may specify alternative criteria for some situations, for example, high voltage ignition sources.

*Compliance is checked by inspection and measurement.*

**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 2. Apertures are assumed to be covered by a piece of flat metal.

NOTE 1 **Creepage distances** are measured as specified in Annex B.

NOTE 2 The relationship between material group and proof tracking index (PTI) values is found in 6.13.

The PTI values refer to values obtained in accordance with IEC 60112, and tested with solution A.

Materials, the PTI values of which have previously been found to comply with these material groups, are acceptable without further testing.

NOTE 3 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.

**Table 23 (20.3 of edition 3) – Minimum creepage distances for basic insulation**

| Rated voltage up to and including<br><br>V | Creepage distances <sup>a</sup><br>mm                    |      |                |                |     |                |                  |      |                |                  |      |      |
|--------------------------------------------|----------------------------------------------------------|------|----------------|----------------|-----|----------------|------------------|------|----------------|------------------|------|------|
|                                            | Pollution degree                                         |      |                |                |     |                |                  |      |                |                  |      |      |
|                                            | Printed wiring material <sup>b</sup><br>Pollution degree | 1    | 2              |                |     | 3              |                  |      | 4              |                  |      |      |
|                                            |                                                          |      | Material group |                |     | Material group |                  |      | Material group |                  |      |      |
|                                            |                                                          |      | 1 <sup>c</sup> | 2 <sup>d</sup> | I   | II             | III <sup>e</sup> | I    | II             | III <sup>e</sup> | I    | II   |
| 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 |

<sup>a</sup> 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 22.

<sup>b</sup> When printed circuit boards are coated in accordance with Annex P or Clause Q.1 and the coating has a PTI of at least 175, the values specified for **pollution degree** 1 are permitted. The PTI shall be measured in accordance with IEC 60112.

<sup>c</sup> Material groups I, II, IIIa and IIIb.

<sup>d</sup> Material groups I, II and IIIa.

<sup>e</sup> 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.

**Table 24 (20.4 of edition 3) – Minimum creepage distances for functional insulation**

| Working voltage<br>r.m.s. <sup>a</sup><br><br>V | Creepage distances <sup>b c</sup><br>mm                  |       |       |                |      |      |                |                  |      |                |                  |      |
|-------------------------------------------------|----------------------------------------------------------|-------|-------|----------------|------|------|----------------|------------------|------|----------------|------------------|------|
|                                                 | Pollution degree                                         |       |       |                |      |      |                |                  |      |                |                  |      |
|                                                 | Printed wiring material <sup>d</sup><br>Pollution degree |       | 1     | 2              |      |      | 3              |                  |      | 4              |                  |      |
|                                                 |                                                          |       |       | Material group |      |      | Material group |                  |      | Material group |                  |      |
| 1 <sup>e</sup>                                  | 2 <sup>f</sup>                                           |       | I     | II             | III  | I    | II             | III <sup>g</sup> | I    | II             | III <sup>g</sup> |      |
| 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   |

<sup>a</sup> For higher **working voltages**, the values of Table F.4 of IEC 60664-1:2007 apply.

<sup>b</sup> For glass, ceramics and other inorganic materials which do not track, **creepage distances** need not be greater than their associated **clearance**.

<sup>c</sup> 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.

<sup>d</sup> When printed circuit boards are coated in accordance with Annex P or Clause Q.1 and the coating has a PTI of at least 175, the values specified for **pollution degree** 1 are permitted. The PTI shall be measured in accordance with IEC 60112.

<sup>e</sup> Material groups I, II, IIIa and IIIb.

<sup>f</sup> Material groups I, II and IIIa.

<sup>g</sup> 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.*

**20.2.3 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**.

*Compliance is checked by inspection and measurement.*



**20.2.4 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.*

**20.2.5** See Annex J.

### **20.3 Solid insulation**

Solid insulation shall be capable of durably withstanding electrical and mechanical stresses as well as thermal and environmental influences which may occur during the anticipated life of the equipment.

**20.3.1** There is no dimensional requirement for the thickness of **basic insulation** or **functional insulation**.

**20.3.2** 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.

**20.3.2.1** The requirement of 20.3.2 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 13.2 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 13.2 for **reinforced insulation**.

*Compliance is checked by inspection and by test.*

**20.3.2.2** The requirement of 20.3.2 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 Clauses 27 and H.27 does not exceed the permissible value specified in Table 13.
- 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 14, withstands the electric strength test of 13.2, 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 Clauses 14, 27 and H.27, the optocoupler being operated under the most unfavourable conditions which occur during these tests.

*Compliance is checked by inspection and by test.*

## 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** are checked by the tests of 21.3.*

*No requirements exist for small parts as defined in 3.1 of IEC 60695-2-11:2000.*

NOTE In the USA, compliance is checked by the procedure given in Annex D.

### 21.2 Integrated, incorporated and in-line cord controls

The following 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.

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.

**21.2.1** *For parts which are accessible when the **control** is mounted in its manner of intended use, and the deterioration of which may result in the **control** becoming unsafe:*

- *ball pressure test 1 of G.5.1;*
- *the glow-wire test of Clause G.2 carried out at 550 °C.*

**21.2.2** *For parts which retain in position current-carrying parts other than electrical connections:*

- *ball pressure test 2 of G.5.2;*
- *the glow-wire test of Clause G.2 carried out at 550 °C.*

NOTE The tests are not applicable to parts retaining in position current-carrying parts in low-power circuits as described in H.27.1.1.1.

**21.2.3** *For parts which maintain or retain in position electrical connections,*

- *ball pressure test 2 of G.5.2,*

*followed by the glow-wire test at the temperature appropriate for the application and as declared for the **control**:*

NOTE 1 See Annex F for further information.

*Glow-wire test at 650 °C*

- *the glow-wire test of Clause G.2 carried out at 650 °C.*

*Glow-wire test at 750 °C*

- *the glow-wire test of Clause G.2 carried out at 750 °C.*

*Glow-wire test at 850 °C*

- *the glow-wire test of Clause G.2 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 H.27.1.1.1.

NOTE 2 **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.

NOTE 3 For **controls** intended for incorporation into appliances within the scope of IEC 60335-1 parts within 3 mm of electrical connections can be evaluated as per 30.2 of that standard.

#### 21.2.4 For all other parts, (except decorative trim, knobs, etc.)

- the glow-wire test of Clause G.2 carried out at 550 °C.

shall be carried out.

NOTE Unless otherwise indicated in a part 2, diaphragms, gaskets and sealing rings of glands are not subjected to the tests of 21.2.4.

#### 21.2.5 Void

#### 21.2.6 Void

#### 21.2.7 Resistance to tracking

All non-metallic parts for which a **creepage distance** is specified in 20.2 shall have a resistance to tracking as declared.

NOTE 1 Required values of resistance to tracking are given either in the Part 2s of IEC 60730 or in the relevant equipment standard.

**Controls** designed for **operation** at **ELV** levels are not subjected to a tracking test.

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.4 carried out at one of the following PTI values as declared in Table 1, requirement 30:*

- 100 V;
- 175 V;
- 250 V;
- 400 V;
- 600 V.

NOTE 3 For the purposes of 21.2.7, the proximity of arcing contacts is not considered to increase the deposition of external conductive material as the endurance tests of Clause 17, followed by the electric strength tests of Clause 13, are deemed sufficient to determine the effect of **pollution** arising from within the **control**.

### 21.3 Independently mounted controls

The test sequence of 21.2.1 through 21.2.7 applies, preceded by the preconditioning of 21.3.1.

#### 21.3.1 Preconditioning

*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;
- 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*<sub>max</sub> ± 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*<sub>max</sub> ± 2) K with **covers**, with the circuit of the switching part and driving mechanism being connected.

## 21.4 Controls with mercury-tube switch

**Controls** employing a mercury-tube switch intended for connection to a working-voltage circuit as defined in 2.1.3 shall perform acceptably when tested in series with a standard non-renewable cartridge fuse on a d.c. circuit of the voltage specified for test in 17.1.1, except that a.c. with a non-inductive load may be employed if the device is intended for use on a.c. only. The fuse rating and capacity of the test circuit shall be as specified in Table 25.

*The enclosure and any other exposed metal are to be grounded and cotton is to be placed around all openings in the enclosure.*

*There shall be no ignition of the cotton or insulation on circuit conductors nor emission of flame or molten metal except mercury from the enclosure housing the switch. Wiring attached to the device, except tube leads, shall not be damaged. Successive **operations** are to be conducted by alternately closing the mercury-tube switch on the short circuit and closing the short circuit on the mercury tube by means of any suitable switching device.*

NOTE In the countries members of CENELEC, 21.4 does not apply.

**Table 25 (21.4 of edition 3) – Mercury switch short-circuit conditions**

| V       | Maximum rating <sup>a</sup> | S.C. current<br>A | Minimum fuse rating <sup>b c</sup> |         |         |
|---------|-----------------------------|-------------------|------------------------------------|---------|---------|
|         |                             |                   | 0–125                              | 126–250 | 251–660 |
| 0–250   | 2 000 VA                    | 1 000             | 20                                 | 15      | –       |
| 0–250   | 30 A                        | 3 500             | 30                                 | 30      | –       |
| 0–250   | 63 A                        | 3 500             | 70                                 | 70      | –       |
| 251–660 | 63 A                        | 5 000             | –                                  | –       | 30      |

<sup>a</sup> Requirements for applications greater than 63 A are under consideration.

<sup>b</sup> Minimum fuse rating shall be at least equal to switch ampere rating or the nearest standard fuse not exceeding four times motor full-load ampere rating and in any case not less than that shown.

<sup>c</sup> For the purpose of this test, ampere ratings for fuses are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250. Intermediate size fuses may be used.

Cotton used shall be as specified in Annex C.

*The switch need not be operative after the tests.*

## 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 standard, 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 the following test:*

**22.1.4** *The parts are subjected to a test of 14 days duration at 93 % to 97 % relative humidity at  $(40 \pm 2)$  °C.*

**22.1.5** After the parts have been dried for 10 min in a heating cabinet at a temperature of  $(100 \pm 5) ^\circ\text{C}$ , their surfaces shall show no corrosion which might impair compliance with Clauses 8, 13, and 20.

**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, a layer of grease can provide sufficient protection against rusting. Such parts are subjected to the test only if there is doubt about the effectiveness of the grease film, and the test is then made without removal of the grease.

## 23 Electromagnetic compatibility (EMC) requirements – Emission

See also Clause H.23.

**23.1 Free-standing and independently mounted controls**, which cycle during normal operation, shall be so constructed that they do not generate excessive radio interference. **Integrated** and **incorporated controls** are not subjected to the tests of 23.1, as the result of these tests can be affected by the incorporation of the **control** in equipment. They may, however, be carried out on such **controls** if requested by the manufacturer.

Equipment that uses integrated or **incorporated controls** should comply with its relevant product EMC standard. **Integrated** and **incorporated controls** are tested in the end use equipment.

Compliance is checked by one of the following methods:

- Testing in accordance with CISPR 14-1, with the following modification and/or CISPR 22, class B. In 4.2.3.3 of CISPR 14-1:2005, the value of 200 ms is replaced by 20 ms.
- Testing as detailed in 23.1.1 and 23.1.2, resulting in a maximum duration of radio frequency emission of 20 ms. Where such **controls** have a click rate greater than 5, method a) shall be followed.
- Examination and/or tests to show that the minimum time between contact **operations** during normal **operation** cannot be less than 10 min.

Compliance with method b) or c) shows compliance with method a).

### 23.1.1 Test conditions

Three previously untested samples are subjected to the test.

The electrical and thermal conditions are as specified in 17.2 and 17.3, except as follows:

- for **sensing controls**, the rate of change of activating quantities is  $\alpha_1$  and  $\beta_1$ ;
- 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 7. For **controls** declared with purely resistive loads, the power factor is 1,0.

### 23.1.2 Test procedure

The **control** is operated for five cycles of contact operation.

*The duration of radio interference is measured by an oscilloscope connected to the **control** so as to measure the voltage drop across the contacts.*

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**.

**23.2 Controls** 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 See also Table 1, requirement 89.

## 24 Components

**24.1** Transformers 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.

Capacitors used to provide radio interference suppression shall comply with the requirements of IEC 60384-14.

Fuses shall comply with the requirements of IEC 60127-1 or IEC 60269-1, as appropriate.

**24.1.1 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 17.2.2, 17.2.3.1 and 17.2.3.2.

Switch mode power supplies or transformers used in converters shall comply with the requirements of IEC 61558-2-16.

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 2.1.5.

If a converter or switch mode power supply is used as the source of supply to a **SELV**-circuit or PELV-circuit, Clause T.3 applies.

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.

**24.2** Components other than those detailed in 24.1 are checked when carrying out the tests of this standard.

**24.2.1** However, 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 standard of any conditions not covered by the previous testing to the IEC safety standard.

See also Annex J.

**24.3** Annex U is not applicable to relays used as components in a **control**.

**24.4** Switch mode power supplies not covered by 24.2.1, including their peripheral circuitry, used in **electronic controls** shall comply with the tests of 24.4.1 and all of the applicable requirements of this standard.

NOTE Subclause 24.4.1.11 gives the compliance criteria for the tests.

#### **24.4.1 Overload tests for switch mode power supplies**

**24.4.1.1** *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.*

**24.4.1.2** *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.*

**24.4.1.3** *For this test, any protective devices such as a fuse, manual reset circuit protector, thermal protector, etc. are allowed to remain in the circuit.*

**24.4.1.4** *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.*

**24.4.1.5** *If no overcurrent protection is provided, the maximum overload is the maximum power output obtainable from the power supply.*

**24.4.1.6** *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.*

**24.4.1.7** *The duration of the test is to be for 1 h or until ultimate results are reached.*

**24.4.1.8** *The maximum open-circuit voltage of each winding (directly at the winding of the transformer) and the maximum load current are measured and recorded such that the maximum output power may be determined.*

**24.4.1.9** *The maximum open circuit voltage measurements shall be made during normal operation and under single component failure, see Table H.24.*

**24.4.1.10** *For SELV applications, where the maximum open circuit voltage measured directly at the secondary of the transformer exceeds the limits specified in 2.1.5, the measurement of the maximum output voltage of each winding may be made after certain protective impedances. In this case, the limits shall be in accordance with H.8.1.10.1.*

**24.4.1.11** *Following each test (while still in a heated condition), the transformer is to be subjected to the electric strength test of 13.2.*

**24.4.1.12** *Compliance shall be in accordance with items a), b), c), d), e) and f) of H.27.1.1.3.*

**24.5** Annex J is not applicable to **thermistors** used in a circuit which meets all of the following requirements:

- type 1 **control** as declared in Table 1, requirement 39;
- connected to a **SELV/PELV** circuit as specified in Clause T.1;
- low power circuit as specified in H.27.1.1.1;



- the **control** or final equipment complies with Clause H.27 when the **thermistor** is open or short circuited;
- **control** with **class A control functions** as declared in Table 1, requirement 92.

## 25 Normal operation

See Annex H.

## 26 Electromagnetic compatibility (EMC) requirements – Immunity

See Clause H.26.

NOTE In general, the tests of Clause H.26 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 typically included in other clauses of the appropriate part 2.

## 27 Abnormal operation

27.1 See Annex H and Annex J.

### 27.2 Burnout test

**Controls** incorporating electro-magnets shall withstand the effects of blocking of the **control** mechanism.

*Compliance is checked by the tests of 27.2.1 and 27.2.2.*

NOTE For relays and contactors, compliance with this requirement is established by successful completion of the tests of Clause 17.

**27.2.1** *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 17.2.2, 17.2.3.1 and 17.2.3.2.*

*The duration of the test is either 7 h; or until an internal protective device, if any, operates; or until burnout, whichever occurs first.*

**27.2.2** *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 standard;*
- *the requirements of 13.2 are still met.*

NOTE The **control** need not be operative following the test.

### 27.2.3 Blocked mechanical output test (abnormal temperature test)

**Controls** with motors, such as electric actuators, shall withstand the effects of blocked output without exceeding the temperatures indicated in Table 26. Temperatures are measured by the method specified in 14.7.1. 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 13.

**27.2.3.1** ***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.*

NOTE In Canada and the USA, the test is conducted at the voltages indicated in 17.2.3.1 and 17.2.3.2.

For **controls** with motors declared for three-phase **operation**, the test is to be carried out with any one phase disconnected.

**Table 26 (27.2.3 of edition 3) – 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 |

**27.2.3.2** The average temperature shall be within the limits during both the second and the twenty-four 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.

**27.2.3.3** During the test, power shall be continually supplied to the motor.

**27.2.3.4** Immediately upon completion of the test, the motor shall be capable of withstanding the electric strength test specified in Clause 13, without first applying the humidity treatment of 12.2.

### 27.3 Overvoltage and undervoltage test

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  $0,85 V_{R \min}$ .*

**27.4** See Annex H.

## 27.5 Overload tests on in-line cords controls

The following overload tests are carried out on **in-line cord controls** as indicated in 11.10.2 and provided with a plug and socket outlet:

- **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.
- **Controls** protected by incorporated fuses complying with IEC 60127-1 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 **electronic control** has been loaded for 30 min.
- **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 temperature shall not exceed those indicated in Table 13.

## 27.6 Battery short-circuit test

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.

**27.6.1** 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 standard;
- the requirements of 13.2 are still met.

NOTE The **control** need not be operative following the test.

## 28 Guidance on the use of electronic disconnection

See Annex H.

*Dimensions in millimetres*

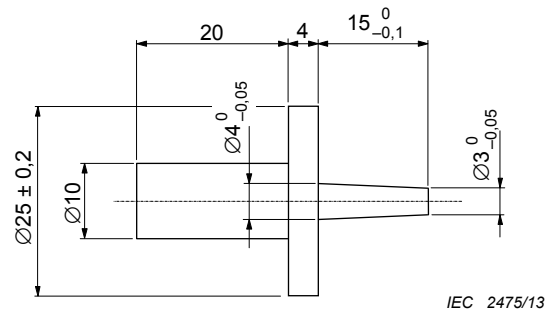
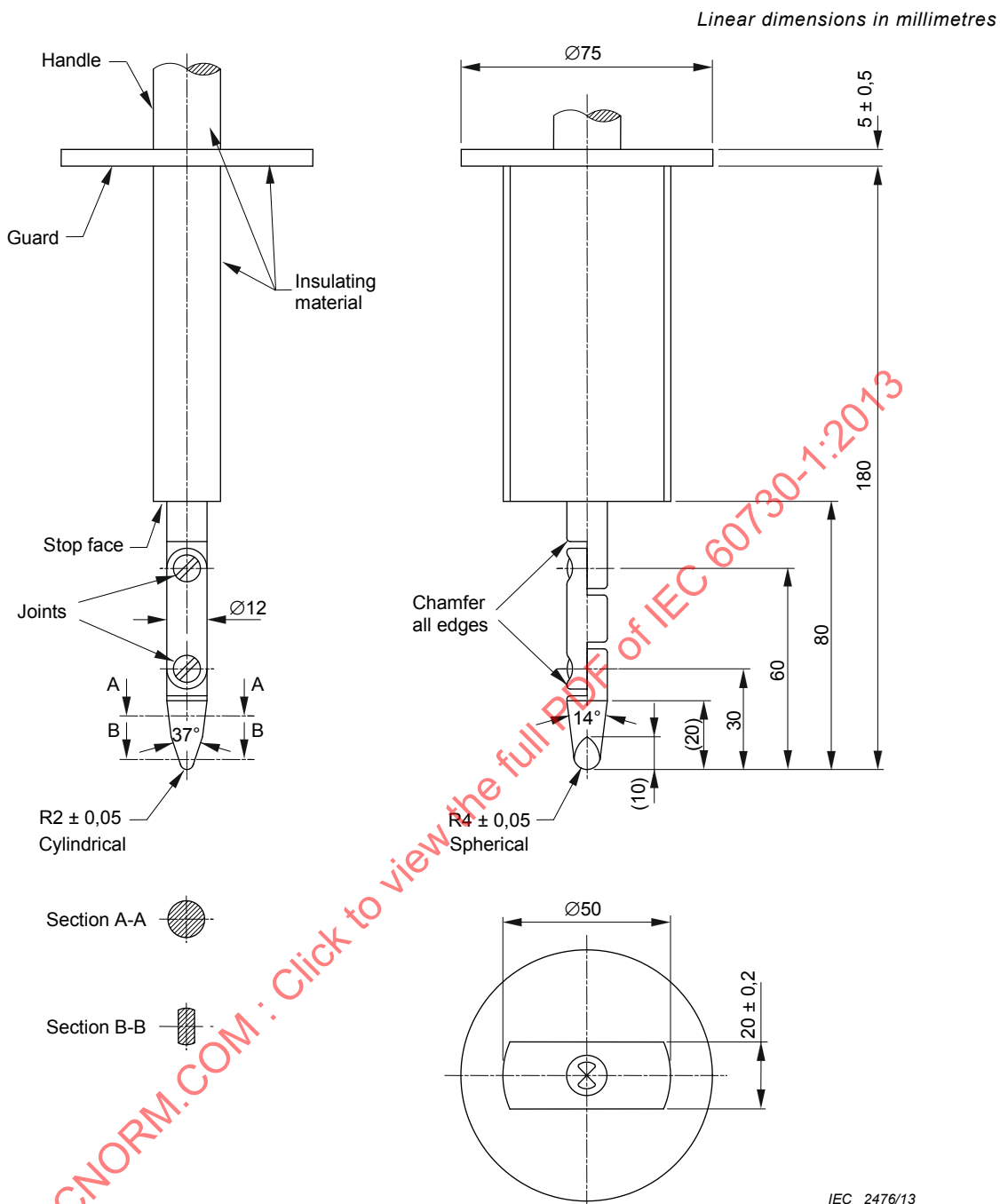


**Figure 1 – Test pin**

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Tolerances on dimensions without specific tolerance:

on angles  $\begin{matrix} 0 \\ -10 \end{matrix}^{\circ}$

on linear dimensions:

up to 25 mm:  $\begin{matrix} 0 \\ -0,05 \end{matrix}$

over 25 mm:  $\pm 0,2$

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 must ensure a 90° bending angle with a 0° to 10° tolerance.

**Figure 2 – Standard test finger**

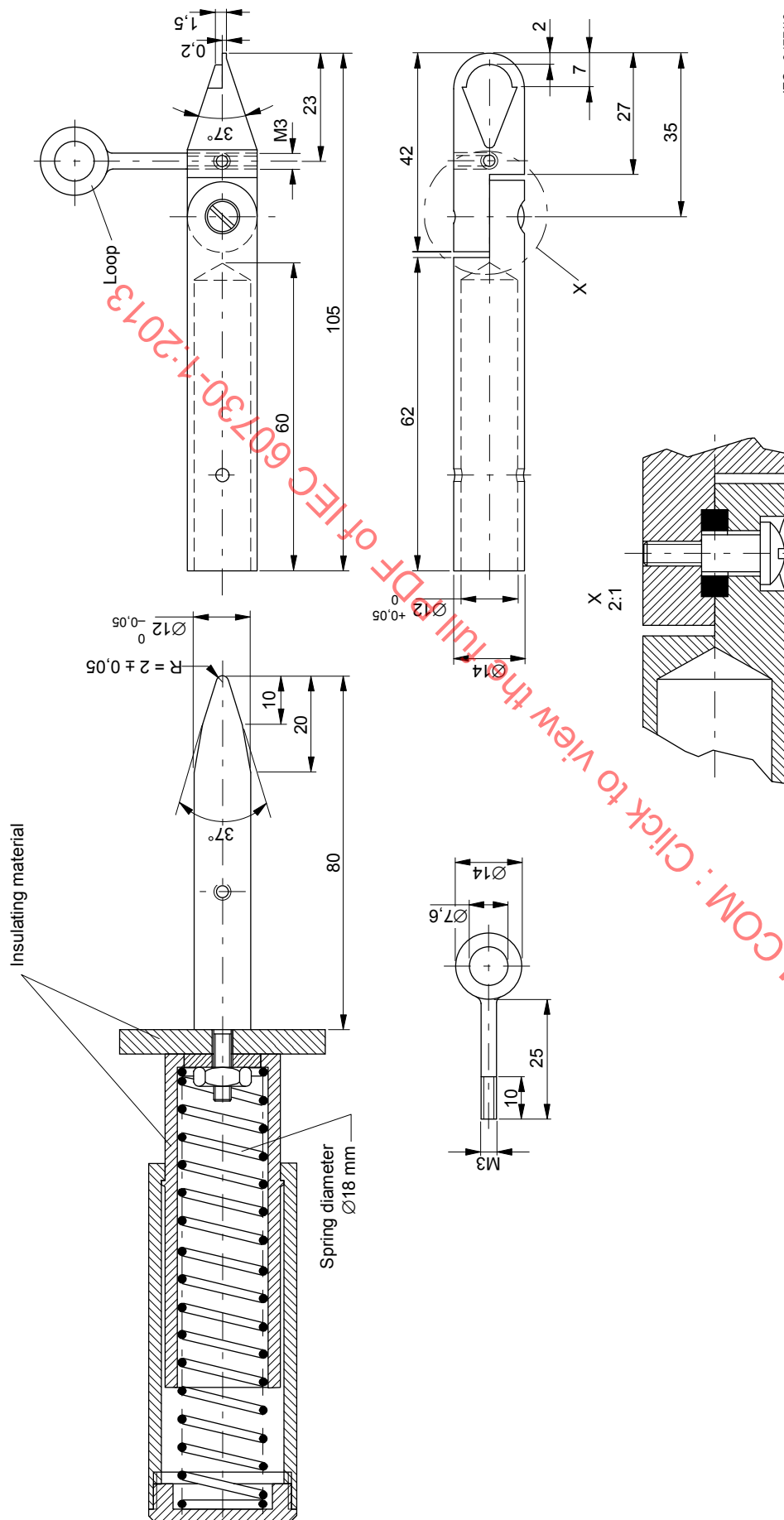
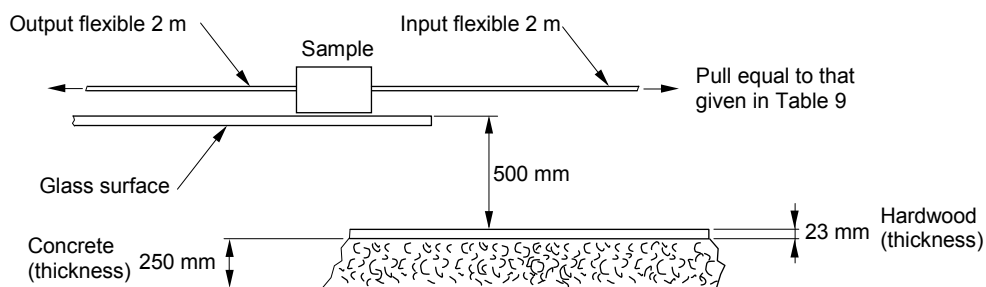


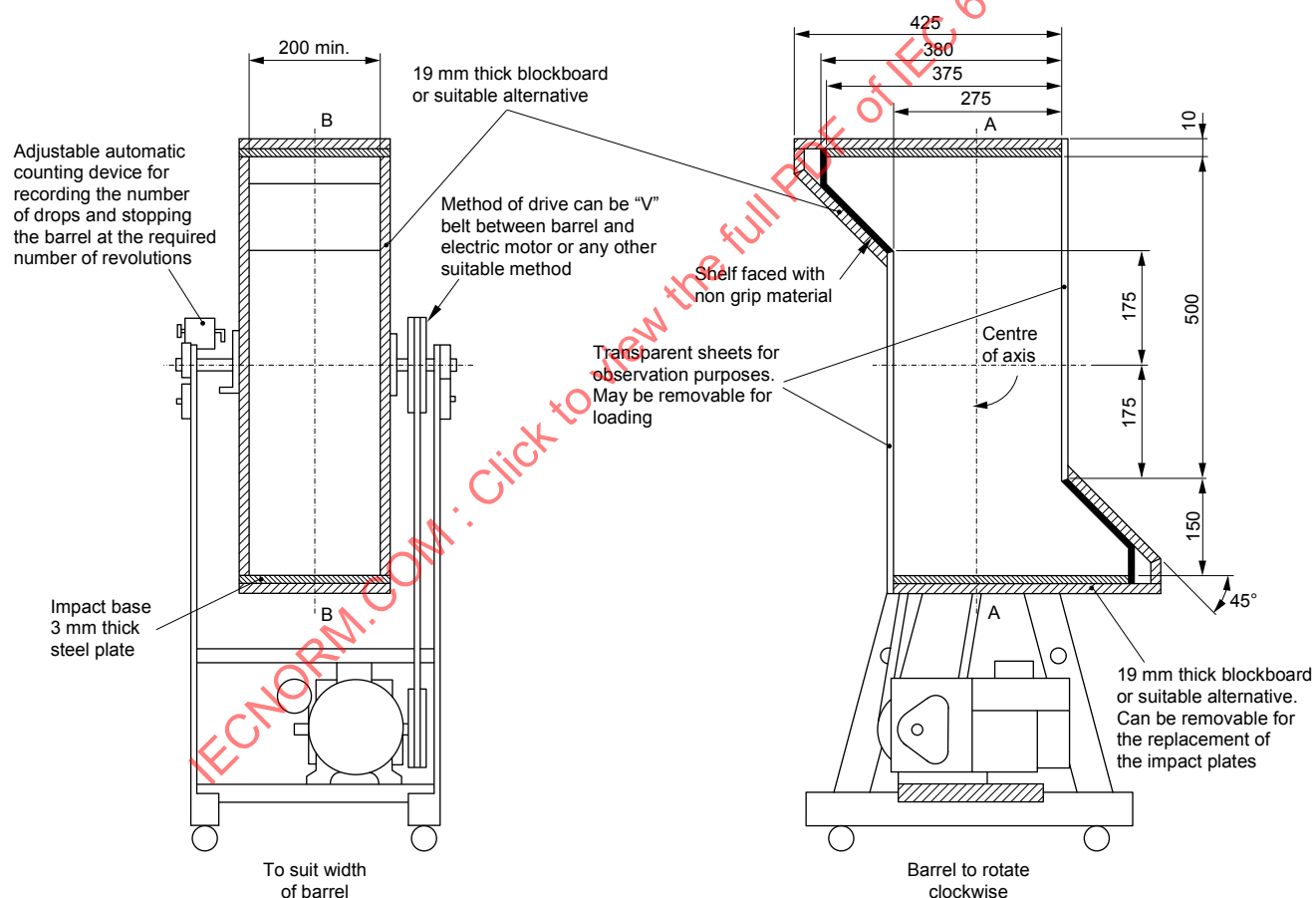
Figure 3 – Test nail



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Figure 4 – Impact test for free-standing controls

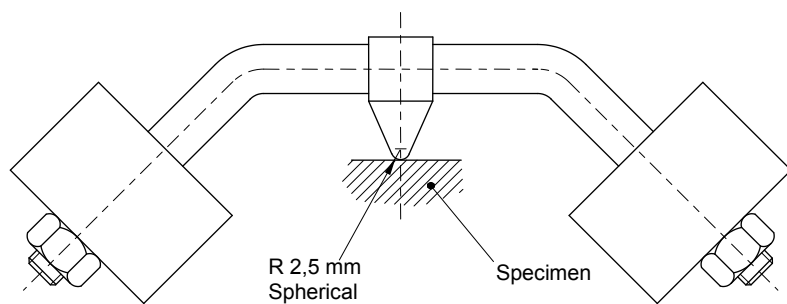
Dimensions in millimetres



IEC 2479/13

Figure 5 – Tumbling barrel



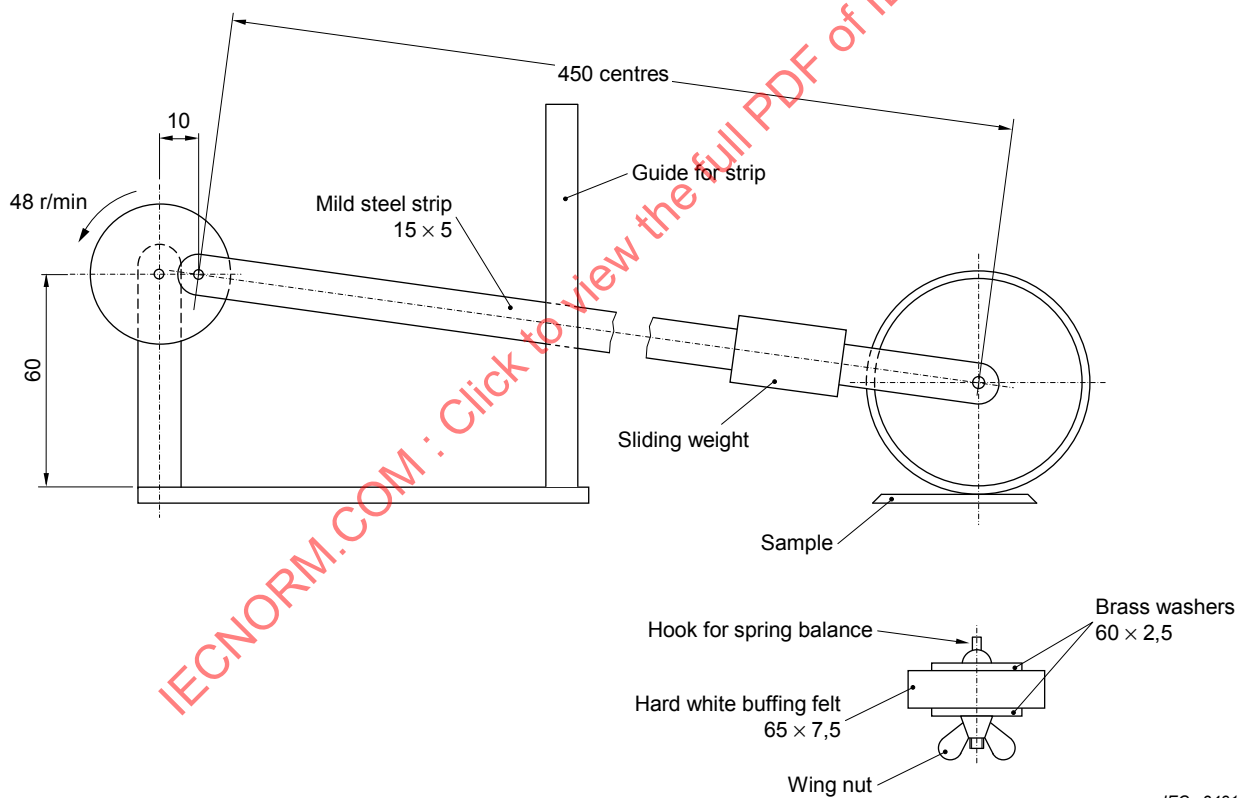


IEC 2480/13

**Figure 6 – Ball-pressure apparatus**

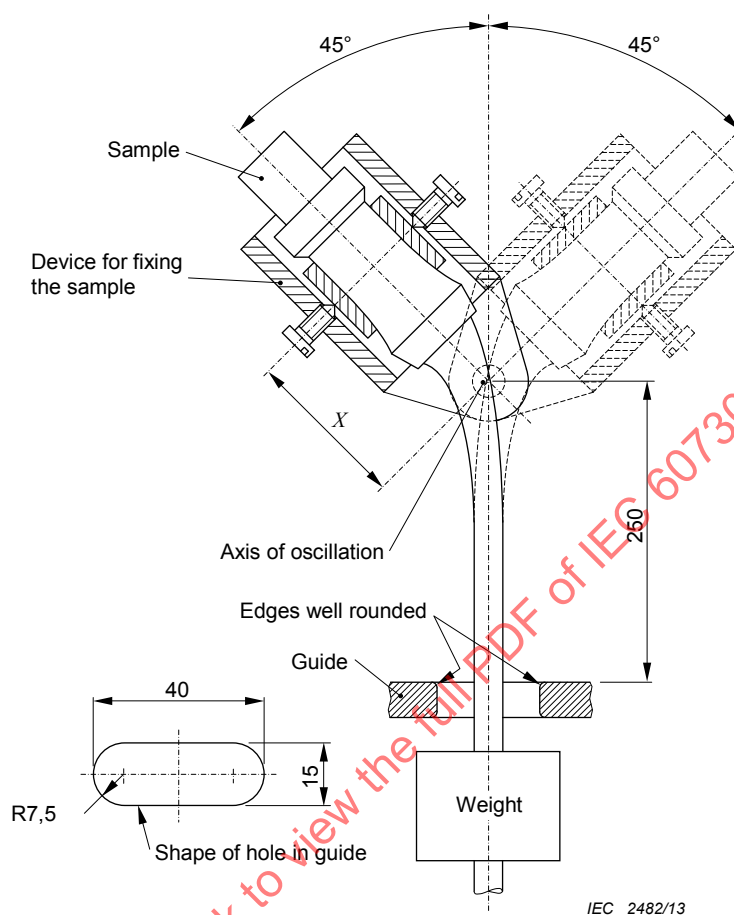
**Figure 7 – Void**

*Dimensions in millimetres*



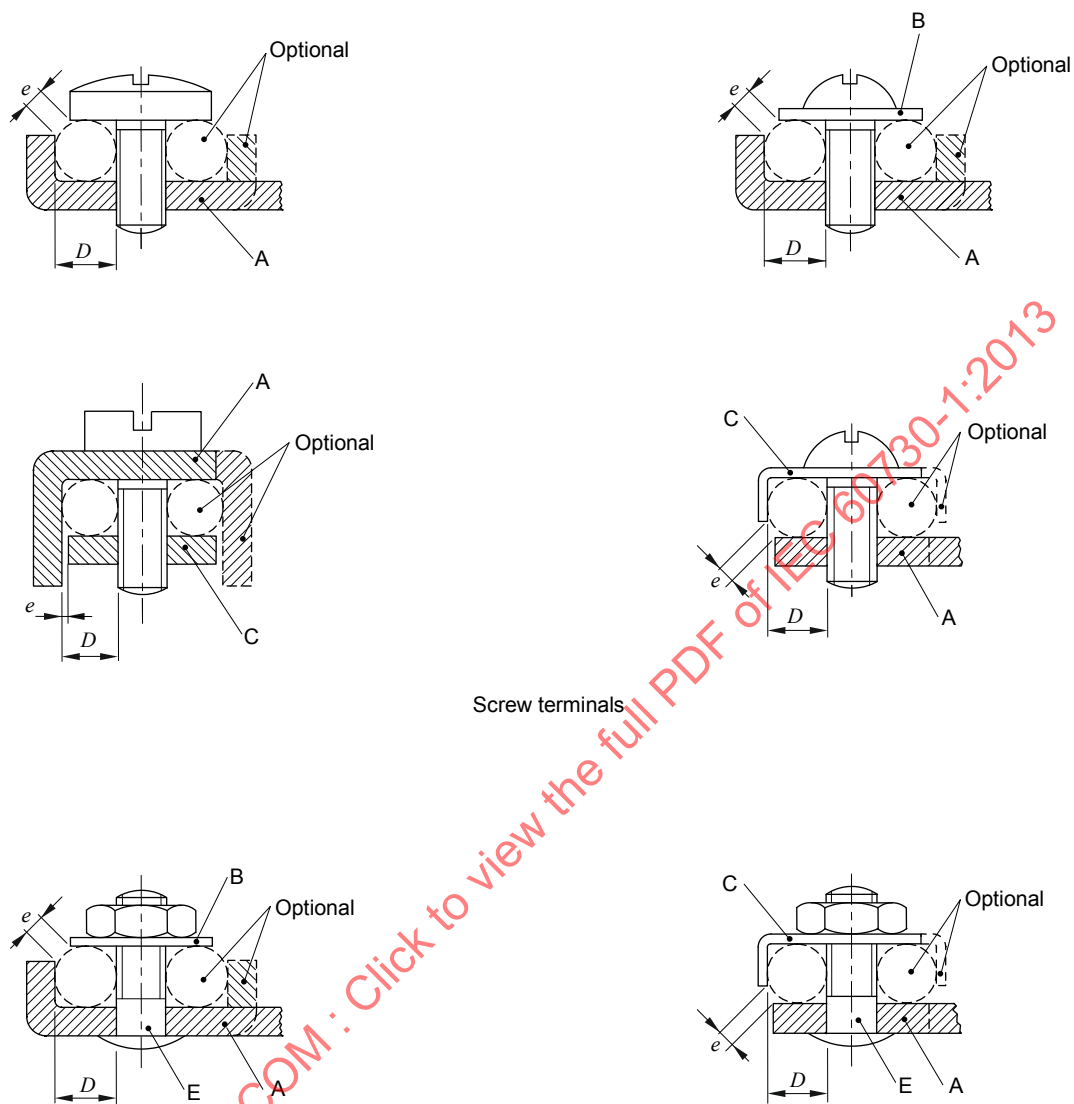
IEC 2481/13

**Figure 8 – Apparatus for testing durability of markings on rating labels**

*Dimensions in millimetres***Figure 9 – Apparatus for flexing test**

Screws not requiring washer, clamping plate or anti-spread device

Screws requiring washer, clamping plate or anti-spread device



Screw terminals

Stud terminals

IEC 2483/13

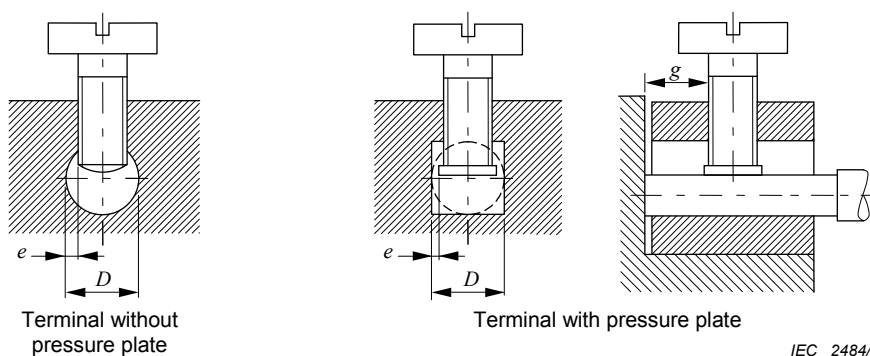
- A fixed part
- B washer or clamping plate
- C anti-spread device
- D conductor space
- E stud

Figure 10 – Screw terminals and stud terminals (1 of 2)

Dimensions in millimetres

| Current carried by terminal <sup>a</sup>                                                                                                                                                        |                                 | Minimum diameter conductor space<br><i>D</i> | Maximum gap between conductor restraining parts<br><i>e</i> | Minimum torque<br>Nm  |                        |              |            |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|----------------------------------------------|-------------------------------------------------------------|-----------------------|------------------------|--------------|------------|
| For flexible conductor<br><i>A</i>                                                                                                                                                              | For fixed conductor<br><i>A</i> |                                              |                                                             | Slotted screws        |                        | Other screws |            |
|                                                                                                                                                                                                 |                                 |                                              |                                                             | One screw<br><i>g</i> | Two screws<br><i>g</i> | One screw    | Two screws |
| 0-6                                                                                                                                                                                             | 0-6                             | 1,4                                          | 1,0                                                         | 0,4                   | –                      | 0,4          | –          |
| 6-10                                                                                                                                                                                            | 0-6                             | 1,7                                          | 1,0                                                         | 0,5                   | –                      | 0,5          | –          |
| 10-16                                                                                                                                                                                           | 6-10                            | 2,0                                          | 1,5                                                         | 0,8                   | –                      | 0,8          | –          |
| 16-25                                                                                                                                                                                           | 10-16                           | 2,7                                          | 1,5                                                         | 1,2                   | 0,5                    | 1,2          | 0,5        |
| 25-32                                                                                                                                                                                           | 16-25                           | 3,6                                          | 1,5                                                         | 2,0                   | 1,2                    | 2,0          | 1,2        |
| –                                                                                                                                                                                               | 25-32                           | 4,3                                          | 2,0                                                         | 2,0                   | 1,2                    | 2,0          | 1,2        |
| 32-40                                                                                                                                                                                           | 32-40                           | 5,5                                          | 2,0                                                         | 2,0                   | 1,2                    | 2,0          | 1,2        |
| 40-63                                                                                                                                                                                           | 40-63                           | 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.                                                                                                          |                                 |                                              |                                                             |                       |                        |              |            |
| <sup>a</sup> Requirements for applications greater than 63 A are under consideration.                                                                                                           |                                 |                                              |                                                             |                       |                        |              |            |

Figure 10 – Screw terminals and stud terminals (2 of 2)



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Dimensions in millimetres

| Current carried by terminal <sup>a</sup> |                          | Minimum diameter conductor space<br><i>D</i> | Maximum gap between conductor restraining parts<br><i>e</i> | Minimum distance between clamping screw and end of conductor when fully inserted |                        | Minimum torque<br>Nm |            |                |            |              |            |
|------------------------------------------|--------------------------|----------------------------------------------|-------------------------------------------------------------|----------------------------------------------------------------------------------|------------------------|----------------------|------------|----------------|------------|--------------|------------|
|                                          |                          |                                              |                                                             |                                                                                  |                        | Screws without heads |            | Slotted screws |            | Other screws |            |
| For flexible conductor<br>A              | For fixed conductor<br>A |                                              |                                                             | One screw<br><i>g</i>                                                            | Two screws<br><i>g</i> | One screw            | Two screws | One screw      | Two screws | One screw    | Two screws |
| 0-10                                     | 0-6                      | 2,5                                          | 0,5                                                         | 1,5                                                                              | 1,5                    | 0,2                  | 0,2        | 0,4            | 0,4        | 0,4          | 0,4        |
| 10-16                                    | 6-10                     | 3,0                                          | 0,5                                                         | 1,5                                                                              | 1,5                    | 0,25                 | 0,2        | 0,5            | 0,4        | 0,5          | 0,4        |
| 16-25                                    | 10-16                    | 3,6                                          | 0,5                                                         | 1,8                                                                              | 1,5                    | 0,4                  | 0,2        | 0,8            | 0,4        | 0,8          | 0,4        |
| 25-32                                    | 16-25                    | 4,0                                          | 0,6                                                         | 1,8                                                                              | 1,5                    | 0,4                  | 0,25       | 0,8            | 0,5        | 0,8          | 0,5        |
| -                                        | 25-32                    | 4,5                                          | 1,0                                                         | 2,0                                                                              | 1,5                    | 0,7                  | 0,25       | 1,2            | 0,5        | 1,2          | 0,5        |
| 32-40                                    | 32-40                    | 5,5                                          | 1,3                                                         | 2,5                                                                              | 2,0                    | 0,8                  | 0,7        | 2,0            | 1,2        | 2,0          | 1,2        |
| 40-63                                    | 40-63                    | 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.

<sup>a</sup> Requirements for applications greater than 63 A are under consideration.

Figure 11 – Pillar terminals

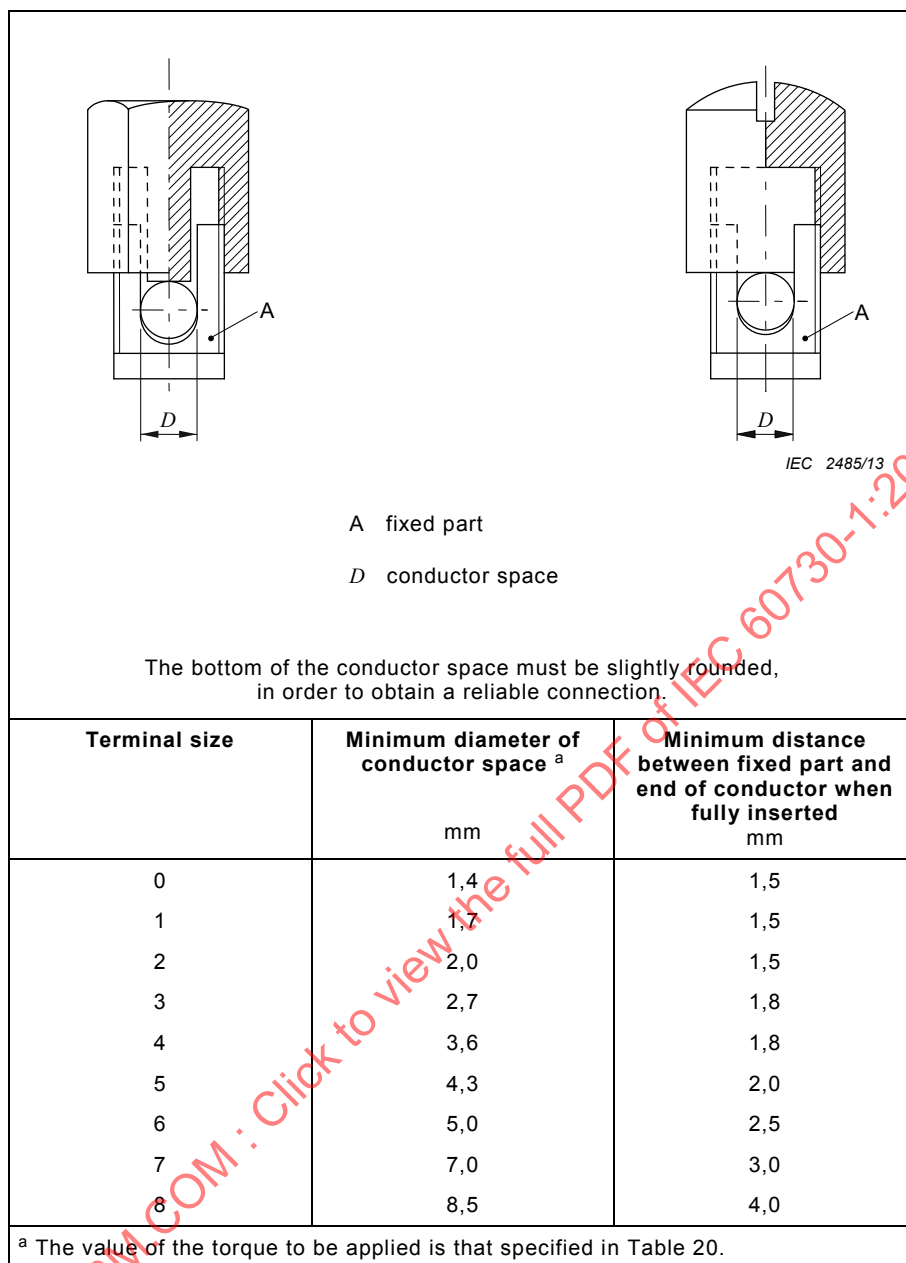
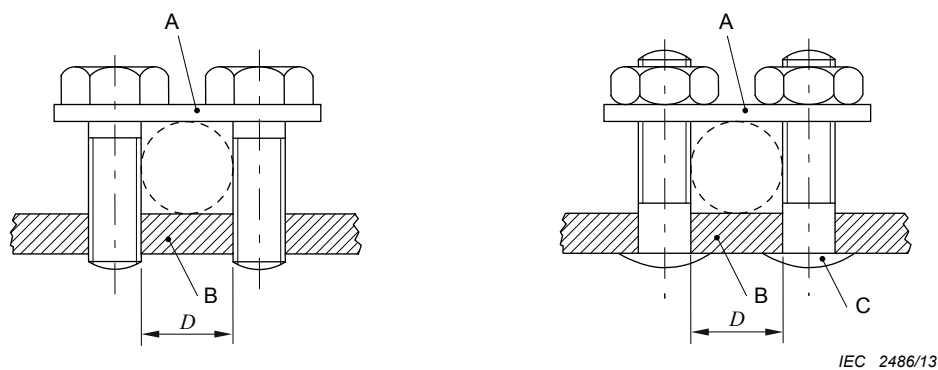


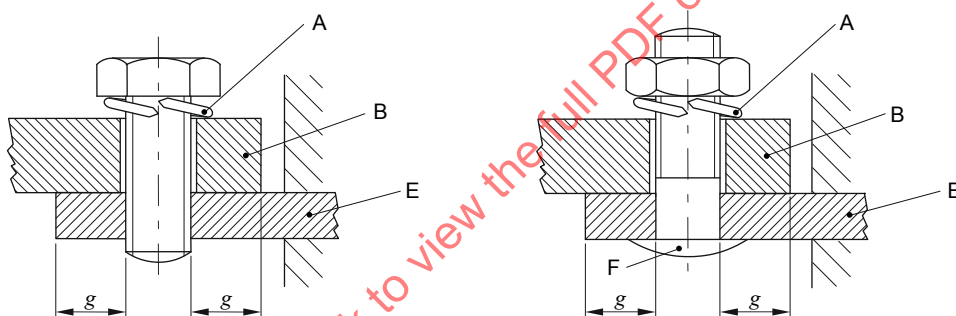
Figure 12 – Mantle terminals



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- A saddle
- B fixed part
- C stud
- D conductor space

#### a) Saddle terminals



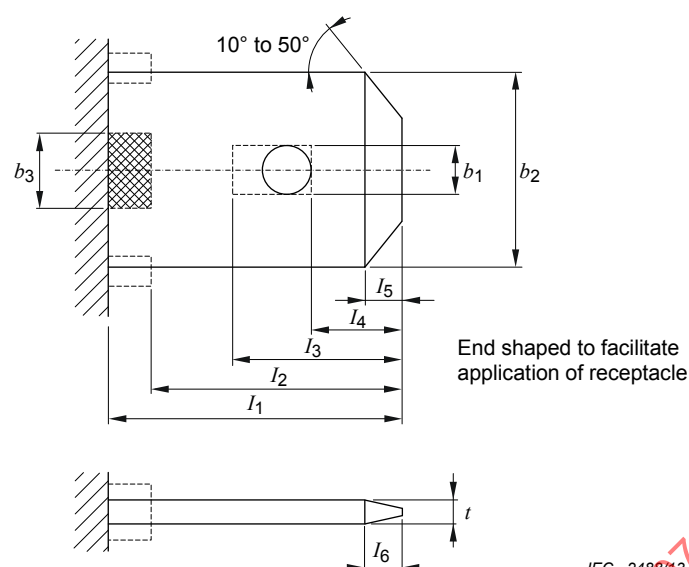
IEC 2487/13

- A locking means
- B cable lug or bar
- E fixed part
- F stud

#### b) Lug terminals

**Figure 13 – Saddle and lug terminals**





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Dimensions in millimetres

| Dimension for<br>Figures 14<br>and 15 <sup>a</sup> | Connector size  |                  |                             |                             |
|----------------------------------------------------|-----------------|------------------|-----------------------------|-----------------------------|
|                                                    | 2,8             | 4,8              | 6,3                         | 9,5                         |
| $L_1$ (min.) <sup>b</sup>                          | 7,7             | 6,9              | 8,6                         | 14,0                        |
| $L_2$ (min.) <sup>b</sup>                          | 7,0             | 6,2              | 7,9                         | 12,0                        |
| $L_3$ (max.) <sup>c</sup>                          | 3,0             | 5,2              | 6,7                         | 8,2                         |
| $L_4$                                              | $1,0 \pm 0,2$   | $2,5 \pm 0,25$   | $3,2 \pm 0,3$               | $4,2 \pm 0,3$               |
| $L_5$ (max.)                                       | 0,7             | 1,2              | 1,3                         | 1,7                         |
| $L_6$ (max.)                                       | 0,7             | 1,2              | 1,3                         | 1,7                         |
| $b_1$ (hole) <sup>a</sup>                          | $1,2^{+0,1}_0$  | $1,4^{+0,2}_0$   | $1,6^{+2,0}_0$ <sup>d</sup> | $2,1^{+2,0}_0$ <sup>d</sup> |
| $b_1$ (slot) <sup>a</sup>                          | $1,2^{+0,1}_0$  | $1,4^{+0,2}_0$   | $1,6^{+0,1}_0$              | $2,1^{+2,0}_0$              |
| $b_2$                                              | $2,8 \pm 0,1$   | $4,75 \pm 0,2$   | $6,3^{+0,15}_{-0,1}$        | $9,5^{+0,15}_{-0,1}$        |
| $b_3$ (min.) <sup>e</sup>                          | 2,0             | 2,0              | 2,5                         | 2,5                         |
| $t$ <sup>f</sup>                                   | $0,5 \pm 0,025$ | $0,8 \pm 0,03$   | $0,8 \pm 0,03$              | $1,2 \pm 0,03$              |
| $p$ (max.) <sup>g</sup>                            | 0,8             | 1,2              | 1,2                         | 1,7                         |
| $k$                                                | –               | $0,7^{0}_{-0,1}$ | $1,0^{0}_{-0,1}$            | $1,5^{0}_{-0,1}$            |
| $x$                                                | –               | $1,0 \pm 0,2$    | $1,0 \pm 0,2$               | $1,4 \pm 0,2$               |

NOTE The sketches are not intended to govern design except as regards the dimensions shown.

<sup>a</sup> **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 standard.

Details for **tabs** having corrugations or depressions are under consideration.

<sup>b</sup> 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.

<sup>c</sup> The length of the slot ( $L_3$ – $L_4$ ) must be at least equal to its width ( $b_1$ ).

<sup>d</sup> These tolerances are chosen so as to allow the **tabs** to be used as a part of a terminal with screw clamping.

<sup>e</sup> Over the double-hatched area, the thickness shall not exceed the upper limit of the material thickness specified.

<sup>f</sup> 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 ( $3,2 \pm 0,2$ ) mm<sup>2</sup>, in a circular area. In addition, the overall flatness shall have a tolerance of 0,03 mm.

<sup>g</sup> 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 14 – Tabs

For dimensions, see Figure 14

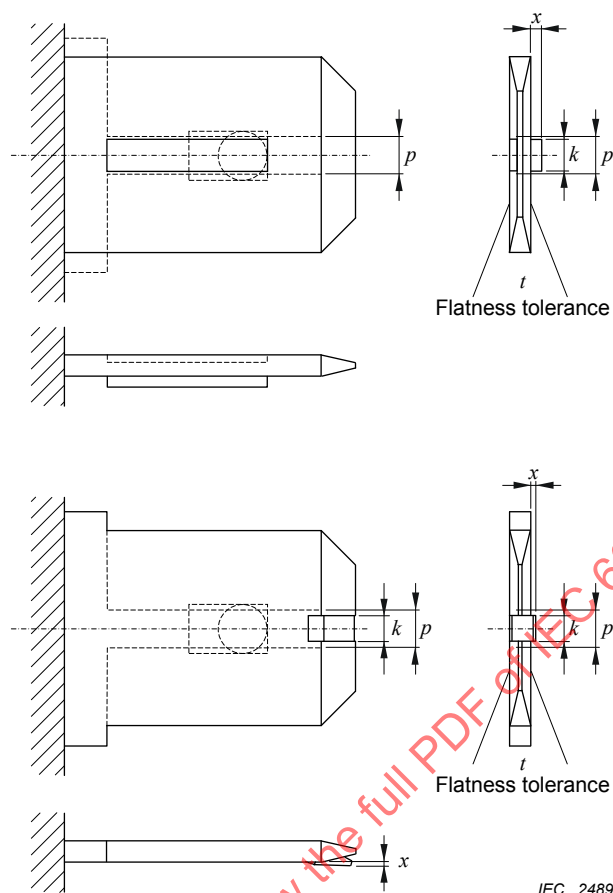
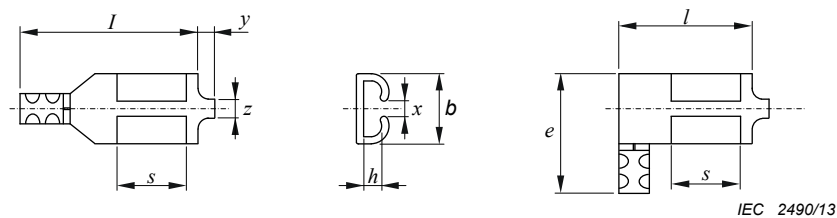


Figure 15 – Tabs for non-reversible connectors



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.) <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1              | 2   | 2,5 | 3,2  |
| $l$ (max.)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 18             | 18  | 22  | 27   |
| $s$ (min.)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 4,5            | 5   | 6   | 10   |
| $x$ (min.) <sup>b</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | -              | 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  |
| <p>The dimensions shown apply to the crimped condition.</p> <p>Dimensions for <b>receptacles</b> provided with a sleeve and for <b>receptacles</b> with a pre-insulated barrel are under consideration.</p> <p>The sketches are not intended to govern design except as regards the dimensions shown.</p> <p><sup>a</sup> Maximum offset dimension from the centre line of the <b>tab</b> blade.</p> <p><sup>b</sup> Applies only to <b>receptacles</b> for non-reversible connectors.</p> |                |     |     |      |

Figure 16 – Receptacles

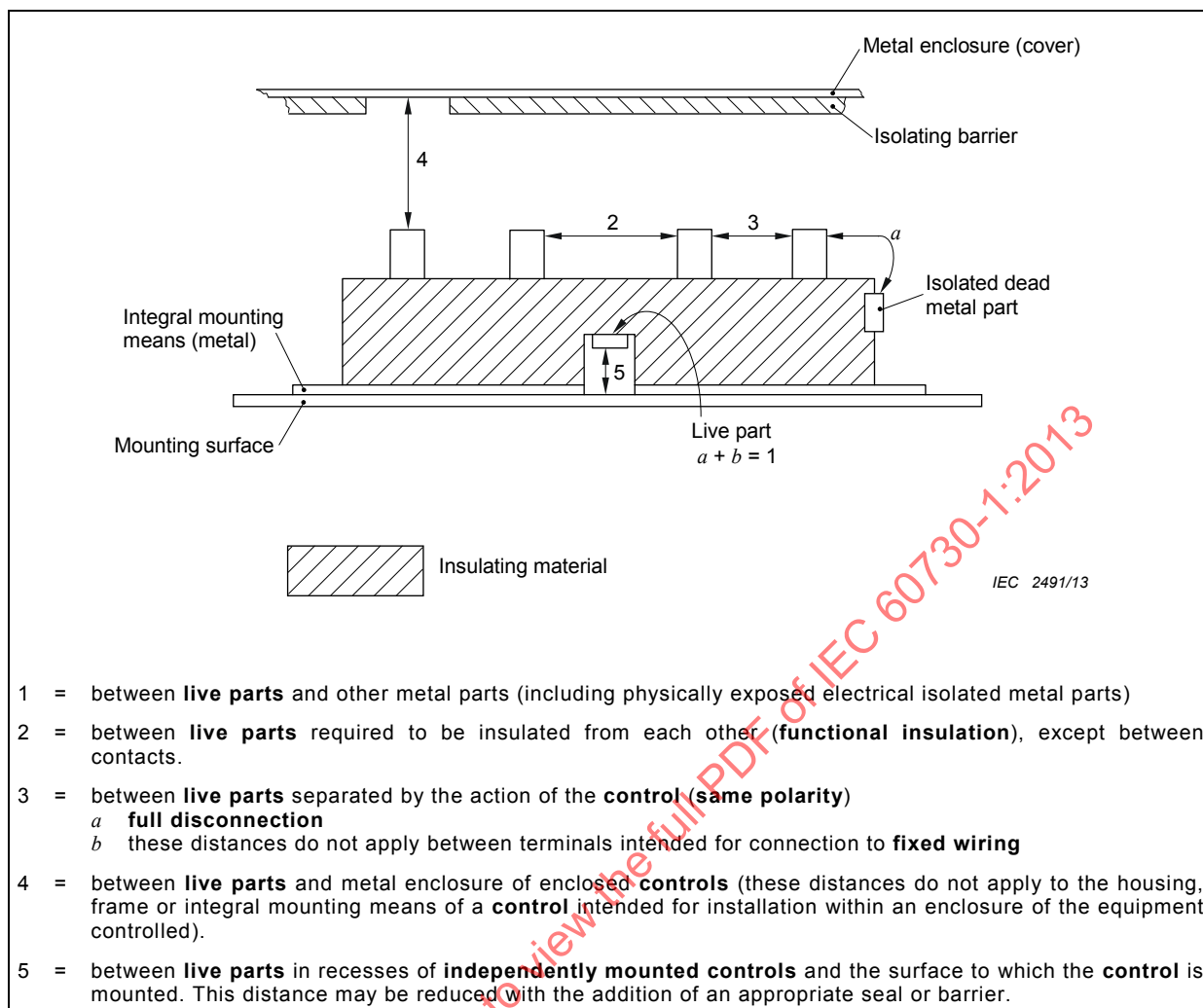
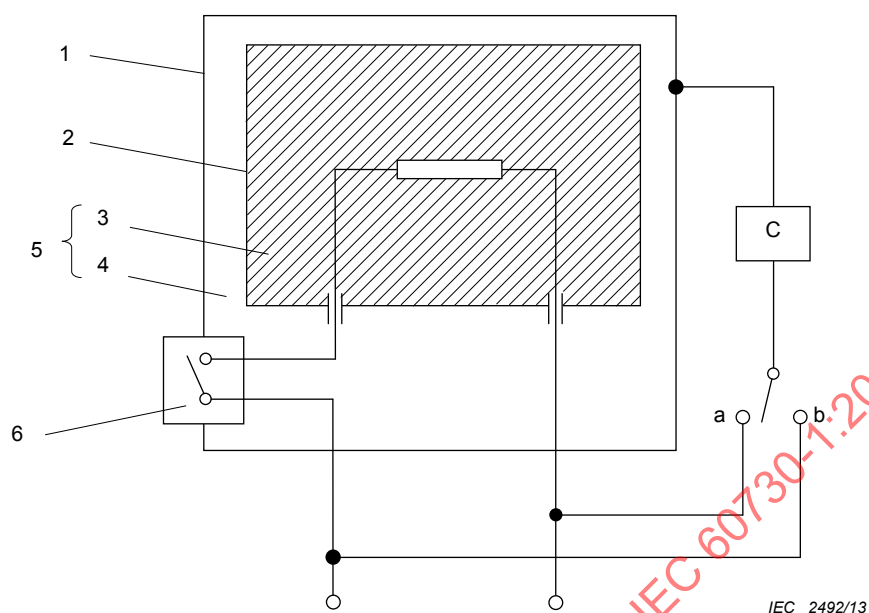
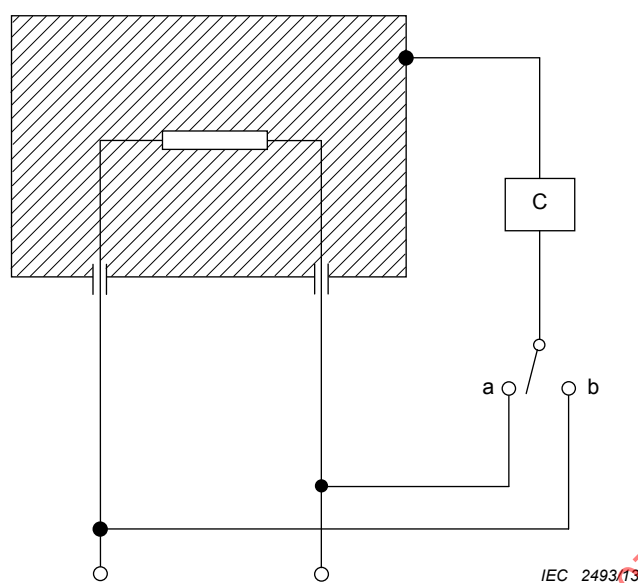


Figure 17 – Measurement of creepage distance and clearance

**Figures 18 to 24 Void****Key**

- C circuit of Figure E.1
- 1 **accessible part**
- 2 **inaccessible metal part**
- 3 **basic insulation**
- 4 **supplementary insulation**
- 5 **double insulation**
- 6 **reinforced insulation**

**Figure 25 – Diagram for leakage current measurement at operating temperature for single-phase connection of class II controls**

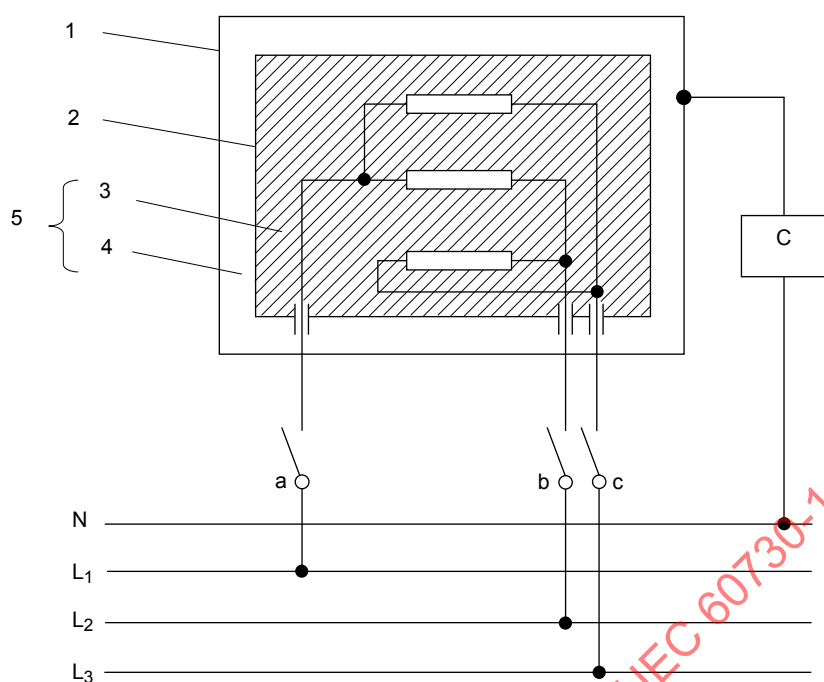


**Key**

C circuit of Figure E.1

**Figure 26 – Diagram for leakage current measurement at operating temperature for single-phase connection of controls other than class II**

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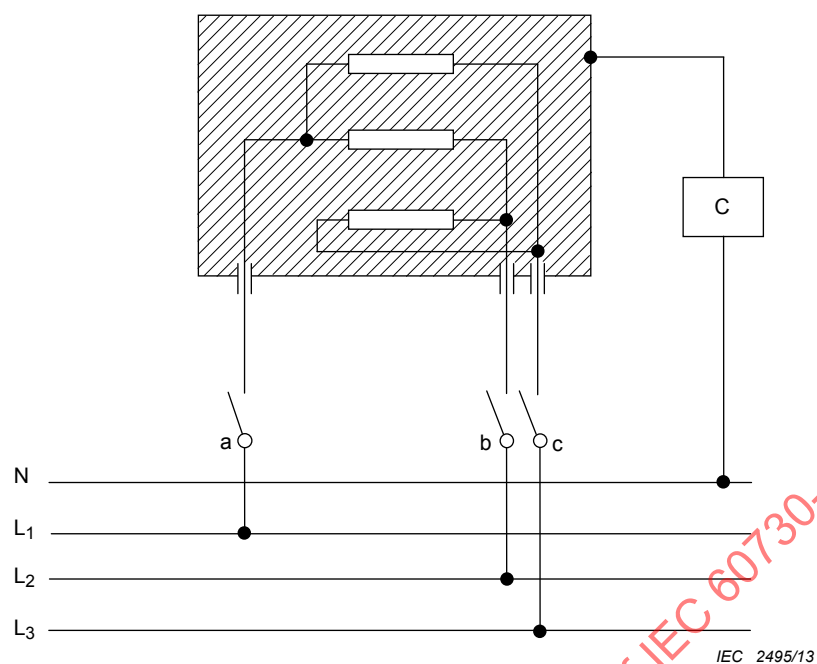
**Key**

- C circuit of Figure E.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 27 – Diagram for leakage current measurement at operating temperature for three-phase connection of class II controls**



**Key**

C circuit of Figure E.1

**Connections and supplies**

L<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub> N supply voltage with neutral

**Figure 28 – Diagram for leakage current measurement at operating temperature for three-phase connection of controls other than class II**

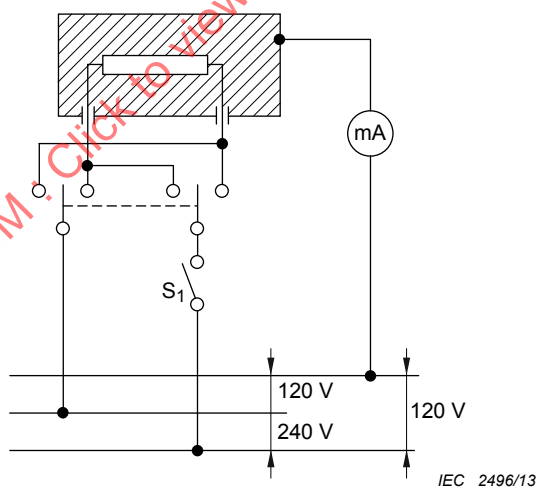
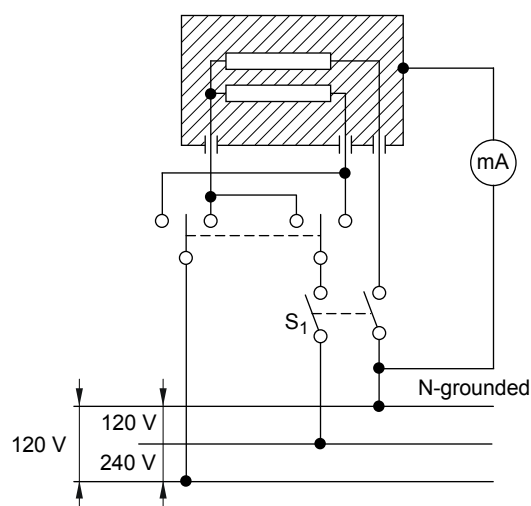


**Figure 29 – Diagram for leakage current measurement at operating temperature for single-phase connection of controls other than class II**





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**Figure 30 – Diagram for leakage 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** Markings on **controls** shall be adequately indelible for safety and are therefore classified according to the requirements for indelibility:

**A.1.1** Markings which are not mandatory within the requirements of this standard.

**A.1.2** Markings which are mandatory within the requirements of this standard 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.1.3** Markings which are mandatory within the requirements of this standard 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.1.2, have also to withstand the rubbing and handling expected during the use of the equipment. Markings on knobs, 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.1.4** *Compliance with the requirements for indelibility of markings classified according to A.1.2 and A.1.3 is checked by the tests of Clause A.2 or A.3 using the apparatus shown in Figure 8.*

*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;*
- *petroleum spirit (aliphatic solvent hexane with a content of aromatics of maximum 0,1 volume %, a Kauributanol value of 29, initial boiling point of approximately 65 °C and dry point approximately 69 °C, and specific gravity of approximately 0,68 g/cm<sup>3</sup>); and*
- *water.*

**A.2** *Compliance with the requirements for indelibility of markings classified according to A.1.2 is checked by the following tests:*

**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.*

**A.2.2** The sample shall then be allowed to dry completely in an ambient room temperature of  $(25 \pm 5)$  °C.

**A.2.3** The sample shall then be rubbed in the apparatus of Figure 8, 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** Compliance with the requirements for indelibility of markings classified according to A.1.3 is checked by the following tests:

**A.3.1** The marking under consideration shall be rubbed in the apparatus of Figure 8 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  $(40 \pm 5)$  °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 may be progressively reduced from 7,5 mm in order that the marking may be 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.

## 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 Figures B.1 to 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  $80^\circ$  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 at 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 Figures B.1 to B.10, the following identification is used:

..... is a **creepage distance**;

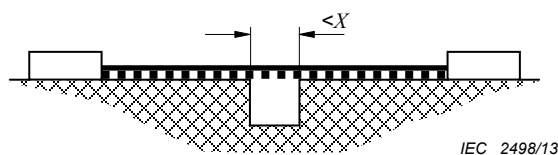
\_\_\_\_\_ is a **clearance** in air.

See Table B.1 for the value of  $X$ .

**Table B.1 – Value of  $X$**

| Pollution degree | Width $X$ of grooves:<br>minimum values<br>mm |
|------------------|-----------------------------------------------|
| 1                | 0,25                                          |
| 2                | 1,0                                           |
| 3                | 1,5                                           |
| 4                | 2,5                                           |

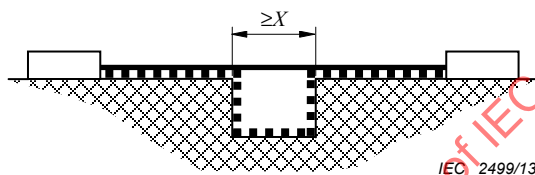
If the associated **clearance** is less than 3 mm, the minimum groove width may be reduced to one-third of this **clearance**.



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**

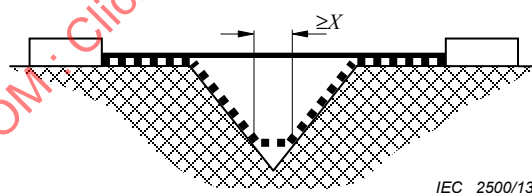


The path under consideration includes a groove of any depth, having a width equal to or more than  $X$ .

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**



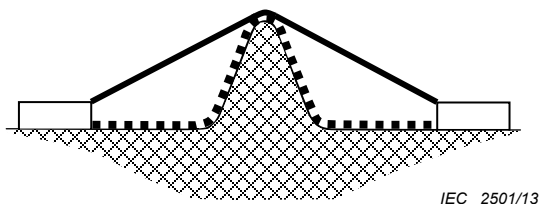
The path under consideration includes a V-shaped groove having a width greater or equal to  $X$ .

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**

————— Clearance                      ■■■■■■■■■ Creepage distance

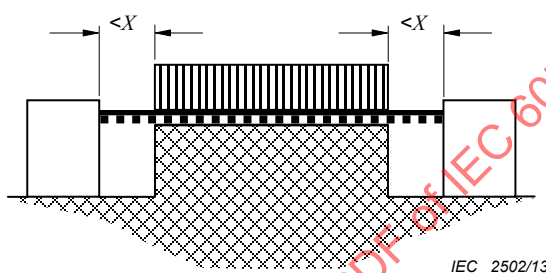


The path under consideration includes a rib.

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.

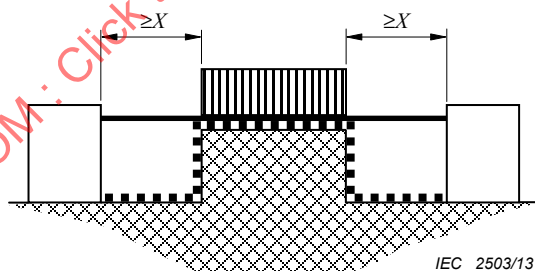
**Figure B.4 – Rib**



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**



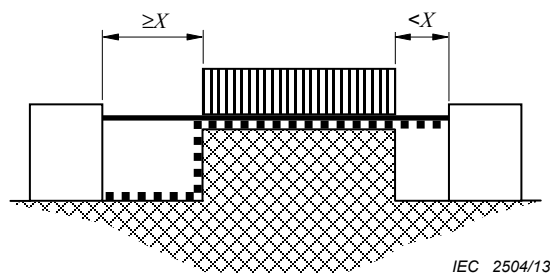
The path under consideration includes an uncemented joint and grooves having a width equal to or more than  $X$ .

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**

————— Clearance                      ..... Creepage distance

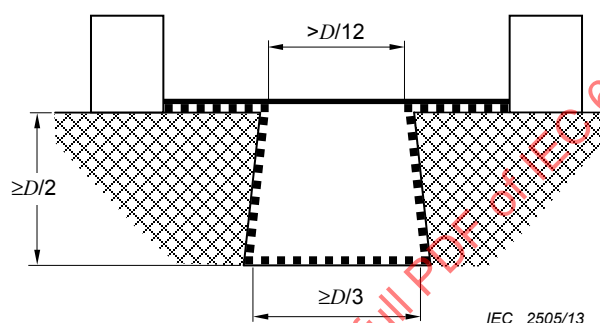


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The path under consideration includes an uncemented joint, a groove on one side having a width less than  $X$ , and a groove on the other having a width equal to or more than  $X$ .

Rule: The **clearance** path and the **creepage distance** path are as shown.

**Figure B.7 – Uncemented joint with narrow and wide grooves**



IEC 2505/13

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.

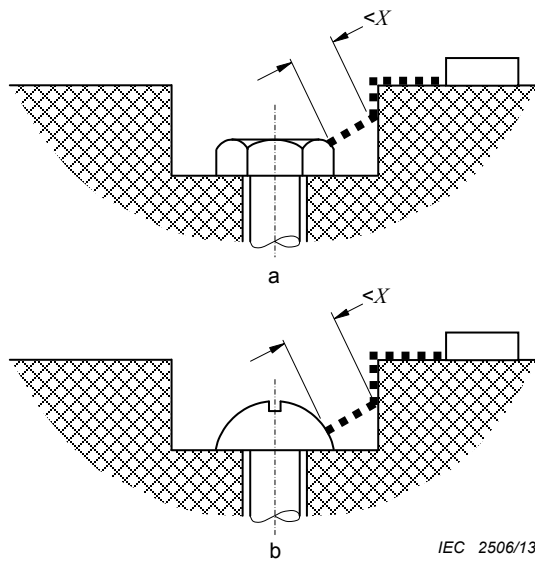
The **creepage distance** path follows the contour of the groove.

The rule for Figure B.3 applies as well to the internal corners if they are less than  $80^\circ$ .

**Figure B.8 – Diverging side walls**

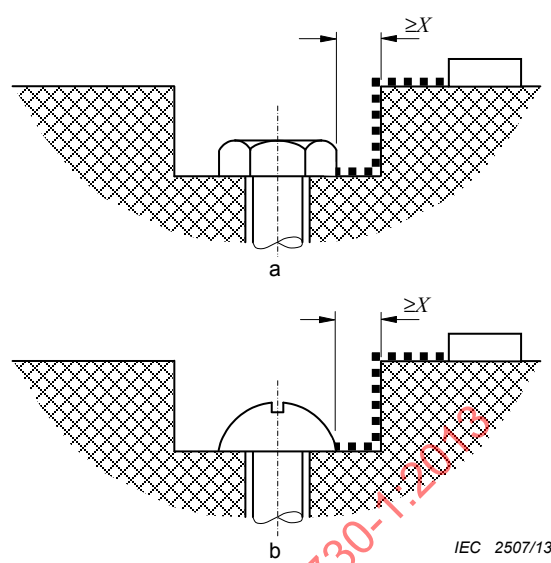
— Clearance

..... Creepage distance



Gap between head of screw and wall of recess too narrow to be taken into account for the creepage distance path.

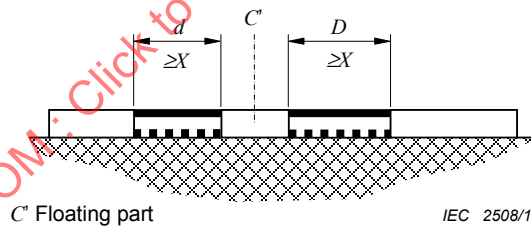
Figure B.9 – Narrow recess



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      ■■■■■ Creepage distance



Clearance is the distance  $d + D$

Creepage distance is also  $d + D$

— Clearance      ■■■■■ Creepage distance

Figure B.11 – Conductive floating part



## **Annex C** (normative)

### **Cotton used for mercury switch test** (not applicable in the countries members of CENELEC)

#### **C.1 Classification**

Non-sterile.

#### **C.2 General requirements**

Absorbent cotton shall be made from corded fibres, bleached white, free from adhering impurities and fatty material.

#### **C.3 Fibre length**

Not less than 60 % of the fibres by mass shall be at least 12 mm in length; not more than 10 % by mass may be 6 mm or less in length.

#### **C.4 Absorbency**

A specimen of cotton shall be completely submerged in water within 10 s. The specimen shall retain not less than 24 times its mass of water.

#### **C.5 Acidity and alkalinity**

A water extract of the cotton shall be neutral.

#### **C.6 Residue on ignition**

There shall be not more than 0,2 % of residue.

#### **C.7 Water soluble material**

There shall be not more than 0,25 % of residue.

#### **C.8 Fatty material**

There shall be no trace of blue, green or brownish colour in the ether solution and the amount of residue shall not exceed 0,7 %.

#### **C.9 Dyes**

There shall be no evidence of a blue or green tint. A slight yellow is acceptable.

#### **C.10 Other foreign matter**

The pinches of cotton taken for determination of fibre length shall not contain oil stains or metallic particles.

**Annex D**  
(informative)

**Heat, fire and tracking**

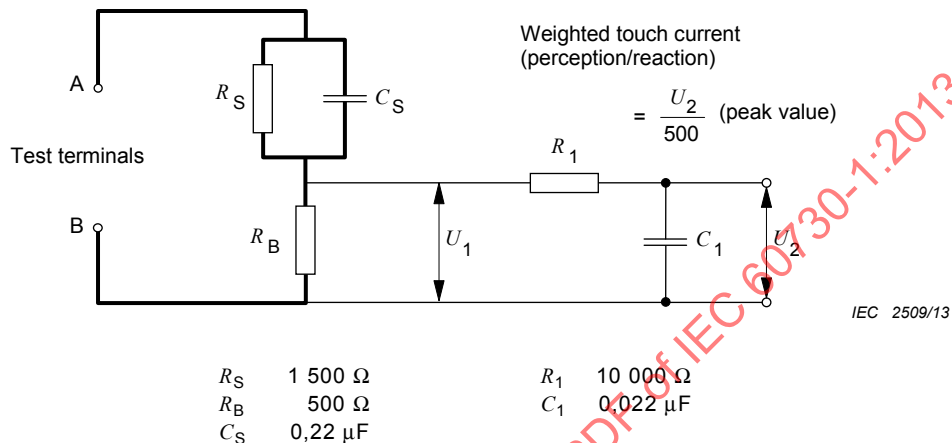
UL 746C is applicable in Canada and the USA. Revision is under consideration.

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## Annex E (normative)

### Circuit for measuring leakage current

A suitable circuit for measuring **leakage current** in accordance with H.8.1.10 is shown in Figure E.1.



NOTE This figure is taken from IEC 60990:1999, Figure 4.

**Figure E.1 – Circuit for measuring leakage currents**

## **Annex F** (informative)

### **Fire hazard testing**

Information for **controls** to be integrated or incorporated into appliances according to the IEC 60335 series is given by a reference to IEC 60335-1.

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## **Annex G** (normative)

### **Heat and fire resistance tests**

#### **G.1 Void**

#### **G.2 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.3 Void**

#### **G.4 Proof tracking test**

*The proof tracking test is made in accordance with IEC 60112.*

*For the purpose of this standard, the following applies:*

- *In Clause 5 of IEC 60112:2003, Test specimen, Note 3 also applies to the proof tracking tests of Clause 10 of IEC 60112:2003.*
- *In Clause 7 of IEC 60112:2003, Test apparatus, Note 1 in 7.1 does not apply. The test solution A described in 7.3 of IEC 60112:2003, Amendment 1:2009 is used.*
- *In 7.3 of IEC 60112:2003, Amendment 1:2009, Test solutions, Solution A shall be used generally.*
- *In 8.2 of IEC 60112:2003, "Preparation", the voltage referred to in the last sentence is set in 21.2.7 of this standard. The proof tracking test of Clause 10 of IEC 60112:2003 is carried out, five times.*

#### **G.5 Ball pressure test**

*The ball pressure test is carried out in accordance with IEC 60695-10-2 (see Figure 6 for test apparatus).*

##### **G.5.1 Ball pressure test 1**

*For the purpose of this standard, 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 14,*
- *75 °C ± 2 °C,*
- *as declared.*

NOTE 1 For **controls** intended for incorporation into appliances within the scope of IEC 60335-1 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.

### G.5.2 Ball pressure test 2

*The ball pressure test is carried out as described in G.5.1 except that the temperature in the heating oven shall be  $T_b \pm 2$  °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 14;*
- the temperature achieved during the test of H.27.1.1.3, 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, the temperature might differ as per 30.1 of that standard.

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## Annex H (normative)

### Requirements for electronic controls

Annex H supplements or modifies the corresponding clauses of this standard.

#### H.2 Terms and definitions

##### H.2.4 Definitions relating to disconnection and interruption

###### H.2.4.2 Addition:

NOTE An **electronic device** does not provide this disconnection.

###### H.2.4.3 Addition:

NOTE An **electronic device** does not provide this disconnection.

###### H.2.4.4 Addition:

NOTE An **electronic device** does not provide this disconnection.

*Add the following definition:*

###### H.2.4.6

###### **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 36.

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

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

**Electronic disconnection** may not be suitable for some applications. See Clause H.28.

##### H.2.5 Definitions of type of control according to construction

*Add the following definitions:*

###### H.2.5.7

###### **electronic control**

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

###### H.2.5.8

###### **electronic device**

device which produces a dynamic imbalance of electrons

Note 1 to entry: The essential function and construction are based on semi-conductor device, vacuum tube or gas discharge tube technology.

#### H.2.5.9

##### **electronic assembly**

group of components, at least one of which is an **electronic device**, but in which individual parts may 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.

#### H.2.5.10

##### **integrated circuit**

**electronic device** contained within the bulk of a semi-conductor material and interconnected at or near the surface of that material

Note 1 to entry: The semi-conductor material is normally enclosed within some form of encapsulation.

#### H.2.5.11

##### **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

### H.2.7 Definitions relating to protection against electric shock

Add the following definition:

#### H.2.7.14

##### **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

Add the following definitions:

### H.2.16 Definitions relating to the structure of controls using software

#### H.2.16.1

##### **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.2.16.2

##### **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.2.16.3

##### **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.2.16.4

##### **single channel**

structure in which a single functional means is used to execute specified **operations**



**H.2.16.5****single channel with functional test**

**single channel** structure in which test data is introduced to the functional unit prior to its operation

**H.2.16.6****single channel with periodic self-test**

**single channel** structure in which components of the **control** are periodically tested during operation

**H.2.16.7****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

**H.2.17 Definitions relating to error avoidance in controls using software****H.2.17.1****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.2.17.2****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.2.17.3****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.2.17.4****hardware simulation**

method of analysis in which circuit function and component tolerances are examined by use of a computer model

**H.2.17.5****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.2.17.6****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.2.17.7 Static analysis****H.2.17.7.1****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.2.17.7.2

##### **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.2.17.8

##### **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**.

#### H.2.17.8.1

##### **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.2.17.8.2

##### **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.2.17.9

##### **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.2.17.10

##### **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.2.18 Definitions relating to fault/error control techniques for controls using software

#### H.2.18.1 Bus redundancy

##### H.2.18.1.1

##### **full bus redundancy**

**fault/error control** technique in which full redundant data and/or address are provided by means of redundant bus structure

##### H.2.18.1.2

##### **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.2.18.1.3****single bit bus parity**

**fault/error control** technique in which the bus is extended by one bit and this additional bit is used for error detection

**H.2.18.2****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.2.18.2.1 and H.2.18.2.2)

**H.2.18.2.1****data redundancy**

form of **code safety** in which the storage of redundant data occurs

**H.2.18.2.2****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.

**H.2.18.3****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.2.18.4****d.c. 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.2.18.5****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.2.18.6****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.2.18.7**

##### **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.2.18.8**

##### **input comparison**

**fault/error control** technique by which inputs that are designed to be within specified tolerances are compared

#### **H.2.18.9**

##### **internal error detection**

**fault/error control** technique in which special circuitry is incorporated to detect or correct errors

#### **H.2.18.10 Programme sequence**

##### **H.2.18.10.1**

##### **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.2.18.10.2**

##### **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.2.18.10.3**

##### **time-slot and logical monitoring**

this is a combination of H.2.18.10.2 and H.2.18.10.4

##### **H.2.18.10.4**

##### **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.2.18.11**

##### **multiple parallel outputs**

**fault/error control** technique in which **independent** outputs are provided for operational error detection or for **independent comparators**

#### **H.2.18.12**

##### **output verification**

**fault/error control** technique in which outputs are compared to **independent** inputs

Note 1 to entry: This technique may or may not relate an error to the output which is defective.

**H.2.18.13****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.2.18.14****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.2.18.15****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.

**H.2.18.16****redundant data generation**

availability of two or more **independent** means, such as code generators, to perform the same task

**H.2.18.17****redundant monitoring**

availability of two or more **independent** means such as watchdog devices and **comparators** to perform the same task

**H.2.18.18****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.2.18.19****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.2.18.20****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.2.18.21****tested monitoring**

the provision of **independent** means such as watchdog devices and **comparators** which are tested at start-up or periodically during **operation**

#### **H.2.18.22 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.2.19 Definitions relating to memory tests for controls using software**

#### **H.2.19.1 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  $30n$ , 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.2.19.2 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.

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.2.19.2.1 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.2.19.3 Checksum**

#### **H.2.19.3.1 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.2.19.3.2****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.2.19.4 Cyclic redundancy check (CRC)****H.2.19.4.1****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.2.19.4.2****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.2.19.5****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

**H.2.19.6****static memory test**

**fault/error control** technique which is intended to detect only static errors

**H.2.19.6.1****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.2.19.6.2****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.2.19.7

#### **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.2.19.8 Word protection

#### H.2.19.8.1

##### **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.2.19.8.2

##### **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.2.20 Definitions of software terminology – General

#### H.2.20.1

##### **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

#### H.2.20.2

##### **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.2.20.3

##### **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.2.20.4

##### **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.2.20.5****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.2.20.6****variable memory**

memory ranges in a processor system containing data which is intended to vary during programme execution

**H.2.21 Void****H.2.22 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:

**H.2.22.1****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.2.22.2****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.

**H.2.22.3****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.2.23 Definitions relating to functional safety****H.2.23.1****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.2.23.2**

##### **fault reaction time**

time between the occurrence of a **fault** and the point where the **control** has reached a **defined state**

#### **H.2.23.3**

##### **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.2.23.4**

##### **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 H.24

#### **H.2.23.5**

##### **reset**

action which provides reset from safe-state to allow the **system** to attempt a restart

#### **H.2.23.6 Void**

#### **H.2.23.7**

##### **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**.

[SOURCE: IEC 60050-161:1990, 161-01-19]

#### **H.2.23.8 Void**

#### **H.2.23.9**

##### **harm**

physical injury or damage to health of people, or damage to property or the **environment**

[SOURCE: ISO/IEC Guide 51:1999, 3.3]

#### **H.2.23.10**

##### **hazard**

potential source of **harm**

[SOURCE: ISO/IEC Guide 51:1999, 3.5]

**H.2.23.11****risk**

combination of the probability of occurrence of **harm** and the severity of that **harm**

[SOURCE: ISO/IEC Guide 51:1999, 3.2]

**H.2.23.12****reasonably foreseeable misuse**

use of a product, process or service under conditions or for purposes not intended by the supplier, but which may happen, induced by the design of the product in combination with, or as result of, common human behaviour

[SOURCE: ISO/IEC Guide 51:1999, 3.14 modified, – "in a way not intended by the supplier, but which may result from readily predictable human behaviour" have been added.]

**H.2.23.13****functional safety**

safety related to the application which depends on the correct functioning of the safety-related **control**

**H.2.24 Definitions related to access to data exchange****H.2.24.1****sequence number**

additional data field containing a number that changes in a predefined way from message to message

**H.2.24.2****time stamp**

information concerning time of **transmission** attached to a message by the sender

**H.2.24.3****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.2.24.4****feed-back message**

response from a receiver to the sender, via a return channel

**H.2.24.5****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.2.24.6****safety code**

redundant data included in a safety-related message to permit data corruptions to be detected by the safety-related transmission function

#### H.2.24.7

##### **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.2.24.8

##### **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.4 General notes on tests

#### H.4.1 Conditions of test

##### H.4.1.4 *Addition:*

*For **electronic controls**, the tests of Clauses H.25, H.26 and H.27 are carried out before the tests of Clause 21.*

*Additional subclauses:*

**H.4.1.9** ***Electronic controls** shall be tested as **electrical controls**, unless otherwise specified.*

**H.4.1.10** *When conducting the test sequence for **electronic controls**, care shall be taken that the results of a test are not influenced adversely by any preceding testing of the sample unless specifically required by the standard. It may be necessary to replace that sample, or parts thereof, or to use an additional sample.*

NOTE The number of samples can be kept to the minimum by an evaluation of the relevant circuits.

**H.4.1.11** *Except for the test specified in Clause H.26, care shall be taken that the supply is free of such perturbations from external sources as may influence the results of the tests on **electronic controls**.*

### H.6 Classification

#### H.6.4 According to features of automatic action

##### H.6.4.3 *Additional subclause:*

**H.6.4.3.13** – **electronic disconnection on operation** (Type 1.Y – 2.Y)

#### H.6.9 According to circuit disconnection or interruption

*Addition:*

**H.6.9.5** – **electronic disconnection**

**H.6.18** According to classes of control functions (see Table 1, requirement 92)

**H.6.18.1** – **Control of class A control functions**

**H.6.18.2 – Control of class B control functions****H.6.18.3 – Control of class C control functions****H.7 Information***Additional items to Table 1<sup>m</sup> (1 of 2)*

| Information                         |                                                                                                                                                                                                                                                                                                                                             | Clause or subclause                                              | Method |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|--------|
| <i>Modification:</i>                |                                                                                                                                                                                                                                                                                                                                             |                                                                  |        |
| 36                                  | Limits of <b>activating quantity</b> for any <b>sensing element</b> over which <b>micro-disconnection</b> or <b>electronic disconnection</b> is secure                                                                                                                                                                                      | 11.3.2,<br>H.11.4.16,<br>H.17.14,<br>H.18.1.5,<br>H.27.1.1, H.28 | X      |
| <i>Additional items to Table 1:</i> |                                                                                                                                                                                                                                                                                                                                             |                                                                  |        |
| 52                                  | The minimum parameters of any heat dissipator (for example, heat sink) not provided with an <b>electronic control</b> but essential to its correct <b>operation</b>                                                                                                                                                                         | 14                                                               | D      |
| 53                                  | Type of output waveform if other than sinusoidal                                                                                                                                                                                                                                                                                            | H.25                                                             | X      |
| 54                                  | Details of the <b>leakage current</b> waveform produced after <b>failure</b> of the <b>basic insulation</b>                                                                                                                                                                                                                                 | H.27                                                             | X      |
| 55                                  | The relevant parameters of those <b>electronic devices</b> or other circuit components considered as unlikely to fail (see paragraph 1 of H.27.1.1.4)                                                                                                                                                                                       | H.27                                                             | X      |
| 56                                  | Type of output waveform(s) produced after <b>failure</b> of an <b>electronic device</b> or other circuit component (see item g) of H.27.1.1.3)                                                                                                                                                                                              | H.27                                                             | X      |
| 57                                  | The effect on controlled output(s) after electronic circuit component <b>failure</b> if relevant (item c) of H.27.1.1.3)                                                                                                                                                                                                                    | H.27                                                             | X      |
| 58a                                 | For integrated and incorporated <b>electronic controls</b> , if any protection against mains borne perturbations, magnetic and electromagnetic disturbances is claimed, which of the tests of Clause H.26 shall be performed and the effect on controlled output(s) and function after a <b>failure</b> to operate as a result of each test | H.26.2<br>H.26.15                                                | X      |
| 58b                                 | For other than integrated and incorporated <b>electronic controls</b> , the effect on controlled output(s) and function after a <b>failure</b> to operate as a result of the tests of Clause H.26                                                                                                                                           | H.26.2<br>H.26.15                                                | X      |
| 59                                  | Any component on which reliance is placed for <b>electronic disconnection</b> which is disconnected as required by footnote n to Table 12                                                                                                                                                                                                   | 13.2<br>H.27.1                                                   | X      |
| 60                                  | Installation class (surge immunity)                                                                                                                                                                                                                                                                                                         | H.26.8.2<br>Annex R                                              | X      |
| 66                                  | Software sequence documentation <sup>m n o p</sup>                                                                                                                                                                                                                                                                                          | H.11.12.2.9                                                      | X      |
| 67                                  | Programme documentation <sup>m q p</sup>                                                                                                                                                                                                                                                                                                    | H.11.12.2.9<br>H.11.12.2.12                                      | X      |
| 68                                  | Software <b>fault</b> analysis <sup>m o p</sup>                                                                                                                                                                                                                                                                                             | H.11.12<br>H.27.1.1.4                                            | X      |
| 69                                  | Software class(es) and structure <sup>r</sup>                                                                                                                                                                                                                                                                                               | H.11.12.2<br>H.11.12.3<br>H.27.1.2.2.1<br>H.27.1.2.3.1           | D      |
| 70                                  | Analytical measures and <b>fault/error</b> control techniques employed <sup>m s</sup>                                                                                                                                                                                                                                                       | H.11.12.1.2<br>H.11.12.2.2<br>H.11.12.2.4                        | X      |
| 71                                  | <b>Software fault/error detection time(s)</b> for <b>controls</b> with software classes B or C <sup>m t</sup>                                                                                                                                                                                                                               | H.2.17.10<br>H.11.12.2.6                                         | X      |
| 72                                  | <b>Control</b> response(s) in case of detected <b>fault/error</b> <sup>m</sup>                                                                                                                                                                                                                                                              | H.11.12.2.7                                                      | X      |
| 73                                  | <b>Controls</b> subjected to a second <b>fault</b> analysis and declared condition as a result of the second <b>fault</b>                                                                                                                                                                                                                   | H.27.1.2.3                                                       | X      |
| 74                                  | External load and emission control measures to be used for test purposes                                                                                                                                                                                                                                                                    | H.23.1.1                                                         | X      |

Additional items to Table 1 (2 of 2)

| Information                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Clause or subclause                                                                                      | Method |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|--------|
| 91 Fault reaction time                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | H.2.23.2<br>H.27.1.2.2.2<br>H.27.1.2.2.3<br>H.27.1.2.3.2<br>H.27.1.2.3.3<br>H.27.1.2.4.2<br>H.27.1.2.4.3 | X      |
| 92 Class or classes of <b>control</b> function(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | H.6.18<br>H.27.1.2.2<br>H.27.1.2.3                                                                       | X      |
| 93 Maximum number of <b>reset</b> actions within a time period                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | H.11.12.4.3.6<br>H.11.12.4.3.4                                                                           | D      |
| 94 Number of remote <b>reset</b> actions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | H.17.1.4.3                                                                                               | X      |
| <p><sup>m</sup> For <b>controls</b> declared as entirely Class A, the requirements 66, 67, 68, 70, 71 and 72 are exempted. For <b>controls</b> 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.</p> <p><sup>n</sup> The software sequence shall be documented and, together with the <b>operating sequence</b> of table requirement 46, shall include a description of the <b>control system</b> philosophy, the <b>control</b> flow, data flow and the timings.</p> <p><sup>o</sup> Safety-related data and safety-related segments of the software sequence, the malfunction of which could result in non-compliance with the requirements of 17, 25, 26 and 27, shall be identified. This identification shall include the <b>operating sequence</b> and may, for example, take the form of a <b>fault</b> tree analysis which shall include those <b>fault</b>/errors of Table H.1 which could result in non-compliance. The software <b>fault</b> analysis shall be related to the hardware <b>fault</b> analysis in Clause H.27.</p> <p><sup>p</sup> Examples of other information which may be suitable for inclusion in the documentation required by footnotes m, n, o, q, r and s are:</p> <p>Original software system specification, for example:</p> <ul style="list-style-type: none"> <li>– functional specification, including procedure for restart on loss of supply,</li> <li>– module design, including description of equipment interfaces, and description of <b>user</b> interfaces,</li> <li>– detailed design, including description of use of memory,</li> <li>– code listing, including programming language identification, comments and listing of subroutines,</li> <li>– test specification,</li> <li>– manuals for installation, use and/or maintenance.</li> </ul> <p><sup>q</sup> Programming documentation shall be supplied in a programming design language declared by the manufacturer.</p> <p><sup>r</sup> Within a <b>control</b>, different software classes may apply to different <b>control</b> functions. Examples of <b>control</b> functions that may include software classes A to C are as follows:</p> <p>Class A – Examples are room thermostats, humidity controls, lighting controls, timers and time switches.</p> <p>Class B – An example is a thermal cut-out.</p> <p>Class C – Examples are automatic burner <b>controls</b> and thermal cut-outs for closed water heater systems (unvented).</p> <p><sup>s</sup> Measures to be declared are those chosen by the manufacturer from the requirements of H.11.12.1.2 to H.11.12.2.4 inclusive.</p> <p><sup>t</sup> This can be expressed as a time following the execution of a specific software segment.</p> |                                                                                                          |        |

## H.8 Protection against electric shock

### H.8.1 General requirements

*Additional subclauses:*

**H.8.1.10 Accessible parts** shall not be considered as **hazardous live parts** if separated from the supply by **protective impedance**.

**H.8.1.10.1** When **protective impedance** is used, the current between the part or parts and either pole of the supply source shall not exceed 0,7 mA (peak value) a.c. or 2 mA d.c;

- 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  $\mu\text{F}$ ;
- 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  $\mu\text{C}$ ;
- 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 part** (or any combination of such parts) and either pole of the supply source.*

*The measuring circuit shall have a total impedance of  $(1\,750 \pm 250)\, \Omega$  and be shunted by a capacitor such that the time constant of the circuit is  $(225 \pm 15)\, \mu\text{s}$ .*

Details of a suitable measuring circuit are shown in Figure E.1.

The measuring circuit shall have an accuracy of within 5 % for all frequencies in the range of 20 Hz to 5 kHz. For frequencies above 5 kHz, alternative methods of measurement are required.

## H.11 Constructional requirements

### H.11.2 Protection against electric shock

*Additional subclauses:*

**H.11.2.5 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 pointed out in Table H.24, footnote c.

Alternatively, the resistors shall comply with the requirements of 14.1 of IEC 60065:2001, Amendment 1:2005.

*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 Clause H.27);
- c) applying a **fault** condition according to Clause H.27 to any part of the circuit which might influence the maximum **leakage 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 H.8.1.10.

#### H.11.4 Actions

*Additional subclauses:*

**H.11.4.16** Type 1.Y or 2.Y action shall operate to provide **electronic disconnection**.

*Compliance is checked by the tests of H.11.4.16.*

**H.11.4.16.1** The test is carried out with the **control** connected to its declared maximum load, supplied with rated voltage, and at temperature  $T_{\max}$ .

**H.11.4.16.2** The current through the **electronic disconnection** shall not exceed 5 mA or 10 % of the rated current, whichever is the lower.

#### H.11.12 Controls using software

**Controls** using software shall be so constructed that the software does not impair **control** compliance with the requirements of this standard.

*Compliance is checked by the tests for **electronic controls** in this standard, by **inspection** according to the requirements of H.11.12 and by examination of the documentation required in requirements 66 to 72 inclusive of Table 1.*

Subclauses H.11.12.1 to H.11.12.4 inclusive are only applicable to **control** functions using software class B or class C.

Subclause H.11.12.4 contains additional requirements for **remotely actuated control functions**.

##### H.11.12.1 Requirements for the architecture

**H.11.12.1.1** **Control** functions with software class B or C shall use measures to control and avoid software-related **faults**/errors in safety-related data and safety-related segments of the software, as detailed in H.11.12.1.2 to H.11.12.3 inclusive.

##### H.11.12.1.2 Structure for control functions with software class B or C

**H.11.12.1.2.1** **Control** functions with software class C shall have one of the following structures:

- **single channel with periodic self-test and monitoring** (H.2.16.7);
- **dual channel (homogenous) with comparison** (H.2.16.3);
- **dual channel (diverse) with comparison** (H.2.16.2).



NOTE Comparison between **dual channel** structures can be performed:

- by the use of a **comparator** (H.2.18.3) or
- by **reciprocal comparison** (H.2.18.15).

**H.11.12.1.2.2 Control** functions with software class B shall have one of the following structures:

- **single channel with functional test** (H.2.16.5);
- **single channel with periodic self-test** (H.2.16.6);
- **dual channel** without comparison (H.2.16.1).

A software class C structure is also acceptable for a software class B structure.

**H.11.12.1.3** Other structures are permitted if they can be shown to provide an equivalent level of safety to those in H.11.12.1.2.

#### **H.11.12.2 Measures to control faults/errors**

**H.11.12.2.1** 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 **software diversity**).

**H.11.12.2.2 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.11.12.2.3** 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. Such means shall take into account errors in data, addressing, **transmission** timing and sequence of protocol.

**H.11.12.2.4** 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.1 and identified in Table 1, requirement 68.

**Table H.1 (H.11.12.7 of edition 3) – Acceptable measures to address fault/errors<sup>a</sup> (1 of 6)**

| Component <sup>b</sup>                    | Fault/error                  | Software class |    | Example of acceptable measures <sup>c d e</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Definitions                                                                                                                                                                   |
|-------------------------------------------|------------------------------|----------------|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                           |                              | B              | C  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                               |
| 1. CPU<br>1.1<br>Registers                | Stuck at<br><br>DC fault     | rq             | rq | Functional test, or<br>periodic self-test using either:<br>– <b>static memory test</b> , or<br>– <b>word protection with single bit redundancy</b><br>Comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> , or<br><b>internal error detection</b> , or<br><b>redundant memory with comparison</b> , or<br>periodic self-tests using either<br>– <b>walkpat memory test</b><br>– <b>Abraham test</b><br>– <b>transparent GALPAT test</b> , or<br><b>word protection with multi-bit redundancy</b> , or<br><b>static memory test</b> and word protection with single bit redundancy | H.2.16.5<br>H.2.16.6<br>H.2.19.6<br>H.2.19.8.2<br>H.2.18.15<br>H.2.18.3<br>H.2.18.9<br>H.2.19.5<br>H.2.19.7<br>H.2.19.1<br>H.2.19.2.1<br>H.2.19.8.1<br>H.2.19.6<br>H.2.19.8.2 |
| 1.2<br>Instruction decoding and execution | Wrong decoding and execution |                | rq | Comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> , or<br><b>internal error detection</b> , or<br>periodic self-test using <b>equivalence class test</b>                                                                                                                                                                                                                                                                                                                                                                                                                        | H.2.18.15<br>H.2.18.3<br>H.2.18.9<br>H.2.18.5                                                                                                                                 |
| 1.3<br>Programme counter                  | Stuck at<br><br>DC fault     | rq             | rq | Functional test, or<br>periodic self-test, or<br><b>independent time-slot monitoring of the program sequence</b> , or<br><b>logical monitoring of the programme sequence</b><br>Periodic self-test and monitoring using either:<br>– <b>independent time-slot and logical monitoring</b><br>– <b>internal error detection</b> , or<br>comparison of redundant functional channels by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b>                                                                                                                                                                          | H.2.16.5<br>H.2.16.6<br>H.2.18.10.4<br>H.2.18.10.2<br>H.2.16.7<br>H.2.18.10.3<br>H.2.18.9<br>H.2.18.15<br>H.2.18.3                                                            |

Table H.1 (2 of 6)

| Component <sup>b</sup>                       | Fault/error                                                                                                                              | Software class |    | Example of acceptable measures <sup>c d e</sup>                                                                                                                                                                                                                                                                    | Definitions                                                                            |
|----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|----------------|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
|                                              |                                                                                                                                          | B              | C  |                                                                                                                                                                                                                                                                                                                    |                                                                                        |
| 1.4<br>Addressing                            | DC <b>fault</b>                                                                                                                          |                | rq | Comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> ; or<br><b>Internal error detection</b> ; or<br>periodic self-test using a <b>testing pattern</b> of the address lines; or<br><b>full bus redundancy</b> , or<br><b>multi-bit bus parity</b> | H.2.18.15<br>H.2.18.3<br>H.2.18.9<br>H.2.16.7<br>H.2.18.22<br>H.2.18.1.1<br>H.2.18.1.2 |
| 1.5<br>Data paths<br>instruction<br>decoding | DC <b>fault</b><br>and<br>execution                                                                                                      |                | rq | Comparison of redundant CPUs by either:<br><b>reciprocal comparison</b> , or<br><b>independent hardware comparator</b> , or<br><b>Internal error detection</b> , or<br>periodic self-test using a <b>testing pattern</b> , or<br><b>data redundancy</b> , or<br><b>multi-bit bus parity</b>                        | H.2.18.15<br>H.2.18.3<br>H.2.18.9<br>H.2.16.7<br>H.2.18.2.1<br>H.2.18.1.2              |
| 2.<br>Interrupt<br>handling and<br>execution | No interrupt<br>or too<br>frequent<br>interrupt<br>No interrupt<br>or too<br>frequent<br>interrupt<br>related to<br>different<br>sources | rq             | rq | Functional test; or<br>time-slot monitoring<br><br>Comparison of redundant functional<br>channels by either<br><b>reciprocal comparison</b> ,<br><b>independent hardware comparator</b> , or<br><b>Independent time-slot and logical<br/>monitoring</b>                                                            | H.2.16.5<br>H.2.18.10.4<br><br>H.2.18.15<br>H.2.18.3<br>H.2.18.10.3                    |

**Table H.1 (3 of 6)**

| Component <sup>b</sup>                       | Fault/error                                                                   | Software class |    | Example of acceptable measures <sup>c d e</sup>                                                                                                                                                                                                                                                                                                                                                                                                                       | Definitions                                                                                                           |
|----------------------------------------------|-------------------------------------------------------------------------------|----------------|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|
|                                              |                                                                               | B              | C  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                       |
| 3.<br>Clock                                  | Wrong frequency (for quartz synchronized clock: harmonics/ subharmonics only) | rq             | rq | <b>Frequency monitoring</b> , or<br>time slot monitoring<br><b>Frequency monitoring</b> , or<br>time-slot monitoring, or<br>comparison of redundant functional channels by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b>                                                                                                                                                                                                      | H.2.18.10.1<br>H.2.18.10.4<br>H.2.18.10.1<br>H.2.18.10.4<br>H.2.18.15<br>H.2.18.3                                     |
| 4. Memory<br>4.1<br><b>Invariable memory</b> | All single bit faults<br><br>99,6 % coverage of all information errors        | rq             | rq | Periodic <b>modified checksum</b> , or<br><b>multiple checksum</b> , or<br><b>word protection with single bit redundancy</b><br>Comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> , or<br><br><b>redundant memory with comparison</b> , or<br>periodic cyclic redundancy check, either<br>single word<br>– double word, or<br><b>word protection with multi-bit redundancy</b>                    | H.2.19.3.1<br>H.2.19.3.2<br>H.2.19.8.2<br>H.2.18.15<br>H.2.18.3<br>H.2.19.5<br>H.2.19.4.1<br>H.2.19.4.2<br>H.2.19.8.1 |
| 4.2<br>Variable memory                       | DC fault<br><br>DC fault and dynamic cross links                              | rq             | rq | Periodic <b>static memory test</b> , or<br><b>word protection with single bit redundancy</b><br>Comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> , or<br><b>redundant memory with comparison</b> , or<br>periodic self-tests using either:<br>– <b>walkpat memory test</b><br>– <b>Abraham test</b><br>– <b>transparent GALPAT test</b> , or<br><b>word protection with multi-bit redundancy</b> | H.2.19.6<br>H.2.19.8.2<br>H.2.18.15<br>H.2.18.3<br>H.2.19.5<br>H.2.19.7<br>H.2.19.1<br>H.2.19.2.1<br>H.2.19.8.1       |

Table H.1 (4 of 6)

| Component <sup>b</sup>                                                                                            | Fault/error                                                | Software class |    | Example of acceptable measures <sup>c d e</sup>                                                                                                                                                                                                                                                                                                                                                                                                | Definitions                                                                                                               |
|-------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|----------------|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                   |                                                            | B              | C  |                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                           |
| 4.3<br>Addressing<br>(relevant to<br><b>variable</b><br><b>memory</b> and<br><b>invariable</b><br><b>memory</b> ) | Stuck at<br><br>DC <b>fault</b>                            | rq             | rq | <b>Word protection with single bit redundancy</b><br>including the address, or<br>comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b> , or<br>– <b>independent hardware comparator</b> , or<br><b>full bus redundancy</b><br><b>Testing pattern</b> , or<br>periodic cyclic redundancy check, either:<br>– single word<br>– double word, or<br><b>word protection with multi-bit redundancy</b><br>including the address | H.2.19.18.2<br><br><br><br><br>H.2.18.15<br>H.2.18.3<br>H.2.18.1.1<br>H.2.18.22<br>H.2.19.4.1<br>H.2.19.4.2<br>H.2.19.8.1 |
| 5. Internal data path<br><br>5.1 Data                                                                             | Stuck at<br><br>DC <b>fault</b>                            | rq             | rq | <b>Word protection with single bit redundancy</b><br>Comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> , or<br><b>word protection with multi-bit redundancy</b><br>including the address, or <b>data redundancy</b> , or<br><b>testing pattern</b> , or<br><b>protocol test</b>                                                                                            | H.2.19.8.2<br><br><br><br><br>H.2.18.15<br>H.2.18.3<br>H.2.19.8.1<br>H.2.18.2.1<br>H.2.18.22<br>H.2.18.14                 |
| 5.2 Addressing                                                                                                    | Wrong address<br><br>Wrong address and multiple addressing | rq             | rq | <b>Word protection with single bit redundancy</b><br>including the address<br>Comparison of redundant CPUs by:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> , or<br><b>word protection with multi-bit redundancy</b> ,<br>including the address, or <b>full bus redundancy</b> ; or <b>testing pattern</b> including the address                                                                              | H.2.19.8.2<br><br><br><br><br>H.2.18.15<br>H.2.18.3<br>H.2.19.8.1<br>H.2.18.1.1<br>H.2.18.22                              |
| 6<br>External communication                                                                                       | <b>Hamming distance 3</b>                                  | rq             |    | <b>Word protection with multi-bit redundancy</b> ,<br>or <b>CRC – single word</b> , or<br><b>transfer redundancy</b> , or<br><b>protocol test</b>                                                                                                                                                                                                                                                                                              | H.2.19.8.1<br>H.2.19.4.1<br>H.2.18.2.2<br>H.2.18.14                                                                       |

**Table H.1 (5 of 6)**

| Component <sup>b</sup>                                 | Fault/error                                        | Software class |                        | Example of acceptable measures <sup>c d e</sup>                                                                                                                                                                                                                                                                                                                                                                                                  | Definitions                                                                                                      |
|--------------------------------------------------------|----------------------------------------------------|----------------|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
|                                                        |                                                    | B              | C                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                  |
| 6.1<br>Data                                            | <b>Hamming distance 4</b>                          |                | rq                     | <b>CRC – double word</b> , or<br><br><b>data redundancy</b> or comparison of redundant functional channels by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b>                                                                                                                                                                                                                                              | H.2.19.4.2<br><br>H.2.18.2.1<br>H.2.18.15<br>H.2.18.3                                                            |
| 6.2<br>Addressing                                      | Wrong address<br><br>Wrong and multiple addressing | rq             | rq                     | <b>Word protection with multi-bit redundancy</b> , including the address, or <b>CRC – single word</b> including the addresses, or<br><b>transfer redundancy</b> or<br><b>protocol test</b><br><b>CRC – double word</b> , including the address, or<br><b>full bus redundancy</b> of data and address, or comparison of redundant communication channels by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> | H.2.19.8.1<br>H.2.19.4.1<br><br>H.2.18.2.2<br>H.2.18.14<br>H.2.19.4.2<br>H.2.18.1.1<br><br>H.2.18.15<br>H.2.18.3 |
| 6.3<br>Timing                                          | Wrong point in time<br><br>Wrong sequence          | rq             | rq<br><br>rq<br><br>rq | Time-slot monitoring, or <b>scheduled transmission</b><br><br><b>Time-slot and logical monitoring</b> , or comparison of redundant communication channels by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b><br><br>Logical monitoring, or time-slot monitoring, or <b>scheduled transmission</b><br>(same options as for wrong point in time)                                                             | H.2.18.10.4<br>H.2.18.18<br>H.2.18.10.3<br><br>H.2.18.15<br>H.2.18.3<br>H.2.18.10.2<br>H.2.18.10.4<br>H.2.18.18  |
| 7.<br>Input/output periphery<br><br>7.1<br>Digital I/O | <b>Fault</b> conditions specified in Clause H.27   | rq             | rq                     | <b>Plausibility check</b><br><br>Comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> , or<br><br><b>input comparison</b> , or<br><b>multiple parallel outputs</b> ; or<br><b>output verification</b> , or<br><b>testing pattern</b> , or<br><b>code safety</b>                                                                                                                 | H.2.18.13<br><br>H.2.18.15<br>H.2.18.3<br><br>H.2.18.8<br>H.2.18.11<br>H.2.18.12<br>H.2.18.22<br>H.2.18.2        |

Table H.1 (6 of 6)

| Component <sup>b</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Fault/error                                                                           | Software class |    | Example of acceptable measures <sup>c d e</sup>                                                                                                                                                                                                                                                   | Definitions                                                                               |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|----------------|----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                       | B              | C  |                                                                                                                                                                                                                                                                                                   |                                                                                           |
| 7.2<br>Analog I/O<br>7.2.1 A/D- and<br>D/A- convertor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <b>Fault</b><br>conditions<br>specified in<br>Clause H.27                             | rq             | rq | <b>Plausibility check</b><br><br>Comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> , or<br><b>input comparison</b> , or<br><b>multiple parallel outputs</b> , or<br><b>output verification</b> , or<br><b>testing pattern</b> | H.2.18.13<br><br>H.2.18.15<br>H.2.18.3<br>H.2.18.8<br>H.2.18.11<br>H.2.18.12<br>H.2.18.22 |
| 7.2.2 Analog<br>multiplexer                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Wrong<br>addressing                                                                   | rq             | rq | <b>Plausibility check</b><br><br>Comparison of redundant CPUs by either:<br>– <b>reciprocal comparison</b><br>– <b>independent hardware comparator</b> , or<br><b>input comparison</b> or<br><b>testing pattern</b>                                                                               | H.2.18.13<br><br>H.2.18.15<br>H.2.18.3<br>H.2.18.8<br>H.2.18.22                           |
| 8.<br>Monitoring<br>devices and<br><b>comparators</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Any output<br>outside the<br>static and<br>dynamic<br>functional<br>specification     |                | rq | <b>Tested monitoring</b> , or<br><b>redundant monitoring</b> and comparison, or<br><b>error recognizing means</b>                                                                                                                                                                                 | H.2.18.21<br>H.2.18.17<br>H.2.18.6                                                        |
| 9.<br>Custom<br>chips <sup>f</sup><br>for example,<br>ASIC,<br>GAL, Gate<br>array                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Any output<br>outside the<br>static and<br><br>dynamic<br>functional<br>specification | rq             | rq | Periodic self-test<br><br>Periodic self-test and monitoring, or<br><br><b>dual channel (diverse) with comparison</b> , or<br><b>error recognizing means</b>                                                                                                                                       | H.2.16.6<br><br>H.2.16.7<br><br>H.2.16.2<br>H.2.18.6                                      |
| <p>CPU: Central programming unit</p> <p>rq: Coverage of the <b>fault</b> is required for the indicated software class.</p> <p><sup>a</sup> Table H.1 is applied according to the requirements of H.11.12 to H.11.12.2.12 inclusive.</p> <p><sup>b</sup> For <b>fault</b>/error assessment, some components are divided into their subfunctions.</p> <p><sup>c</sup> For each subfunction in the table, the software class C measure will cover the software class B <b>fault</b>/error.</p> <p><sup>d</sup> It is recognized that some of the acceptable measures provide a higher level of assurance than is required by this standard.</p> <p><sup>e</sup> Where more than one measure is given for a subfunction, these are alternatives.</p> <p><sup>f</sup> To be divided as necessary by the manufacturer into subfunctions.</p> |                                                                                       |                |    |                                                                                                                                                                                                                                                                                                   |                                                                                           |

**H.11.12.2.5** Measures others than those specified in H.11.12.2.4 are permitted if they can be shown to satisfy the requirements listed in Table H.1.

**H.11.12.2.6** Software **fault**/error detection shall occur not later than the time declared in requirement 71 of Table 1. The acceptability of the declared time(s) is evaluated during the **fault** analysis of the **control**.

Part 2 standards may limit this declaration.

**H.11.12.2.7** For **controls** with functions, classified as Class B or C, detection of a **fault**/error shall result in the response declared in Table 1, requirement 72. For **controls** with functions declared as class C, **independent** means capable of performing this response shall be provided.

**H.11.12.2.8** 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.11.12.2.9** The software shall be referenced to relevant parts of the **operating sequence** and the associated hardware functions.

**H.11.12.2.10** Where labels are used for memory locations, these labels shall be unique.

**H.11.12.2.11** The software shall be protected from **user** alteration of safety-related segments and data.

**H.11.12.2.12** The software and safety-related hardware under its control shall be initialized to, and terminate at, a declared state as indicated in Table 1, requirement 66.

### **H.11.12.3 Measures to avoid errors**

**Control** functions with software class C shall have one of the following structures.

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. Such means shall take into account errors in data, addressing, **transmission** timing and sequence of protocol.

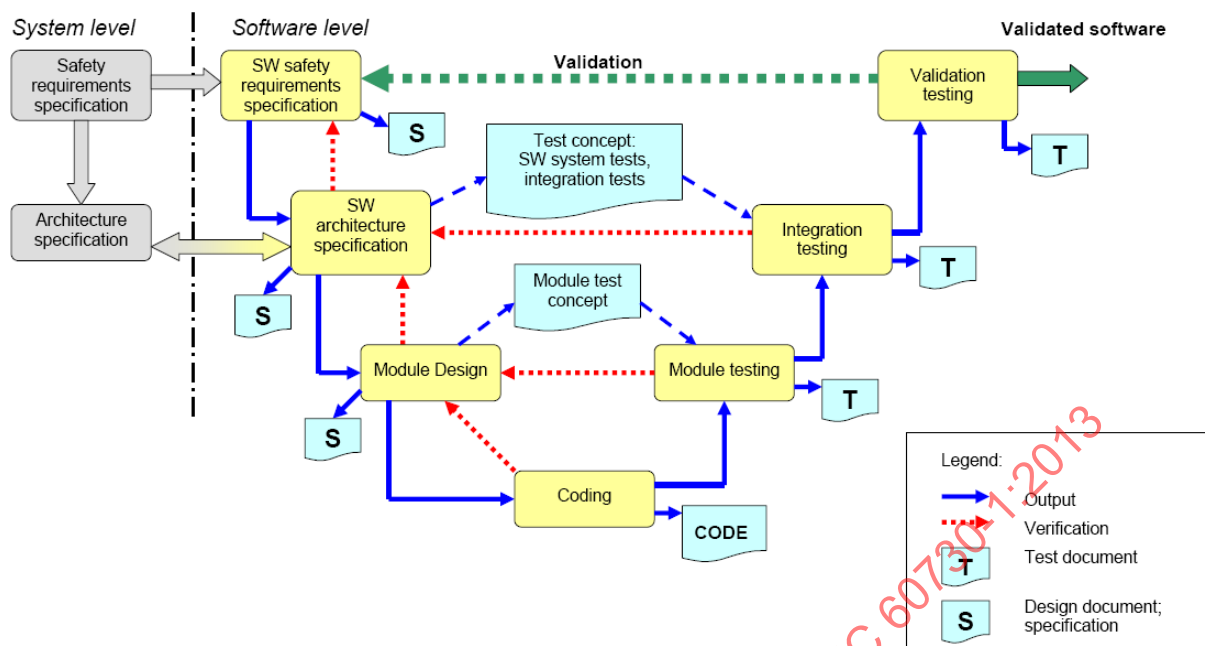
#### **H.11.12.3.1 General**

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 standard.





IEC 2510/13

**Figure H.1 – V-Model for the software life cycle**

Other methods are possible if they incorporate disciplined and structured processes including design and test phases.

#### H.11.12.3.2 Specification

##### H.11.12.3.2.1 Software safety requirements

H.11.12.3.2.1.1 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.2.

**Table H.2 – Semi-formal methods**

| Technique/Measure                                                                                                                                                                                                                  | References (informative)                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Standards identification                                                                                                                                                                                                           |                                                          |
| Semi-formal methods <ul style="list-style-type: none"> <li>– Logical/functional block diagrams</li> <li>– Sequence diagrams</li> <li>– Finite state machines/state transition diagrams</li> <li>– Decision/truth tables</li> </ul> | B.2.3.2 of IEC 61508-7:2010<br>C.6.1 of IEC 61508-7:2010 |

Other methods to comply with the requirements can be applied.

### H.11.12.3.2.2 Software architecture

**H.11.12.3.2.2.1** The description of software architecture shall include the following aspects:

- techniques and measures to control software **faults**/errors (refer to H.11.12.2);
- 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.3.

**Table H.3 – Software architecture specification**

| Technique/Measure                                                                                                                                                                                                            | References (informative)                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Fault</b> detection and diagnosis                                                                                                                                                                                         | C.3.1 of IEC 61508-7:2010                                |
| Semi-formal methods: <ul style="list-style-type: none"> <li>– Logic/function block diagrams</li> <li>– Sequence diagrams</li> <li>– Finite state machines/state transition diagrams</li> <li>– Data flow diagrams</li> </ul> | B.2.3.2 of IEC 61508-7:2010<br>C.2.2 of IEC 61508-7:2010 |

**H.11.12.3.2.2.2** 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.11.12.3.2.3 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 C.2.5 of IEC 61508-7:2010.

**H.11.12.3.2.3.1** 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.4.

**Table H.4 – Module design specification**

| Technique/Measure                                                                                                                                                                                                            | References (informative)                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Limited size of software modules                                                                                                                                                                                             | C.2.9 of IEC 61508-7:2010                                |
| Information hiding/encapsulation                                                                                                                                                                                             | C.2.8 of IEC 61508-7:2010                                |
| One entry/one exit point in subroutines and functions                                                                                                                                                                        | C.2.9 of IEC 61508-7:2010                                |
| Fully defined interface                                                                                                                                                                                                      | C.2.9 of IEC 61508-7:2010                                |
| Semi-formal methods: <ul style="list-style-type: none"> <li>– Logic/function block diagrams</li> <li>– Sequence diagrams</li> <li>– Finite state machines/state transition diagrams</li> <li>– Data flow diagrams</li> </ul> | B.2.3.2 of IEC 61508-7:2010<br>C.2.2 of IEC 61508-7:2010 |

**H.11.12.3.2.3.2 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.5.

**Table H.5 – Design and coding standards**

| Technique/Measure                                                                                                                                                                                                                                               | References (informative)    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|
| Use of coding standard (see H.11.12.3.2.4)                                                                                                                                                                                                                      | C.2.6.2 of IEC 61508-7:2010 |
| No use of dynamic objects and variables (see Note)                                                                                                                                                                                                              | C.2.6.3 of IEC 61508-7:2010 |
| Limited use of interrupts                                                                                                                                                                                                                                       | C.2.6.5 of IEC 61508-7:2010 |
| Limited use of pointers                                                                                                                                                                                                                                         | C.2.6.6 of IEC 61508-7:2010 |
| Limited use of recursion                                                                                                                                                                                                                                        | C.2.6.7 of IEC 61508-7:2010 |
| No unconditional jumps in programs in higher level languages                                                                                                                                                                                                    | C.2.6.2 of IEC 61508-7:2010 |
| 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.11.12.3.2.3.3 Coded software shall be verified against the module specification, and the module specification shall be verified against the architecture specification by static analysis.**

NOTE Examples of methods for **static analysis** are:

- **control** flow analysis;
- data flow analysis;
- **walk-throughs**/design reviews.

**H.11.12.3.2.4 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.11.12.3.3 Testing

#### H.11.12.3.3.1 Module design (software system design, software module design and coding)

**H.11.12.3.3.1.1** A test concept with suitable test cases shall be defined based on the module design specification.

**H.11.12.3.3.1.2** Each software module shall be tested as specified within the test concept.

**H.11.12.3.3.1.3** Test cases, test data and test results shall be documented.

**H.11.12.3.3.1.4** 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.6.

**Table H.6 – Software module testing**

| Technique/Measure                                                                                                                                                            | References (informative)                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| <b>Dynamic analysis</b> and testing: <ul style="list-style-type: none"> <li>– Test case execution from boundary value analysis</li> <li>– Structure-based testing</li> </ul> | B.6.5 of IEC 61508-7:2010<br>C.5.4 of IEC 61508-7:2010<br>C.5.8 of IEC 61508-7:2010         |
| Data recording and analysis                                                                                                                                                  | C.5.2 of IEC 61508-7:2010                                                                   |
| Functional and black-box testing: <ul style="list-style-type: none"> <li>– Boundary value analysis</li> <li>– Process simulation</li> </ul>                                  | B.5.1, B.5.2 of IEC 61508-7:2010<br>C.5.4 of IEC 61508-7:2010<br>C.5.18 of IEC 61508-7:2010 |
| Performance testing: <ul style="list-style-type: none"> <li>– Avalanche/stress testing</li> <li>– Response timings and memory constraints</li> </ul>                         | C.5.20 of IEC 61508-7:2010<br>C.5.21 of IEC 61508-7:2010<br>C.5.22 of IEC 61508-7:2010      |
| Interface testing                                                                                                                                                            | C.5.3 of IEC 61508-7:2010                                                                   |

NOTE Software module testing is a verification activity.

#### H.11.12.3.3.2 Software integration testing

**H.11.12.3.3.2.1** A test concept with suitable test cases shall be defined based on the architecture design specification.

**H.11.12.3.3.2.2** The software shall be tested as specified within the test concept.

**H.11.12.3.3.2.3** Test cases, test data and test results shall be documented.

Examples of techniques/measures can be found Table H.7.

**Table H.7 – Software integration testing**

| Technique/Measure                                                                                                                                    | References (informative)                                                                |
|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|
| Functional and black-box testing: <ul style="list-style-type: none"> <li>– Boundary value analysis</li> <li>– Process simulation</li> </ul>          | B.5.1, B.5.2 of IEC 61508-7:2010<br>C.5.4 of IEC 61508-7:2010<br>C.5.18 of IEC 61508-7, |
| Performance testing: <ul style="list-style-type: none"> <li>– Avalanche/stress testing</li> <li>– Response timings and memory constraints</li> </ul> | C.5.20 of IEC 61508-7:2010<br>C.5.21 of IEC 61508-7:2010<br>C.5.22 of IEC 61508-7:2010  |

NOTE Software integration testing is a verification activity.

### **H.11.12.3.3.3 Software validation**

**H.11.12.3.3.3.1** A validation concept with suitable test cases shall be defined based on the software safety requirements specification.

**H.11.12.3.3.3.2** 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.11.12.3.3.3.3** Test cases, test data and test results shall be documented.

Examples of techniques/measures can be found in Table H.8.

**Table H.8 – Software safety validation**

| Technique/Measure                                                                                                                           | References (informative)                                                                    |
|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| Functional and black-box testing: <ul style="list-style-type: none"> <li>– Boundary value analysis</li> <li>– Process simulation</li> </ul> | B.5.1, B.5.2 of IEC 61508-7:2010<br>C.5.4 of IEC 61508-7:2010<br>C.5.18 of IEC 61508-7:2010 |
| Simulation, modeling: <ul style="list-style-type: none"> <li>– Finite state machines</li> <li>– Performance modeling</li> </ul>             | B.2.3.2 of IEC 61508-7:2010<br>C.5.20 of IEC 61508-7:2010                                   |

NOTE Testing is the main validation method for software; modelling can be used to supplement the validation activities.

### **H.11.12.3.4 Other Items**

#### **H.11.12.3.4.1 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 C.4.4 of IEC 61508-7:2010.

#### **H.11.12.3.4.2 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.11.12.3.4.3 Software modification

**H.11.12.3.4.3.1** Software modifications shall be based on a modification request which details the following:

- the **hazards** which may be affected,
- the proposed change,
- the reasons for change.

**H.11.12.3.4.3.2** An analysis shall be carried out to determine the impact of the proposed modification on **functional safety**.

**H.11.12.3.4.3.3** 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.11.12.3.4.3.4** The modification shall be carried out as planned.

**H.11.12.3.4.3.5** The assessment of the modification shall be carried out based on the specified verification and validation activities. This may include:

- a reverification of changed software modules;
- a reverification of affected software modules;
- a revalidation of the complete **system**.

**H.11.12.3.4.3.6** All details of modification activities shall be documented.

**H.11.12.3.5** 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.9 during hardware development.

**Table H.9 (H.11.12.6 of edition 3) – 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.2.17.5 <b>Inspection</b>               | x |   | x |   | x |   | x |   | x |   | x |   | x |   | x |   |
| H.2.17.9 <b>Walk-through</b>             |   |   |   | x |   | x |   | x |   | x |   | x |   | x |   | x |
| H.2.17.7.1 <b>Static analysis</b>        | x | x |   |   |   |   |   |   | x | x |   |   |   |   |   |   |
| H.2.17.1 <b>Dynamic analysis</b>         |   |   | x | x |   |   |   |   |   |   | x | x |   |   |   |   |
| H.2.17.3 <b>Hardware analysis</b>        |   |   |   |   | x | x |   |   |   |   |   |   | x | x |   |   |
| H.2.17.4 <b>Hardware simulation</b>      |   |   |   |   |   |   | x | x |   |   |   |   |   |   | x | x |
| H.2.17.2 <b>Failure rate calculation</b> | x | x | x | x | x | x | x | x |   |   |   |   |   |   |   |   |
| H.2.20.2 <b>FMEA</b>                     |   |   |   |   |   |   |   |   | x | x | x | x | x | x | x | x |
| H.2.17.6 <b>Operational test</b>         | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |

#### H.11.12.4 Remotely actuated control functions

##### H.11.12.4.1 Data exchange

###### H.11.12.4.1.1 General

**Remotely actuated control functions** may be connected to separate, **independent** devices, which may 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**.

#### H.11.12.4.1.2 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 H.10.

**Table H.10 – 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 <b>class B control function</b> or <b>class C control function</b>     | Messages modifying parameters that determine performance related functions     |
| Software modules         | Modules downloaded into a system, that determine related <b>class B control function</b> or <b>class C control function</b> | Modules downloaded into a system, that determine performance related functions |

#### H.11.12.4.1.3 Communication of safety related data

##### H.11.12.4.1.3.1 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 Annex H.*

NOTE 1 Special attention is drawn to Table H.1, component 6, 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.

In addition to the items in Note 1, the following **failure** modes shall be addressed:

- permanent “auto-sending” or repetition,
- interruption of data transfer.

NOTE 2 Additional examples of measures are given in Table H.11.

#### H.11.12.4.1.3.2 Access to data exchange

All types of access to **class B control function** or **class C control function** related data exchange systems shall be clearly restricted.

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 ensure that no unauthorized access to the **control** function is possible. Passwords or cryptographical techniques are considered adequate measures, however other techniques are acceptable, examples of which are given in Table H.11.

**Table H.11 – Examples of defences against unauthorised access and transmission failure modes**

| Threats                                                                                                            | Defences        |            |          |                  |                                |                          |                |                           |
|--------------------------------------------------------------------------------------------------------------------|-----------------|------------|----------|------------------|--------------------------------|--------------------------|----------------|---------------------------|
|                                                                                                                    | Sequence number | Time stamp | Time-out | Feedback message | Sourced destination identifier | Identification procedure | Safety code    | Cyrpto-graphic techniques |
| Repetition of a message                                                                                            | x               | x          |          |                  |                                |                          |                |                           |
| Deletion of data in message                                                                                        | x               |            |          |                  |                                |                          |                |                           |
| Insertion of data in message                                                                                       | x               |            |          | x                | x                              | x                        |                |                           |
| Changed sequence of data in message                                                                                | x               | x          |          |                  |                                |                          |                |                           |
| Corrupted data in message                                                                                          |                 |            |          |                  |                                |                          | X <sup>a</sup> | x                         |
| Delay in sending / receiving the message                                                                           |                 | x          | x        |                  |                                |                          |                |                           |
| Masquerade, making an inauthentic message look like an authentic message                                           |                 |            |          | x                |                                | x                        |                | x                         |
| Examples of defences against unauthorized access can also be found in the applications covered by EN 50159 (2011). |                 |            |          |                  |                                |                          |                |                           |
| <sup>a</sup> See Table H.1, items 6.1 and 6.2.                                                                     |                 |            |          |                  |                                |                          |                |                           |

#### H.11.12.4.1.3.3 Revision of Class B and Class C software

Requirements of H.11.12.3 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 standard.

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.11.12.4.1.4** For **remotely actuated control function operation**, 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**.

*Compliance is checked by software inspection.*

**H.11.12.4.2** Care shall be taken that priority over **control** functions shall not lead to a hazardous condition.



*Compliance is checked by inspection.*

#### **H.11.12.4.3 Remote reset action**

**H.11.12.4.3.1** 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.

**H.11.12.4.3.2** **Reset** functions shall be capable of resetting the **system** as intended.

**H.11.12.4.3.3** Unintended **resets** from safe state shall not occur.

**H.11.12.4.3.4** Any **fault** of the **reset** function shall not cause the **control** or controlled function to result in a hazardous condition, and shall be evaluated for its Class B classification.

**H.11.12.4.3.5** 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.

#### **H.11.12.4.3.6 Consideration for the evaluation of reset functions on the final application**

The **reset** function shall be evaluated on the final application.

NOTE Not all types of remote **reset** functions may be found suitable for some applications.

If the **reset** is activated by manual switching of a **thermostat** or device with similar function, this shall be declared by the manufacturer and be suitable in the final application.

### **H.17 Endurance**

#### **H.17.1 General requirements**

**H.17.1.4** No endurance test is carried out on **electronic controls** with **type 1 action** unless this is necessary for the testing of associated components such as those with **manual actions**, relays, etc.

**H.17.1.4.1** **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.17.1.4.2. This test may be combined with the testing of any associated components such as those with **manual actions**, relays, etc., if this is possible.

#### **H.17.1.4.2 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 may 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 standard.

*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 requirements 26 and 27 of Table 1, 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.17.1.4.3 Controls with remote reset actions

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.

#### H.17.14 Evaluation of compliance

*Replacement of first paragraph:*

After all the appropriate tests of 17.6 to 17.13 inclusive and H.17.1.4, modified as specified in the appropriate part 2, the **control** shall be deemed to comply if:

*Additional dashed paragraph:*

- for **controls** providing **electronic disconnection** (type 1.Y or 2.Y), the requirements of H.11.4.16 are still met.

## H.18 Mechanical strength

### H.18.1 General requirements

#### H.18.1.5 Addition:

For **controls** providing **electronic disconnection** (type 1.Y or 2.Y), the requirements of H.11.4.16 shall be met.

## H.20 Creepage distances, clearances and distances through insulation

### H.20.1 Additional subclauses:

#### H.20.1.15 Electronic controls

**H.20.1.15.1 Creepage distances, clearances** and distances through insulation between **live parts** connected electrically to the mains supply and **accessible surfaces** or parts shall comply with the requirements of Clause 20.

**H.20.1.15.2 Creepage distances, clearances** and distances through insulation shall comply:

- across **protective impedance** with the requirements of Clause 20 for **double insulation** or **reinforced insulation**;
- across each separate component of **protective impedance** with the requirements of Clause 20 for **supplementary insulation**.

**H.20.1.15.3 Creepage distances** and **clearances** providing **functional insulation** shall comply with the requirements of Clause 20.

## H.23 Electromagnetic compatibility (EMC) requirements – Emission

Equipment that uses integrated or **incorporated controls** should comply with its relevant product EMC standard. Integrated and **incorporated controls** are tested in the end use equipment.

**H.23.1 Electronic controls** shall be so constructed that they do not emit excessive electric or electromagnetic disturbances in their **environment**.

### H.23.1.1 Low frequency emission, disturbances in supply systems

Integrated and **incorporated controls** are not subjected to the tests of this clause, 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 may, however, be carried out under declared conditions if so requested by the manufacturer.

**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 these tests, a load and measures to control emissions, if any, shall be used as declared by the manufacturer in requirement 74 of Table 1. This requirement does not apply to **controls** declared and designed for **pilot duty** load only.

### H.23.1.2 Radio frequency emission

**Free-standing, independently mounted** and **in-line cord electronic controls** using telecommunication ports, software, oscillating circuits, or switching power supplies shall

comply with the requirements of CISPR 14-1 and/or CISPR 22, class B, as indicated in Table H.12.

NOTE 1 Telecommunication port is defined in 3.6 of CISPR 22:2008.

**Controls** for ISM equipment and **free-standing, independently mounted** and **in-line cord controls** for use with ISM equipment shall comply with the requirements of CISPR 11.

Additional details may be given in the relevant part 2.

NOTE 2 The relevant part 2 will indicate whether the requirements of this clause apply to integrated and incorporated **electronic controls**.

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Table H.12 (H.23 of edition 3) – Emission

| Port                                                                                                                                                                                                  | Frequency range                                                     | Limits                                                                                      | Basic standard                 | Applicability note       | Remarks                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------|--------------------------------|--------------------------|----------------------------------------------------------|
| Enclosure                                                                                                                                                                                             | 30 MHz to 230 MHz<br>230 MHz to 1 000 MHz<br>Above 1 GHz            | 30 dB( $\mu$ V/m) at 10 m<br>37 dB( $\mu$ V/m) at 10 m<br>See Note 3                        | CISPR 22<br>Class B            | See Note 1<br>See Note 3 | The statistical evaluation in the basic standard applies |
| AC mains                                                                                                                                                                                              | 0 kHz to 2 kHz                                                      |                                                                                             | IEC 61000-3-2<br>IEC 61000-3-3 | See Note 2               |                                                          |
|                                                                                                                                                                                                       | 0,15 MHz to 0,5 MHz<br>Limits decrease linearly with log. frequency | 66 dB( $\mu$ V) to 56 dB( $\mu$ V) quasi peak<br>56 dB( $\mu$ V) to 46 dB( $\mu$ V) average | CISPR 22<br>Class B            |                          | The statistical evaluation in the basic standard applies |
|                                                                                                                                                                                                       | 0,5 MHz to 5 MHz                                                    | 56 dB( $\mu$ V) quasi peak<br>46 dB( $\mu$ V) average                                       |                                |                          |                                                          |
|                                                                                                                                                                                                       | 5 MHz to 30 MHz                                                     | 60 dB( $\mu$ V) quasi peak<br>50 dB( $\mu$ V) average                                       |                                |                          |                                                          |
| Load terminals                                                                                                                                                                                        | 0,15 MHz to 30 MHz                                                  | See basic standard<br>Clause: discontinuous interference                                    | CISPR 14-1                     |                          |                                                          |
| NOTE 1 Applicable only to <b>controls</b> containing processing devices, for example, microprocessors operating at frequencies greater than 9 kHz.                                                    |                                                                     |                                                                                             |                                |                          |                                                          |
| NOTE 2 Applicable only to equipment within the scope of IEC 61000-3-2 and IEC 61000-3-3. Limits for <b>controls</b> not currently covered by IEC 61000-3-2 and IEC 61000-3-3 are under consideration. |                                                                     |                                                                                             |                                |                          |                                                          |
| NOTE 3 Limits and applicability, see 6.2 of CISPR 22:2008.                                                                                                                                            |                                                                     |                                                                                             |                                |                          |                                                          |

## H.25 Normal operation

**H.25.1** 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 53.*

NOTE Attention is drawn to IEC 61000-3-2 and 61000-3-3, which impose restriction on mains disturbances.

## H.26 Electromagnetic compatibility (EMC) requirements – Immunity

**H.26.1 Electronic controls** shall be so constructed as to withstand the effects of mains-borne perturbations and electromagnetic phenomena which may occur in **normal use**. For **type 2 controls** the tests of Clause H.26 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 shall be given by the appropriate part 2. Refer to all subclauses in H.26.15 for additional details. These test levels correspond with test levels specified by the IEC 61000 series. 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.26 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, and burner **controls**. As a minimum, test level 2 is applicable to **operating controls** relied on for the normal **operation** of the equipment, such as **thermostats**, **timers**.*

*The tests of Clause H.26 are not applicable to non-electronic **controls** because of their tolerance to such perturbations. The appropriate tests for specific types of non-electronic **controls** may be included in other clauses of the appropriate part 2.*

**H.26.2** Compliance is checked at test levels as indicated by the following Table H.13. The **controls** shall comply with H.26.15.

**Table H.13 (H.26.2.1 of edition 3) – Applicable test levels**

| Control type                                                                                            | Type action | Applicable Clause H.26 tests | Applicable test levels corresponding to H.26.15.3 <sup>a</sup>  |
|---------------------------------------------------------------------------------------------------------|-------------|------------------------------|-----------------------------------------------------------------|
| Operating control                                                                                       | Type 1      | H.26.8, H.26.9               | 2                                                               |
| Operating control                                                                                       | Type 2      | H.26.4 to H.26.14            | 2, 3, or 4 as specified                                         |
| Protective control                                                                                      | Type 2      | H.26.4 to H.26.14            | 3                                                               |
| Protective controls declared in Table 1, requirement 90 intended for use in accordance with IEC 60335-1 | Type 2      | H.26.4 to H.26.14            | Applicable test levels according to 19.11.4 of IEC 60335-1:2010 |
| <sup>a</sup> Lower test levels shall be considered in accordance with IEC 61000-4 series.               |             |                              |                                                                 |

**H.26.2.1** For integrated and **incorporated controls** with **type 1 action**, compliance is checked by the tests of H.26.8 and H.26.9 if declared in Table 1, requirement 58a.

**H.26.2.2** For integrated and **incorporated controls** with **type 2 action**, compliance is checked by H.26.5 and any other tests of Clause H.26 which are declared in Table 1, requirement 58a.

NOTE The suitability of each test in Clause H.26 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.26.3** A separate sample, as submitted, may be used for each test. At the option of the **control** manufacturer, multiple tests may be performed on a single sample.

#### **H.26.4 Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests**

For protective **controls** declared according to requirement 90 of Table 1, 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 Tables 1 to 4 of IEC 61000-4-13:2002 shall be applied at the a.c. power port of the EUT. The **control** is tested under the test conditions as specified in the specific **control** standard.

The following tests are performed in accordance with Figure 1a of IEC 61000-4-13:2002, Amendment 1:2009, for Class 2 environment:

- "Harmonic combination" (see 8.2.1 of IEC 61000-4-13:2002, Amendment 1:2009);
- "Meister curve" (see 8.2.4 of IEC 61000-4-13:2002, Amendment 1:2009).

#### **H.26.5 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.26.5.1 to H.26.5.2 inclusive.

##### **H.26.5.1 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.26.5.1.1 Test levels for voltage dips and interruptions**

The test values in Table H.14 shall be applied to all the test levels.

**Table H.14 – Voltage dips, short interruptions and voltage variations**

| Duration                                                                                                                                                                                                                     | $\Delta U$ |      |       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|------|-------|
|                                                                                                                                                                                                                              | 30 %       | 60 % | 100 % |
| Half-cycle of supply waveform                                                                                                                                                                                                |            |      | X     |
| One cycle of supply waveform                                                                                                                                                                                                 |            |      | X     |
| 2,5 cycles                                                                                                                                                                                                                   | X          | X    | X     |
| 25 cycles                                                                                                                                                                                                                    | X          | X    | X     |
| 50 cycles                                                                                                                                                                                                                    | X          | X    | X     |
| NOTE Where intermediate durations of voltage interruption may affect either the inherent safety of the <b>control</b> or the output of a type 2 <b>control</b> , parts 2 may indicate voltage interruptions at other points. |            |      |       |

**H.26.5.1.2 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.

For protective **controls** declared according to requirement 90 of Table 1, the following additional test applies:

*Protective **controls** 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.26.5.2 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 may occur due to a change of load or stored energy in local power networks.

**H.26.5.2.1 Test levels for voltage variations**

*The test values in Table H.15 shall be applied to all the test levels.*

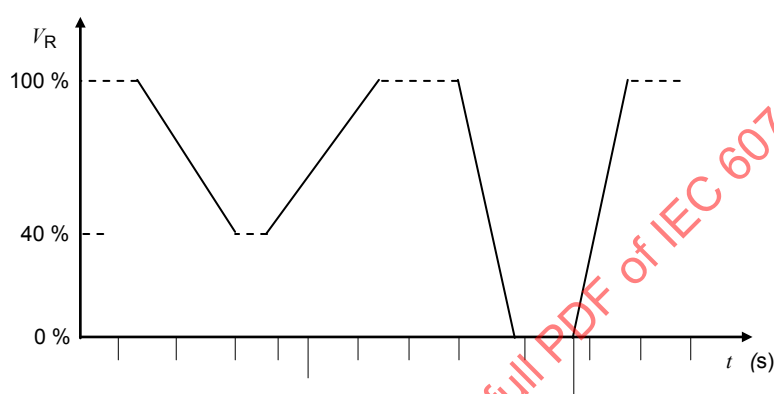
**H.26.5.2.2 Test procedure**

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.15 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.15 (H.26.5.4.2 of edition 3) – 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. |                             |                         |                             |



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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.

## H.26.6 Test of influence of voltage unbalance

### H.26.6.1 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 a.c. rotating machines;*
- *generation of non-characteristic harmonics in electronic power converters.*

*The degree of unbalance is defined by the unbalance factor  $T_i = \frac{U_i}{U_d}$  = negative sequence voltage / positive sequence voltage*

### H.26.6.2 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.26.6.3 Test equipment/test generator

*The test arrangement shall consist of three single-phase auto-transformers, whose outputs are regulated individually, or the like.*

### H.26.6.4 Test level

*The test shall be carried out with an unbalance factor of 2 %.*

### H.26.7 Test of the influence of d.c. in a.c. networks

NOTE Requirements and tests are under consideration.

### H.26.8 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.26.8.2 to H.26.8.3 inclusive.*

#### H.26.8.1 Purpose of the test

*This test applies to the power supply terminals and in specific cases to the **control** terminals (see H.26.8.2).*

**Controls** providing **electronic disconnection** are loaded as indicated in 17.2 and subjected to the test levels for the installation class specified for the **control** by the manufacturer, 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 H.11.4.16.2. 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;
- 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.26.8.2 Test values

*The tests as detailed in Table H.16 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** declared according to requirement 90 of Table 1, the following additional test applies:

The power supply terminals of the **control** are subjected to test level 4 (applicable for the line-to-earth coupling mode) with a generator having a source impedance of 12  $\Omega$  being used and to test level 3 (applicable for the line-to-line coupling mode) with a generator having a source impedance of 2  $\Omega$  being used.

**Table H.16 (H.26.8.2 of edition 3) – Test voltages for test level 2  
(depending on the installation class conditions)**

| Test values<br>peak kV                    |               |               |                                           |               |                                         |               |
|-------------------------------------------|---------------|---------------|-------------------------------------------|---------------|-----------------------------------------|---------------|
| IEC<br>61000-4-5<br>installation<br>class | Power supply  |               | Unbalanced operated circuits<br>and lines |               | Balanced operated circuits<br>and lines |               |
|                                           | Coupling mode |               | Coupling mode                             |               | Coupling mode                           |               |
|                                           | Line to line  | Line to earth | Line to line                              | Line to earth | Line to line                            | Line to earth |
| 2                                         | 0,5           | 1,0           | 0,5                                       | 1,0           | No Test                                 | 1,0           |
| 3                                         | 1,0           | 2,0           | 1,0                                       | 2,0           | No Test                                 | 2,0           |
| 4                                         | 2,0           | 4,0           | 2,0                                       | 4,0           | No Test                                 | 2,0           |

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 R for description of installation class and further explanatory notes.

At test level 2) and 3), after the tests of H.26.8.2, the surge protective components shall not be destroyed.

### H.26.8.3 Test procedure

The test apparatus and procedure shall be as described in IEC 61000-4-5. In accordance with this standard, the **control** is connected to an appropriate source of supply operating at the rated voltage with the impulse generator connected across the terminals.

The tests are carried out by subjecting the **system** to five pulses of each polarity, positive and negative (+, –) and with phase relationships of at least 0°, 90°, 180° and 270° distributed over the relevant operating modes and with the voltage values listed in Table H.16 at intervals not greater than 60 s or as specified in the relevant part 2.

If varistors are used as surge protective devices, they shall comply with IEC 61643-11. Additionally, they shall be selected to withstand the impulses corresponding to the installation class for which the **control** is intended to be used.

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.26.9 Electrical fast transient/burst 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.26.9.2 to H.26.9.3 inclusive.

### H.26.9.1 Purpose of the test

This test applies to the power supply terminals and in specific cases to the **control** terminals (see H.26.9.2).

The purpose of this test is to demonstrate the immunity of the **control** to bursts of fast low energy transients which may be produced by relays, contactors, etc., switch inductive loads and which may be induced into signal and data circuits.

### H.26.9.2 Test levels

The tests shall be applied as specified in Table H.17.

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

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.17 – 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.26.15.3                                                       | 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 90 intended for use in accordance with IEC 60335-1 | 4                                           | 4                                                                    | 5                   | -                                                    | -                   |

### H.26.9.3 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.26.10 Ring wave immunity test

NOTE In Canada and the USA, the ringwave test of H.26.10 is required.

#### H.26.10.1 Purpose of the test – Range of application

The purpose of the test is to verify the immunity of equipment to oscillatory transients ("ring waves") that appear in indoor (cable) residential and industrial LV-networks. This test is

complementary to the 1,2/50  $\mu\text{s}$  surge test that covers transients appearing in outdoor (overhead lines) networks. The energy involved with "ring waves" is however smaller than the energy associated with the surges; on the other hand, they may generate effects in the **control** due to the voltage polarity change.

#### H.26.10.2 Test wave characteristics

The test wave form shall consist of a pulse with a rise time of 0,5  $\mu\text{s}$ , followed by an oscillation at 100 kHz with a decrement so that each peak is 60 % of the preceding peak. See Figure H.3.

#### H.26.10.3 Test equipment/test generator

The surge generator for this immunity test is shown in Figure H.4.

#### H.26.10.4 Test levels

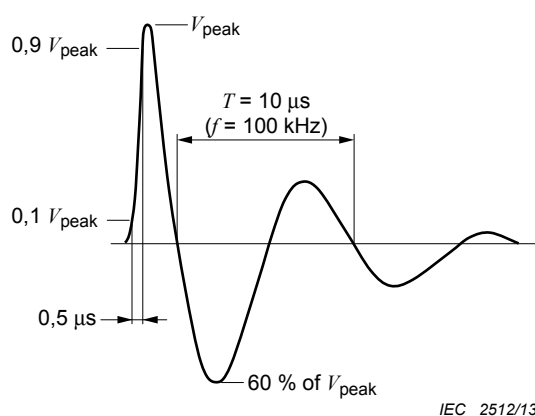
Voltages shall be applied in accordance with Table H.18.

Table H.18 (H.26.10.4 of edition 3) – Peak voltages

| Rated<br>voltage (max.)<br><br>V                                                                                                                              | Category <sup>a b</sup> |       |     |       |     |       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------|-------|-----|-------|-----|-------|
|                                                                                                                                                               | I                       |       | II  |       | III |       |
|                                                                                                                                                               | kV                      | $R_1$ | kV  | $R_1$ | kV  | $R_1$ |
| 100                                                                                                                                                           | 0,5                     | 25    | 0,8 | 25    | 1,5 | 25    |
| 300                                                                                                                                                           | 1,0                     | 25    | 1,6 | 25    | 2,5 | 25    |
| 600                                                                                                                                                           | 2,0                     | 25    | 3,0 | 25    | 5,0 | 25    |
| NOTE In the USA, the peak voltage of the impulse wave is determined by the rated voltage and declared category of the <b>control</b> as given in IEC 60664-1. |                         |       |     |       |     |       |
| <sup>a</sup> kV open-circuit. See Figure H.4 for $R_1$ .                                                                                                      |                         |       |     |       |     |       |
| <sup>b</sup> See Annex L for categories.                                                                                                                      |                         |       |     |       |     |       |

#### H.26.10.5 Test procedure

The **control** shall be tested as indicated in H.26.8.3.



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Figure H.3 – Ring wave characteristics  
(open-circuit voltage)

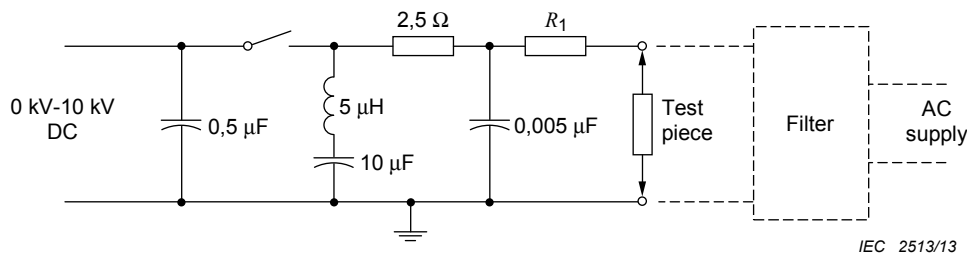


**Figure H.4 – Schematic of a ring wave generator 0,5 µs /100 kHz**

NOTE The value of  $R_1$  is specified in Table H.22:

- $R_1$  of 2,5 Ω will provide a 500 A peak short-circuit current;
- $R_1$  of 25 Ω will provide a 200 A short-circuit current.

#### H.26.11 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.*

*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** declared according to requirement 90 of Table 1, the following additional test applies: This test is carried out in accordance with Clause 5, test level 4 of IEC 61000-4-2:2008. Contact discharges at 8 kV to accessible metal parts, or air discharges at 15 kV to **accessible parts** of insulating material shall apply.

#### H.26.12 Radio-frequency electromagnetic field immunity

##### H.26.12.1 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.26.12.1.1** 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.26.12.2 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.26.12.2.1 to H.26.12.2.2, inclusive.*

### H.26.12.2.1 Test levels for conducted disturbances

*At minimum, the test levels in Table H.19 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.19 (H.26.12.2.1 of edition 3) – Test levels for conducted disturbances on mains and I/O lines**

| Test frequency range: 150 kHz to 80 MHz |                        |            |
|-----------------------------------------|------------------------|------------|
| Test level                              | Voltage level (r.m.s.) |            |
|                                         | $U_0$<br>dB $\mu$ V    | $U_0$<br>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  $\pm$  0,007 MHz and 40,68 MHz  $\pm$  0,02 MHz, CB: Citizen band: 27, 125 MHz  $\pm$  1,5 MHz).

### H.26.12.2.2 Test procedure

*This test shall be carried out in accordance with IEC 61000-4-6.*

*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.26.12.3 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.26.12.3.1 to H.26.12.3.2 inclusive.*

#### H.26.12.3.1 Test level for radiated electromagnetic fields

Test levels for immunity to radiated electromagnetic fields shall be applied in accordance with Table H.20.

Increased test levels for radiated immunity shall be applied in accordance with Table H.21.

**Table H.20 (H.26.12.3.1 of edition 3) – Test level for immunity to radiated electromagnetic fields**

| Test level | Test frequency ranges/Field strength<br>V/m |                    |                    |
|------------|---------------------------------------------|--------------------|--------------------|
|            | 80 MHz to 960 MHz                           | 1,4 GHz to 2,0 GHz | 2,0 GHz to 2,7 GHz |
| 2          | 3                                           | 3                  | 1                  |
| 3          | 10                                          | 3                  | 1                  |

**Table H.21 – Increased test level for radiated immunity (ISM, GSM, DECT bands)**

| Test level | Test frequency ranges/Field strength<br>V/m |                    |                    |                        |                        |                        |
|------------|---------------------------------------------|--------------------|--------------------|------------------------|------------------------|------------------------|
|            | 433 MHz to 435 MHz                          | 864 MHz to 915 MHz | 935 MHz to 960 MHz | 1 710 MHz to 1 784 MHz | 1 805 MHz to 1 960 MHz | 2 446 MHz to 2 454 MHz |
| 2          | 6                                           | 6                  | 6                  | 6                      | 6                      | 2                      |
| 3          | 20                                          | 20                 | 10                 | 6                      | 6                      | 2                      |

### H.26.12.3.2 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 ISM, GSM and DECT bands shall be tested with those test frequencies that have been used when sweeping through the complete test frequency ranges and cover completely the ISM, GSM and DECT bands regarded.*

*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.26.13 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 by the manufacturer in the additional items to Table 1 of Clause H.7.*

#### H.26.13.1 Purpose of the test

The purpose of this test is to verify the effect on the **control** from frequency deviation on the mains.



### H.26.13.2 Test levels

The test values in Table H.22 shall be applied.

**Table H.22 (H.26.13.2 of edition 3) – Test level for supply frequency variations**

| Test level                                            | Variations in supply frequency<br>% <sup>a</sup> |
|-------------------------------------------------------|--------------------------------------------------|
| 2                                                     | ±1 and ±2                                        |
| 3                                                     | ±3, ±4 and ±5                                    |
| <sup>a</sup> Other values may be specified in part 2. |                                                  |

### H.26.13.3 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.26.13.2.

### H.26.14 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.26.14.2.*

NOTE Examples of such **controls** include pressure sensors which use Hall-effect devices, **controls** incorporating reed relays and **controls** utilizing bistable relays.

#### H.26.14.1 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.26.14.2 Test levels

The test levels shall be applied in accordance with Table H.23.

**Table H.23 (H.26.14.2 of edition 3) – Test level for continuous fields**

| Test level | Continuous field strength<br>A/m |
|------------|----------------------------------|
| 2          | 3                                |
| 3          | 10                               |

#### H.26.14.3 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.26.15 Evaluation of compliance

**H.26.15.1** After the tests of H.26.2 through H.26.14 and H.26.16, the sample(s) shall meet the requirements of Clause 8, 17.5 and Clause 20.

**H.26.15.2** In addition, the **control** shall meet the following:

- the requirements of H.17.14 or
- the output(s) and functions shall be as declared in Table 1, requirements 58a and 58b.

*Compliance with the second alternative of H.26.15.2 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.26.15.3** Different outputs and functions may 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.26.15.4** The compliance criteria shall be given in part 2 and shall be based on the operating output conditions and the functional specifications of the **control** under test:

- 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**;
- d) loss of protective function with unsafe **operation**.

## H.27 Abnormal operation

### H.27.1 Electronic controls – Assessment against internal faults

**H.27.1.1 Electronic controls** shall be assessed for the effects of **failure** or malfunction of circuit components to ensure electrical safety.

*Compliance is checked by the tests of H.27.1.1.1 to H.27.1.1.6 inclusive and H.27.4.*

*Components which fail as a result of cumulative stress are replaced if necessary.*

NOTE Non-electronic components such as switches, relays and transformers, which are assessed according to Clause 24 or to the relevant requirements of this standard, are not subjected to the tests of H.27.1.1.

During the tests of H.27.1.1, for a **control** providing **electronic disconnection** (type 1.Y or 2.Y), any **failure** of the device described in footnote n to Table 12 is permitted.

**H.27.1.1.1 Fault** conditions specified in Table H.24 are not applied to circuits or parts of circuits where all of the following conditions are met:

- the electronic circuit is a low-power circuit as described below;
- the protection against electric shock, fire **hazard**, mechanical **hazard** or dangerous malfunction in other parts of the **control** does not rely on the correct functioning of the electronic circuit.

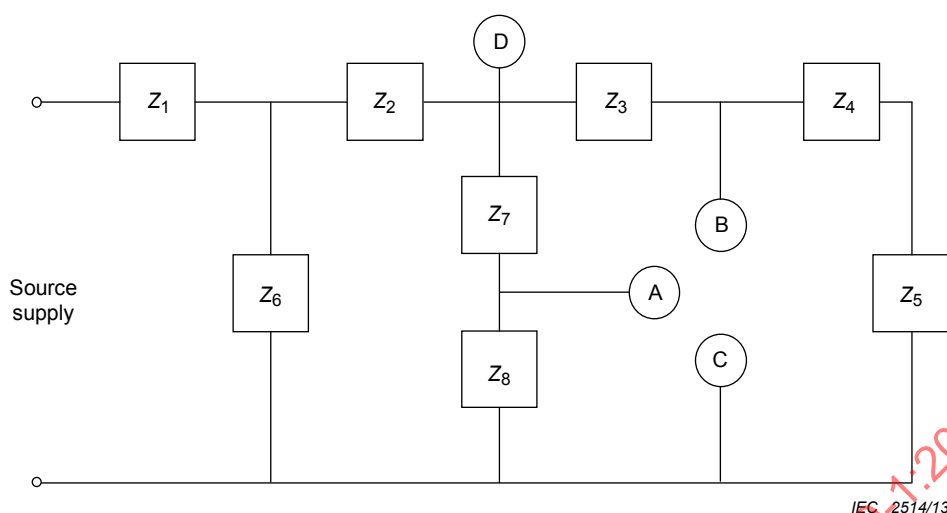
*A low-power circuit is determined as follows and further explained in Figure H.5. The **control** is operated at rated voltage or at the upper limit of the rated voltage range and a variable resistor, adjusted to its maximum resistance, is connected between the point to be investigated and the opposite 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.*

*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.

*If an electronic circuit operates to ensure compliance with Clause H.27, the relevant test is repeated with a single **fault** simulated, as indicated in H.27.1.1.5.*



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.

Points A and B are separately short-circuited to C.

The **fault** conditions specified in H.27.1.1.5 are applied individually to  $Z_1$ ,  $Z_2$ ,  $Z_3$ ,  $Z_6$  and  $Z_7$ , where applicable.

**Figure H.5 – Example of an electronic circuit with low power points**

**H.27.1.1.2** The **control** shall be operated under the following conditions.

- At the most unfavourable voltage in the range 0,9 to 1,1 times the rated supply voltage.
- Loaded with the type of load, within the declared or measured parameters, producing the most onerous effect.
- In an ambient temperature of  $(20 \pm 5) ^\circ\text{C}$ , unless there are significant reasons (as for example during item b) of H.27.1.1.3) for conducting the test at another temperature within the manufacturer's declared range.
- Connected to an electrical supply having a fuse rating such that the result of the test is not influenced by the **operation** of the fuse.
- With any **actuating member** set to the most unfavourable position.

**H.27.1.1.3** With each **fault** described in Table H.24, 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 Clause 14 of IEC 60065:2001, Amendment 1: 2005, Amendment 2:2010, the **controls** need only comply with items a), c), d), f) and g).

NOTE 1 In Canada and the USA, if a component has received qualification approval under the IECQ programme, with appropriate conditioning periods and stress factors, the **faults** of Table H.25 need not be applied.

- 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. For **in-line cord controls** and **independently mounted controls**, compliance is determined by the following test.

The enclosure with the **control** therein is wrapped in tissue wrapping paper. The **control** is operated to steady state or for 1 h, whichever occurs first. There shall be no burning of the wrapped tissue paper. Inside the enclosure, some parts may temporarily glow, and there may be a temporary emission of smoke or flame.

NOTE 2 In Canada and the USA, cheesecloth is used instead of tissue wrapping paper.

Integrated and **incorporated controls** shall either comply with the test specified for **in-line cord controls** and **independently mounted controls** or be classified as requiring, for example, further shielding, in the appliance or equipment.

- b) The temperature for **supplementary insulation** and **reinforced insulation** shall not exceed 1,5 times the relevant values specified in Clause 14, 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 57.
- d) The **control** shall comply with the requirements of Clause 8 and 13.2 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 20.
- f) A fuse in the supply, external to the **control** under test and as described in item d) of H.27.1.1.2 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 H.27.1.1.3;
  - the requirements of Clause 20 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 56.

#### **H.27.1.1.4 Guidelines for the tests of H.27.1.1.3**

*To avoid unnecessary testing, every endeavour should be made to assess all the conditions likely to result in non-compliance with the requirements of H.27.1.1.4. 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 H.27.1.1.4 shall be related to the software **fault** analysis of Table 1, requirement 68.*

*All conditions which result from the introduction of an electronic circuit **fault** as specified in H.27.1.1.5 are considered to be one **fault**.*

*Printed circuit conductors which show signs of deterioration during the tests are considered liable to fail.*

#### **H.27.1.1.5 Electronic circuit fault conditions**

For the purpose of Clause H.27, the applicable **failure** modes are given in Table H.24.

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**Table H.24 (H.27.1 of edition 3) – Electrical/electronic component fault modes table**  
(1 of 3)

| Component type                                                                                 | Short <sup>a</sup> | Open <sup>b</sup> | Remarks                            |
|------------------------------------------------------------------------------------------------|--------------------|-------------------|------------------------------------|
| <b>Fixed resistors</b>                                                                         |                    |                   |                                    |
| Thin-film <sup>c</sup>                                                                         |                    | X                 | Includes SMD type                  |
| Thick-film <sup>c</sup>                                                                        |                    | X                 | Includes SMD type                  |
| Wire-wound <sup>c</sup> (single layer) enamelled or suitably coated                            |                    | X                 |                                    |
| All other types                                                                                | X                  | X                 |                                    |
| <b>Variable resistors</b><br>(for example, potentiometer/trimmer)                              |                    |                   |                                    |
| Wire-wound (single layer)                                                                      |                    | X                 |                                    |
| All other types                                                                                | X <sup>d</sup>     | X                 |                                    |
| <b>Capacitors</b>                                                                              |                    |                   |                                    |
| 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                 |                                    |
| <b>Inductors</b>                                                                               |                    |                   |                                    |
| Wire-wound                                                                                     |                    | X                 |                                    |
| All other types                                                                                | X                  | X                 |                                    |
| <b>Diodes</b>                                                                                  |                    |                   |                                    |
| All types                                                                                      | X                  | X                 |                                    |
| <b>Semiconductor type devices like transistors</b>                                             |                    |                   |                                    |
| All types (for example, bipolar; LF; RF; microwave; FET; thyristor; Diac; Triac; Uni junction) | X <sup>d</sup>     | X                 | <sup>e</sup>                       |
| <b>Hybrid circuit</b>                                                                          | <sup>f</sup>       | <sup>f</sup>      |                                    |
| <b>Integrated circuits</b>                                                                     |                    |                   |                                    |
| All types not covered by H.11.12                                                               | X <sup>g</sup>     | X                 | For IC outputs, footnote e applies |
| <b>Optocouplers</b>                                                                            |                    |                   |                                    |
| According to IEC 60335-1                                                                       | X <sup>h</sup>     | X                 |                                    |
| <b>Relays</b>                                                                                  |                    |                   |                                    |
| Coils                                                                                          |                    | X                 |                                    |
| Contacts                                                                                       | X <sup>i</sup>     | X                 |                                    |
| <b>Reed-relays</b>                                                                             | X                  | X                 | Contacts only                      |
| <b>Transformers</b>                                                                            |                    |                   |                                    |
| According to IEC 61558-2-6 or IEC 61558-2-16                                                   |                    | X                 |                                    |
| All other types                                                                                | X <sup>d</sup>     | X                 |                                    |
| <b>Crystals</b>                                                                                | X                  | X                 | <sup>j</sup>                       |
| <b>Switches</b>                                                                                | X                  | X                 | <sup>k</sup>                       |
| <b>Connections</b> (jumper wire)                                                               |                    | X                 | <sup>l</sup>                       |
| <b>Cable and wiring</b>                                                                        |                    | X                 |                                    |

Table H.24 (2 of 3)

| Component type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Short <sup>a</sup> | Open <sup>b</sup> | Remarks |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|---------|
| <b>Printed circuit board conductors</b><br>According to IEC 62326 series                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | X <sup>m</sup>     | X <sup>n</sup>    |         |
| <b>Sensors</b><br>Polymeric type <b>thermistors</b><br>Ceramic type <b>thermistors</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | X<br>X             | X<br>X            | °       |
| <p><sup>a</sup> The conditions which have led to the design of the <b>clearances</b> and <b>creepage distances</b> according to Clause 20 on the assembly for which exclusion from the <b>fault</b> mode "short" is claimed shall be maintained over the lifetime of the <b>control</b>.</p> <p>These conditions shall be declared or documented as follows.</p> <p><b>Control pollution</b> situation (Table 1, requirement 49).</p> <p><b>Pollution</b> situation in the <b>micro-environment</b> of the <b>creepage distance</b> or <b>clearance</b>, if cleaner than that of the <b>control</b>, and how this is designed (documentation) (Table 1, requirement 79).</p> <p><b>Rated impulse voltage</b> of the <b>control</b> (Table 1, requirement 75).</p> <p><b>Rated impulse voltage</b> for the <b>creepage distance</b> or <b>clearance</b>, if different from that of the <b>control</b>, and how this is ensured (documentation) (Table 1, requirement 80).</p> <p>The values designed for tolerances of distances for which the exclusion from <b>fault</b> mode "short" is claimed. (declaration and documentation) (Table 1, requirement 81).</p> <p><sup>b</sup> Only opening of one pin at any one time.</p> <p><sup>c</sup> These components may be used for <b>protective impedance</b>, if the impedance of components complies with H.20.1.15.3 and withstands the impulse voltage test of 20.1.12 for at least <b>overvoltage category</b> III.</p> <p><sup>d</sup> Short-circuit each pin in turn with every other pin; only two pins at a time.</p> <p><sup>e</sup> 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.</p> <p><b>Failure</b> 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 <b>control</b> function and circuitry. Guidance might be given in parts 2.</p> <p>*Loss of gate control might occur due to, for example, an insufficient solder connection of the FET.</p> <p><sup>f</sup> <b>Failure</b> modes for individual components of the <b>hybrid circuit</b> are applicable as described for the individual components in this table.</p> <p><sup>g</sup> The short circuit of any two adjacent terminals and the short circuiting of</p> <ul style="list-style-type: none"> <li>- each terminal to the IC-supply, when applicable at the IC;</li> <li>- each terminal to the IC-ground, when applicable at the IC.</li> </ul> <p>The number of tests implied for <b>integrated circuits</b> may normally make it impracticable to apply all the relevant <b>fault</b> conditions or to assess the likely <b>hazards</b> from an appraisal of the circuit diagram of the <b>integrated circuit</b>.</p> <p>It is therefore permissible first to analyse in detail all the possible mechanical, thermal and electrical <b>faults</b> which may develop either in the <b>control</b> itself or its output, due to the malfunction of the <b>electronic devices</b> or other circuit components, separately or in any combination.</p> <p>Except for types evaluated by H.11.12, a <b>fault-tree</b> 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 <b>fault</b> conditions for consideration. The <b>failure</b> 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 13.2 for <b>functional insulation</b>.</p> <p><sup>h</sup> When optocouplers comply with 29.2.2 of IEC 60335-1:2010, the shorting between the input and output pins is not considered.</p> |                    |                   |         |



Table H.24 (3 of 3)

|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|---|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| i | <p>The short-circuit mode is excluded for relays where the contact is controlling a Class A or B <b>control</b> function, and is not included in the specified cyclic operation of the application, provided that it is successfully tested to Clause 17 under the following conditions:</p> <p>For Class A <b>control</b> functions, the number of cycles declared by the manufacturer, or certified for the application.</p> <p>For Class B <b>control</b> functions, a minimum of 100 000 cycles or otherwise specified by the manufacturer, whichever is higher, or certified for the application.</p> <p>For Class C <b>control</b> functions, the short-circuit mode is excluded for relays where</p> <ul style="list-style-type: none"> <li>the contact function is switching under normal <b>operation</b> without load (no current flowing during make or break) and</li> <li>the contact function is disconnecting the load under abnormal <b>operation</b> of the burner <b>control system</b> to reach <b>safety shut-down</b> and</li> <li>the relay complies with Clause 17 at a minimum of 100 000 cycles however applying the declared output load, or certified for the application, and</li> <li>the <b>control</b> complies with the requirements of 11.3.5.2.1 (measures to prevent <b>common cause errors</b>).</li> </ul> |
| j | <p>For crystal-based clocks, harmonic and sub-harmonic frequency variations affecting the timings should be considered.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| k | <p>If switches are applied for the selection of safety times, purge times, programmes and/or other safety-related <b>settings</b>, these devices should function so that in the event of their opening, the safest possible condition arises (for example, in a burner <b>control system</b>, the shortest safety time or the longest purge time).</p> <p>The short-circuit mode is excluded for switches where the contact is controlling a Class A or B <b>control</b> function, provided that it is successfully tested to Clause 17 under the following conditions:</p> <p>For Class A <b>control</b> functions, the number of cycles declared by the manufacturer, or certified for the application.</p> <p>For Class B <b>control</b> functions, a minimum of 6 000 cycles for <b>manual action</b>, or 100 000 cycles for automatic action, or otherwise specified by the end product standard, or certified for the application.</p> <p>For Class C control functions, short-circuit mode is not excluded.</p>                                                                                                                                                                                                                                                                                                                          |
| l | <p>The requirements are the same as footnote n, except they are applied to jumper wires intended for clipping when selecting a <b>setting</b>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| m | <p>The short-circuit <b>failure</b> mode is excluded if the requirements of Clause 20 are fulfilled.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| n | <p>The open-circuit <b>failure</b> mode, i.e. interruption of a conductor, is excluded if the thickness of the conductor is equal to, or greater than, 35 µm and the breadth of the conductor is equal to, or greater than, 0,3 mm 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 <b>fault</b> analysis.</p> <p>For temperature and current conditions when accepting conductor sizes, see IEC 62326 series.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| o | <p>For sensor components intended to measure activating quantities such as temperature, pressure etc., <b>fault</b> modes in addition to open and short must be considered. These <b>fault</b> modes can include step wise shift of resistance, non-responsive component, and component drifting out of accuracy.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |

**H.27.1.1.6** *If the load includes a motor load (see 6.2.2 or 6.2.5), 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.*

- 1) *The load shall be adjusted under normal waveform conditions to six times the rated load or the locked rotor rating declared by the manufacturer.*
- 2) *Then the **fault** conditions shall be introduced.*
- 3) *The test is conducted under the conditions described in items a), c), d) and e) of H.27.1.1.2.*

*The control shall be evaluated according to items a) to e) inclusive of H.27.1.1.3, as appropriate to the component being assessed.*

## H.27.1.2 Protection against internal faults to ensure functional safety

### H.27.1.2.1 Design and construction requirements

#### H.27.1.2.1.1 Fault avoidance and fault tolerance

In addition to H.27.1.1, **controls** incorporating **control** functions of class B or C shall be designed according to H.27.1.2 taking into account the **failure** modes of Table H.24 and H.11.12 for software, if applicable.

**Failures** of **complex electronics** can be caused by either systematic errors (built into the design, see H.11.12.3) or by random **faults** (component **faults**, see H.11.12.2). 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 to H.11.12 software class B or 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.27.1.2.3.

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.27.1.2.1.2 Documentation

In general the documentation shall be based on H.11.12.3.2.

The functional analysis of the **control** and the safety related programs under its control shall be documented in a clear hierarchical way in accordance with the safety philosophy and the programme requirements.

As a minimum the following documentation shall be provided with any **system** submitted for assessment:

- a) A description of the **system** philosophy, the **control** flow, data flow and timings.
- b) A clear description of the safety philosophy of the **system** with all safeguards and safety functions clearly indicated. Sufficient design information shall be provided to enable the safety functions or safeguards to be assessed.
- c) Documentation for any software within the **system**.

Programming documentation shall be supplied in a programming design language declared by the manufacturer.

Safety related data and safety related segments of the **operating sequence** shall be identified and classified according to H.11.12.3.2.

There shall be a clear relationship between the various parts of the documentation, for example, the interconnections of process, hardware and the labeling used in software documentation.

If a manufacturer provides documentation of the analytical measures taken during the development stage of the hardware and software, this documentation shall be used by the test house as part of the assessment procedure.

#### H.27.1.2.2 Class B control function

##### H.27.1.2.2.1 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.

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 identified in Table 1, requirement 92.

The assessment shall be performed according to H.27.1.2.2.2 and H.27.1.2.2.3 and under the test conditions and criteria of H.27.1.2.5.

##### H.27.1.2.2.2 First fault

Any first **fault** (see Table H.24) 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 1, requirement 91) 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.27.1.2.2.3 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 H.24), 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** (see Table 1, requirement 91). 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.27.1.2.3 Class C control function

##### H.27.1.2.3.1 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.

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 1, requirement 92.

The assessment shall be performed according to H.27.1.2.3.2, H.27.1.2.3.3 and H.27.1.2.4 and under the test conditions and criteria of H.27.1.2.5.

##### H.27.1.2.3.2 First fault

Any first **fault** (see Table H.24) 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 1, requirement 91) 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.27.1.2.3.3 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.27.1.2.3.2 d)), any further **independent fault** considered together with the first **fault** shall result in either H.27.1.2.3.2 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 1, requirement 91).

It may also specify a different time span in which the second **fault** does not occur, if different from 24 h.

### H.27.1.2.4 Faults during defined state

#### H.27.1.2.4.1 General

Whenever the **control** is in a **defined state** without an internal **fault**, an assessment according to H.27.1.2.4.2 and H.27.1.2.4.3 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.27.1.2.4.3 shall be performed.

NOTE Safety related output terminal as used in H.27.1.2.4.2 and H.27.1.2.4.3 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.27.1.2.4.2 First fault introduced during defined state

Any first **fault** (together with any other **fault** arising from that **fault**) in any one component (see Table H.24), 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.27.1.2.4.2 under the condition that the safety related output terminals are energized not longer than the **fault reaction time** (see Table 1, requirement 91). 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.27.1.2.3.3.

#### H.27.1.2.4.3 Second fault introduced during defined state

Any second **fault** (together with any other **fault** arising from that **fault**) in any one component (see Table H.24), induced while the **control** is staying in the **defined state**, shall result in either H.27.1.2.4.2 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.27.1.2.5 Circuit and construction evaluation**

##### **H.27.1.2.5.1 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  $(20 \pm 5) ^\circ\text{C}$ , 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.

##### **H.27.1.2.5.2 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 8 and 13 or Clauses 8 and 13 of the relevant part 2. If it ceases to function, it shall still continue to comply with Clause 8 or Clause 8 of the relevant part 2.
- 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 20 or Clause 20 of the relevant part 2.

##### **H.27.1.2.5.3 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 may 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.27.1.2.1.2 shall be subjected to further assessment. For the identification of the class, a **fault** tree analysis may be used.



**H.27.4 Controls** providing **electronic disconnection** (type 1.Y or 2.Y) shall withstand the abnormal overvoltage conditions which may occur.

*Compliance is checked by the following test:*

**H.27.4.1** The **control** is loaded as indicated in 17.2 and subjected to  $1,15 \times V_R$  for 5 s, when the **control** is providing **electronic disconnection**.

**H.27.4.2** During and after the test, the **control** shall continue to provide **electronic disconnection** as determined by the test of H.11.4.16.2.

## **H.28 Guidance on the use of electronic disconnection**

### **H.28.1 Main features of solid-state switching devices**

**H.28.1.1** Solid-state switching devices differ from their electro-mechanical counterparts in three respects:

- a) when providing **electronic disconnection**, they will always allow a small current to pass through the circuit which they are controlling;
- b) they are more sensitive to mains perturbations of the supply mains;
- c) they are more sensitive to temperature.

**H.28.1.2** The requirements and tests for **electronic disconnection** in this standard ensure that:

- a) the current through the **electronic disconnection** will not exceed 5 mA or 10 % of the rated current, whichever is lower, with any load up to its maximum declared load in the circuit;
- b) even under extreme conditions of mains perturbation, a **control** will be unaffected and will not permit the device to conduct for more than one half cycle of the supply waveform;
- c) the device will have adequate endurance between the extremes of temperature in which it is designed to operate.

### **H.28.2 Application of solid-state switching devices**

**H.28.2.1** An **electronic disconnection** may be caused to conduct for one half cycle of the supply frequency by the application of a pulse of sufficient voltage. While full isolation from the supply is always achieved by the equivalent of **full disconnection**, there may be some applications when **operation** even for one half cycle is unacceptable.

So far as household appliances are concerned, switching on very occasionally for a maximum of one half cycle of the supply waveform can usually be disregarded. It will be of no consequence to heating appliances and to the majority of motor-operated appliances.

However, for motor-operated appliances where it is possible for the **user** to have contact with hazardous moving parts or to parts that become live either during **normal use** or **user maintenance** (for example, cleaning), it will be necessary to require further safeguards or not to allow such devices. Examples of appliances for which **electronic disconnection** would not be appropriate are certain types of kitchen machines where access to moving parts or **live parts** is possible.

**WARNING:** For some motor-driven appliances, energization of the controlled load at mains frequency for one half cycle may cause rotation of the motor. Operation of solenoid devices may also occur.

**H.28.2.2** Where the controlled load is a high impedance load such as a relay coil or solenoid, care shall be taken that the allowed current through the **control** when it is providing **electronic disconnection** is low enough to ensure disconnection of the load.

## Annex J (normative)

### Requirements for thermistor elements and controls using thermistors

Annex J supplements or modifies the corresponding clauses of this standard.

#### J.1 Scope

##### J.1.1.1 Additional paragraphs:

Annex J is applicable to discrete **thermistor**-type devices and to **controls** using **thermistors** constructed of doped ceramic or polymeric semiconductor materials.

Annex J applies to the 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 **control** elements; or
- as **sensing elements**.

Annex J does not apply to **thermistors** used in **control** functions where further measures to ensure safety are implemented within the **control**.

These requirements apply to positive temperature coefficient (PTC) and negative temperature coefficient (NTC) type devices.

**Control** devices, 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.2 Terms and definitions

##### J.2.15 Definitions pertaining to thermistors

###### J.2.15.1 **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.

Note 2 to entry: **Thermistors** are not considered to be **electronic devices** (see Annex H).



**J.2.15.2****PTC thermistor**

positive temperature coefficient (**PTC**) **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 thermistors** also exhibit a decreasing resistance with applied voltage as a secondary effect.

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.2.15.3****NTC thermistor**

negative temperature coefficient (**NTC**) **thermistor** that exhibits a decrease in resistance with increasing temperature over the useful portion of the resistance/temperature characteristic

**J.2.15.4****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 **control thermistor** 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.2.15.5****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.2.15.6****thermistor sensing element**

**PTC thermistor** or **NTC thermistor** used as a sensor and which does not carry load current

**J.2.15.7****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.2.15.8****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.2.15.9****inrush current**

$I_n$

peak current measured following energization at rated voltage and at  $25\text{ °C} \pm 2\text{ K}$  or at the manufacturer's specified ambient temperature

### J.2.15.10 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.

### J.2.15.11 maximum current

$I_{max}$

current value assigned by the manufacturer that complies with all the requirements of this standard

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 <b>steady-state current</b> <sup>a</sup> |
| PTC motor starter                                                                                                                                               | Maximum start winding current                    |
| PTC current limiter, degausser                                                                                                                                  | Maximum <b>trip current</b> <sup>b</sup>         |
| NTC inrush current limiter                                                                                                                                      | Maximum steady-state current                     |
| PTC or NTC sensor                                                                                                                                               | Not applicable                                   |
| <sup>a</sup> For devices rated in watts by the manufacturer, $I_{max}$ is calculated. This current does not mean <b>inrush current</b> .                        |                                                  |
| <sup>b</sup> For devices assigned a <b>time-to-trip</b> versus current curve by the manufacturer, the <b>maximum current</b> ( $I_{max}$ ) shall be identified. |                                                  |

### J.2.15.12 short-circuit current

$I_{sc}$

maximum current available from the impedance limited source (such as a power supply)

### J.2.15.13 steady-state current

$I_{ss}$

current measured after a **thermistor's** temperature stabilizes in air at  $25\text{ °C} \pm 2\text{ K}$  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.2.15.14 resistance

$R_{min}$

for a ceramic **PTC thermistor**, point of minimum resistance on the  $R/T$  curve

### J.2.15.15 resistance

$R_x$  ( $R_{25}$ )

rated **resistance** at a temperature specified by the manufacturer for  $R_x$  or at  $25\text{ °C} \pm 2\text{ K}$  for  $R_{25}$

### J.2.15.16 switching resistance

$R_{sw}$

for a ceramic **PTC thermistor**, **resistance** value at which the **resistance** begins to increase sharply with temperature increase

Note 1 to entry: For this standard,  $R_{sw}$  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.2.15.17 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.2.15.18 switching temperature

$T_{sw}$

for a ceramic **PTC thermistor**, temperature at which the **resistance** is at  $R_{sw}$

### J.2.15.19 surface temperature

$T_s$

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 (J.7, 7.2 of edition 3) – 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                                                                                                                                                                                                                             | $V_{max}$ | $I_{max}$            |
| <sup>a</sup> Surface temperature measured at $I_{ss}$ reflects the conditions in the tripped state of the <b>thermistor</b> (normal operating conditions for the PTC, abnormal operating condition for the circuit/application controlled by the PTC). |           |                      |

### J.2.15.20 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.2.15.21 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

**J.2.15.22****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 notes on tests****J.4.2 Samples required**

*Additional subclauses:*

**J.4.2.5** Unless otherwise specified, representative samples as indicated in Table J.3 shall be subjected to the tests specified in J.17.18. New samples shall be used for all tests other than the overload and endurance tests.

**Table J.3 – Samples for the test (clause reference)**

|                                                                                                                                  |                                                | Ageing<br>(J.17.18.3) | Heat-cold-<br>humidity<br>cycling<br>(J.17.18.1) | Overload<br>(J.17.18.2.1,<br>J.17.18.7.1) | Endurance<br>(J.17.18.2.2,<br>J.17.18.7.2) | Cold<br>operational<br>cycling<br>(J.17.18.4,<br>J.17.18.8) | Cold<br>thermal<br>cycling<br>(J.17.18.6) | Thermal<br>runaway<br>(J.17.18.5) |
|----------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|-----------------------|--------------------------------------------------|-------------------------------------------|--------------------------------------------|-------------------------------------------------------------|-------------------------------------------|-----------------------------------|
| Number of samples<br>per test                                                                                                    |                                                | 3                     | 3                                                | 3 <sup>a</sup>                            | 3 <sup>a</sup>                             | 3                                                           | 3                                         | 3                                 |
| <b>Ther-<br/>mis-<br/>tor</b><br>appli-<br>cation                                                                                | <b>PTC<br/>self-<br/>controlled<br/>heater</b> | X                     | X                                                | X                                         | X                                          | X                                                           | -                                         | X                                 |
|                                                                                                                                  | <b>PTC<br/>control</b>                         | X                     | X                                                | X                                         | X                                          | X                                                           | -                                         | X                                 |
|                                                                                                                                  | PTC sensor                                     | X                     | X                                                | X                                         | X                                          | -                                                           | X                                         | -                                 |
|                                                                                                                                  | <b>NTC<br/>control</b>                         | X                     | X                                                | X                                         | X                                          | X                                                           | -                                         | -                                 |
|                                                                                                                                  | NTC sensor                                     | X                     | X                                                | X                                         | X                                          | -                                                           | X                                         | -                                 |
| The calibration tests of J.15.7 and J.15.8 shall be conducted before and after each of the above tests (except thermal runaway). |                                                |                       |                                                  |                                           |                                            |                                                             |                                           |                                   |
| <sup>a</sup> The same three samples shall be used for both the overload and endurance tests.                                     |                                                |                       |                                                  |                                           |                                            |                                                             |                                           |                                   |

**J.4.3.2 According to rating**

*Additional paragraph:*

For the purposes of this standard, 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.

*Additional subclause:*

**J.4.3.2.11** 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 <sup>a</sup> | Sensor <sup>a</sup> | Degausser | Sensor <sup>a</sup> | 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 ( $T_s$ )                                                                      | 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. |                        |               |                              |                     |           |                     |                        |
| <sup>a</sup> The range of operating ambient temperature shall be specified.                                |                        |               |                              |                     |           |                     |                        |

#### J.4.3.5 According to purpose

*Additional subclauses:*

**J.4.3.5.4** 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.15.7 or J.15.8, whichever applies.

**J.4.3.5.4.1** **Thermistors** used in **type 1 action controls** that comply with IEC 60738 or IEC 60539 shall be subjected to the thermal runaway test of J.17.18.5 only. Compliance to IEC 60738-1 or IEC 60539 is not required if the **thermistors** comply with the requirements of Annex J.

## J.6 Classification

### J.6.4 According to features of automatic action

#### J.6.4.3.3 Replacement:

For the purpose of this standard, a **PTC thermistor control** or **sensing element** 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.

– **thermistor** (type 1.YJ or 2.YJ)

NOTE See also J.11.4.17.

### J.6.15 According to construction

*Additional subclauses:*

#### J.6.15.6 Control using NTC or PTC thermistors

##### J.6.15.7 Ceramic element

##### J.6.15.8 Polymer element

*Additional subclauses:*

### J.6.17 According to use of the thermistor

#### J.6.17.1 – thermistor control element

##### J.6.17.1.1 – PTC current limiter

##### J.6.17.1.2 – PTC motor starter

##### J.6.17.1.3 – PTC degausser

##### J.6.17.1.4 – NTC inrush current limiter

#### J.6.17.2 – self-controlled heater

#### J.6.17.3 – thermistor sensing element

##### J.6.17.3.1 – PTC sensor

##### J.6.17.3.2 – NTC sensor

## J.7 Information

Table J.5 provides additional requirements to Table 1.

**Table J.5 – Additional items to Table 1**

|                                  | Information                                                                                                                                             | Clause or subclause       | Method |
|----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|--------|
| 61                               | According to the construction and use of a <b>thermistor</b>                                                                                            | J.6.15, J.6.17            | X      |
| 62                               | <i>R/T</i> characteristics, calibration specifications <sup>k</sup>                                                                                     | J.15.7, J.15.8            | X      |
| 63                               | <i>R/T</i> characteristics, calibration specifications, <b>drift</b> <sup>l</sup>                                                                       | J.15.7, J.15.8, J.17.17.1 | X      |
| 64                               | Number of cycles                                                                                                                                        | J.17.18.2                 | X      |
| 65                               | Method of <i>R/T</i> measurement                                                                                                                        | J.15.7.4, J.15.8.3        | X      |
| 82                               | PTC current limiters where the maximum current is reduced to less than or equal to 8 A in $\leq 5$ s.                                                   | J.15.7.6.1.1              | X      |
| Additional footnotes to Table 1: |                                                                                                                                                         |                           |        |
| <sup>k</sup>                     | The <i>R/T</i> characteristics shall be expressed in the form of a curve, a table or various operating points and shall include the declared deviation. |                           |        |
| <sup>l</sup>                     | Additional declarations may be made at intermediate numbers of cycles for the test of J.17.18.2.                                                        |                           |        |

**J.11 Constructional requirements**

*Additional subclauses:*

**J.11.3.10 Thermistors** used in **controls** to provide **functional safety** or as **controls** to provide **functional safety** for a controlled application shall provide **type 2 action** (type 2.YJ), for other applications at least (type 1.YJ).

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.11.4.17 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.

*Compliance is checked by the tests of relevant requirements of this Annex J.*

**J.13 Electric strength and insulation resistance****J.13.2 Electric strength**

*Modification to footnote c of Table 12:*

*Add the word "thermistors," after "electronic parts".*

## J.15 Manufacturing deviation and drift

*Additional subclauses:*

### J.15.7 Calibration tests for PTC thermistors

**J.15.7.1** Ceramic **thermistors** are not influenced by the sequence in which the calibration tests of J.15.7.4 to J.15.7.8 are conducted on the samples. However, polymeric types may be influenced due to the nature of the material. Hence, for polymeric types of **thermistors**, it is recommended to perform the test of J.15.7.4 at the end of all the calibration tests.

**J.15.7.2** 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.15.7.3** Following the tests described in J.17.17 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.17.18 <sup>a</sup> | Compliance criteria designation (before conditioning) <sup>b</sup> | Calibration tests performed on thermistor samples after conditioning tests specified in J.17.18 <sup>a</sup> | Compliance criteria designation (after conditioning) <sup>b</sup> |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| Self-controlled heater                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | $R/T$                                                                                                  | A                                                                  | $T_s$                                                                                                        | D                                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $T_s$                                                                                                  |                                                                    | $I_n$                                                                                                        |                                                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $I_n$                                                                                                  |                                                                    |                                                                                                              |                                                                   |
| Motor starter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | $R/T$                                                                                                  | A                                                                  | $T_s$                                                                                                        | D                                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $T_s$                                                                                                  |                                                                    | $I_n$                                                                                                        |                                                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $I_n$                                                                                                  |                                                                    |                                                                                                              |                                                                   |
| Degausser                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | $R/T$                                                                                                  | A                                                                  | $T_s$                                                                                                        | D                                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $T_s$                                                                                                  |                                                                    | $I_n$                                                                                                        |                                                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $I_n$                                                                                                  |                                                                    |                                                                                                              |                                                                   |
| Current limiter                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $R/T$                                                                                                  | B                                                                  | TT                                                                                                           | E                                                                 |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $T_s$                                                                                                  |                                                                    |                                                                                                              |                                                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | TT                                                                                                     |                                                                    |                                                                                                              |                                                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $I_{ss}$                                                                                               |                                                                    |                                                                                                              |                                                                   |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | $I_h$                                                                                                  |                                                                    |                                                                                                              |                                                                   |
| Sensor                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | $R/T$                                                                                                  | C                                                                  | $R/T$                                                                                                        | F                                                                 |
| <p><math>R/T</math> - <math>R/T</math> measurement for PTC thermistors – all types (J.15.7.4)</p> <p><math>I_h</math> - Hold current test for PTC current limiters (J.15.7.5)</p> <p>TT - Time-to-trip test for PTC current limiters (J.15.7.6)</p> <p><math>T_s</math> - Surface temperature test (J.15.7.7)</p> <p><math>I_n</math> - <b>Inrush current</b> (compliance is determined by measurement, J.15.7.8)</p> <p><math>I_{ss}</math> - <b>Steady-state current</b> (compliance is determined by measurement)</p> <p>A - Resistance at 25 °C, <b>surface temperature</b> and <b>inrush-current</b> values shall be within the declared deviation tolerance specified by the manufacturer.</p> <p>B - Resistance at 25 °C, <b>surface temperature</b>, <b>steady-state current</b> and <b>time-to-trip</b> values shall be within the declared deviation tolerance specified by the manufacturer. The <b>thermistor</b> shall maintain the <b>hold current</b> for the time at the ambient temperature specified by the manufacturer, without tripping.</p> <p>C - The temperatures corresponding to the <b>switching resistance</b> (<math>R_{sw}</math>) and two additional points, located above and below <math>R_{sw}</math> on the <math>R/T</math> curve shall be within the declared deviation tolerance specified by the manufacturer.</p> <p>D - The <b>surface temperature</b> and <b>inrush-current</b> values shall be within the declared <b>drift</b> tolerance specified by the manufacturer.</p> <p>E - Time-to-trip values shall be within the declared <b>drift</b> tolerance specified by the manufacturer.</p> <p>F - The temperatures corresponding to the <b>switching resistance</b> (<math>R_{sw}</math>) and two additional points, located above and below <math>R_{sw}</math> on the <math>R/T</math> curve shall not vary from the corresponding as-received values by more than indicated in Table J.7.</p> |                                                                                                        |                                                                    |                                                                                                              |                                                                   |
| <sup>a</sup> Test abbreviations                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                        |                                                                    |                                                                                                              |                                                                   |
| <sup>b</sup> Compliance criteria                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                        |                                                                    |                                                                                                              |                                                                   |

Table J.7 – Classes for PTC sensing thermistors

| Property                                                                                                      | Class No.      |                |                |                |
|---------------------------------------------------------------------------------------------------------------|----------------|----------------|----------------|----------------|
|                                                                                                               | C <sub>1</sub> | C <sub>2</sub> | C <sub>3</sub> | C <sub>4</sub> |
| Temperature <b>drift</b> , 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 <b>drift</b> . |                |                |                |                |

#### J.15.7.4 R/T measurement for PTC thermistors

**J.15.7.4.1 Thermistor** samples shall be placed in a full draft circulating-air oven or fluid medium, such as silicon oil with the temperature maintained within  $\pm 1$  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 to be measured by an ohmmeter at as many temperatures as required to create a complete R/T curve.

#### J.15.7.5 Hold current ( $I_h$ ) test for PTC current limiters

**J.15.7.5.1** 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.15.7.6 Time-to-trip test for PTC current limiters

**J.15.7.6.1** 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** ( $I_{max}$ ) point on the **time-to-trip** versus current curve.

**J.15.7.6.1.1** A current limiting **thermistor**, as declared in item 82 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.15.7.7 Surface temperature test

**J.15.7.7.1** The **surface temperature** ( $T_s$ ) of a **PTC thermistor** shall be measured using thermocouples or equivalent devices. For a **PTC thermistor** other than a current limiter, the **surface temperature** ( $T_s$ ) shall be measured while the **thermistor** is operating at **maximum voltage** ( $V_{max}$ ) and steady-state current. For a PTC current limiter, the **surface temperature** ( $T_s$ ) shall be measured under two conditions:

- operating condition in hold state where the device shall be operated at its rated **maximum voltage** ( $V_{max}$ ) and rated **hold current** ( $I_h$ ), and
- operating condition in tripped state where the device shall be operated at rated **maximum voltage** ( $V_{max}$ ) and rated **steady-state current** ( $I_{ss}$ ).

See Table J.2.

#### J.15.7.8 Inrush current measurement

**J.15.7.8.1** 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.

### J.15.8 Calibration tests for NTC thermistors

**J.15.8.1** 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.15.8.2** Following the tests described in J.17.17 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.17.18 <sup>a</sup> | Compliance criteria designation (before conditioning) <sup>b</sup> | Calibration tests performed on thermistor samples after conditioning tests specified in J.17.18 <sup>a</sup> | Compliance criteria designation (after conditioning) <sup>b</sup> |
|------------------------|--------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|
| Inrush-current limiter | $R/T$                                                                                                  | A                                                                  | $T_s$                                                                                                        | C                                                                 |
|                        | $T_s$                                                                                                  |                                                                    | $I_n$                                                                                                        |                                                                   |
|                        | $I_n$                                                                                                  |                                                                    |                                                                                                              |                                                                   |
| Sensor                 | $R/T$                                                                                                  | B                                                                  | $R/T$                                                                                                        | D                                                                 |
|                        | Beta                                                                                                   |                                                                    |                                                                                                              |                                                                   |

$R/T$  -  $R/T$  measurement for **NTC thermistors** (J.15.8.3)

$T_s$  - Surface temperature test (J.15.8.4)

Beta - **Resistance ( $R_{25}$ ) and beta value (B)** test for **NTC thermistors** (J.15.8.6)

$I_n$  - **Inrush current** (compliance is determined by measurement (J.15.8.5))

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 indicated in Table J.9. One of the temperatures shall be 25 °C.

<sup>a</sup> Test abbreviations

<sup>b</sup> Compliance criteria

**Table J.9 – Classes for NTC sensing thermistors**

| Property                                                                                                      | Class No.      |                |                |                |
|---------------------------------------------------------------------------------------------------------------|----------------|----------------|----------------|----------------|
|                                                                                                               | C <sub>1</sub> | C <sub>2</sub> | C <sub>3</sub> | C <sub>4</sub> |
| Temperature <b>drift</b> 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 <b>drift</b> . |                |                |                |                |

### J.15.8.3 $R/T$ measurement for NTC thermistors

**J.15.8.3.1** **Thermistor** samples shall be placed in a full draft circulating-air oven or fluid medium, such as silicon oil with the temperature maintained within  $\pm 1$  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** ( $T_s$ ) determined in accordance with J.15.8.4

(**inrush-current** limiters). The **resistance** shall be measured at as many temperatures as required to create a complete *R/T* curve.

#### J.15.8.4 Surface temperature test (**inrush-current** limiting only)

**J.15.8.4.1** The **surface temperature** ( $T_s$ ) of a **NTC inrush-current** limiter shall be measured using thermocouples or equivalent devices while the **NTC thermistor** is being operating at **maximum voltage** ( $V_{max}$ ) and **maximum current** ( $I_{max}$ ) 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.15.8.5 Inrush current measurement (**inrush-current** limiting only)

**J.15.8.5.1** For an **NTC inrush-current** limiter, the **inrush current** shall be measured using an oscilloscope while the **thermistor** is operating at **maximum voltage** ( $V_{max}$ ) and **maximum current** ( $I_{max}$ ) with the rated capacitance value in parallel with the load.

#### J.15.8.6 Resistance ( $R_{25}$ ) and beta value ( $B$ ) test for **NTC thermistors**

**J.15.8.6.1** 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:

$$B = (I_n R_1 - I_n R_2) / (1/T_1 - 1/T_2)$$

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.17 Endurance

Additional subclauses:

**J.17.17** The sequence of tests is as follows:

a) for **PTC thermistors**:

- Ageing (J.17.18.3.1 or J.17.18.3.2);
- Heat-cold-humidity (J.17.18.1);
- Overload (J.17.18.2.1);
- Endurance (J.17.18.2.2);
- Cold operational cycling (J.17.18.4);
- Cold thermal cycling (J.17.18.6);
- Thermal runaway (J.17.18.5).

b) for **NTC thermistors**:

- Ageing (J.17.18.3.1);
- Heat-cold-humidity (J.17.18.1);
- Overload (J.17.18.7.1);

- *Endurance (J.17.18.7.2);*
- *Cold operational cycling (J.17.18.8);*
- *Cold thermal cycling (J.17.18.6).*

**J.17.17.1** After the appropriate tests of J.17.18.1 to J.17.18.4 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.15.7 or J.15.8, whichever applies.

**J.17.17.2** After the appropriate tests of J.17.18, the **control** shall continue to comply with the requirements of Clauses 8 and 13. During and after the tests, there shall be no emission of flames or expulsion of particles.

## **J.17.18 Conditioning tests**

### **J.17.18.1 Heat-cold-humidity**

Following the conditioning specified in J.17.18.1.1, a **thermistor** shall comply with Tables J.6, J.7, J.8 or J.9, whichever applies.

**J.17.18.1.1** 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** ( $T_s$ ) or maximum declared operating temperature. In any case, the temperature shall not be less than 70 °C. The oven temperature shall be maintained within  $\pm 5$  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** ( $T_s$ ) or maximum declared operating temperature. In any case, the temperature shall not be less than 70 °C. The oven temperature shall be maintained within  $\pm 5$  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.

### **J.17.18.2 Extended cycling (PTC)**

#### **J.17.18.2.1 Overload**

**J.17.18.2.1.1** Following the tests specified in J.17.18.2.1.2, J.17.18.2.1.3, or J.17.18.2.1.4 and J.17.18.2.2.1, a **thermistor** shall comply with Table J.6 or Table J.7.

**J.17.18.2.1.2** 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.17.18.2.1.3** 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** ( $I_{\text{sc}}$ ).

Each cycle shall start with the sample thermally stabilized at  $25\text{ }^{\circ}\text{C} \pm 5\text{ K}$ . Each cycle shall cover that portion of the  $R/T$  curve from the lower knee to the high **resistance** state.

**J.17.18.2.1.4** 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  $25\text{ }^{\circ}\text{C} \pm 5\text{ K}$  and increasing the temperature to 120 % of the maximum sensing temperature of the **thermistor**.

#### J.17.18.2.2 Endurance

**J.17.18.2.2.1** The three **thermistor** samples that have been subjected to overload test of J.17.18.2.1, 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 tripping current ( $I_t$ ) or the minimum functioning current ( $I_{\text{fun}}$ ).
  - 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  $25\text{ }^{\circ}\text{C} \pm 5\text{ K}$  and the maximum operating temperature.

**Table J.10 – Number of cycles for endurance test**

| Type of thermistor                                                                                                                                                                                                                                                                                                         | Number of cycles of operation |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| <b>Self-controlled heater</b>                                                                                                                                                                                                                                                                                              | 100 000                       |
| Current limiter intended for use in a <b>functional safety</b> circuit                                                                                                                                                                                                                                                     | 100 000 <sup>a</sup>          |
| Current-limiter not intended for use in a <b>functional safety</b> circuit                                                                                                                                                                                                                                                 | 6 000                         |
| Degausser or motor starter                                                                                                                                                                                                                                                                                                 | 30 000                        |
| Sensor not intended for use in a <b>functional safety</b> circuit                                                                                                                                                                                                                                                          | 6 000                         |
| Sensor intended for use in a <b>functional safety</b> circuit                                                                                                                                                                                                                                                              | 100 000                       |
| <sup>a</sup> The minimum number of cycles is reduced to 6 000 under the following conditions: <ul style="list-style-type: none"> <li>– the trip state of the <b>thermistor</b> is apparent in the end-use application; and</li> <li>– manual intervention is required in order to reset the <b>thermistors</b>.</li> </ul> |                               |

### J.17.18.3 Thermal conditioning

#### J.17.18.3.1 Passive ageing

Following the conditioning specified in J.17.18.3.1.1 and J.17.18.3.2.1, a **thermistor** shall comply with Tables J.6, J.7, J.8 or J.9, as appropriate.

**J.17.18.3.1.1** 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  $\pm 5$  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 <b>surface temperature</b> test, J.15.7.7 (PTC) and J.15.8.4 (NTC) |
| Sensing                  | Highest temperature rating                                                                                   |

#### J.17.18.3.2 Active ageing

**J.17.18.3.2.1** In addition to the test described in J.17.18.3.1.1, 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** ( $V_{\max}$ ) and carrying **steady-state current** ( $I_{ss}$ ).

#### J.17.18.4 Cold operational cycling (PTC)

**J.17.18.4.1** Following the test specified in J.17.18.4.2, a **thermistor** shall comply with Table J.6.

**J.17.18.4.2** 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.17.18.2.2.1 a) for a **self-controlled heater** or J.17.18.2.2.1 b) for a **control thermistor**. The **thermistor** temperature shall be returned to the starting temperature before each cycle.

#### J.17.18.5 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 may 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.17.18.6 Cold thermal cycling

**J.17.18.6.1** Following the cycling specified in J.17.18.6.1.1, a **thermistor** shall comply with Tables J.7 or J.9, whichever applies.

**J.17.18.6.1.1** 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.17.18.7 Extended cycling (NTC)

### J.17.18.7.1 Overload

**J.17.18.7.1.1** Following the tests specified in J.17.18.7.1.2 or J.17.18.7.1.3 and J.17.18.7.2.1, a **thermistor** shall comply with Table J.8.

**J.17.18.7.1.2** For an **inrush-current** limiting **thermistor**, three samples shall be mounted and operated as intended for 50 cycles while connected to **maximum voltage** ( $V_{\max}$ ) and 120 % of the **maximum current** ( $I_{\max}$ ). Each cycle shall start with the sample thermally stabilized at 25 °C.

**J.17.18.7.1.3** 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  $\pm$  5 K and increasing the temperature to 120 % of the maximum sensing temperature of the **thermistor**.

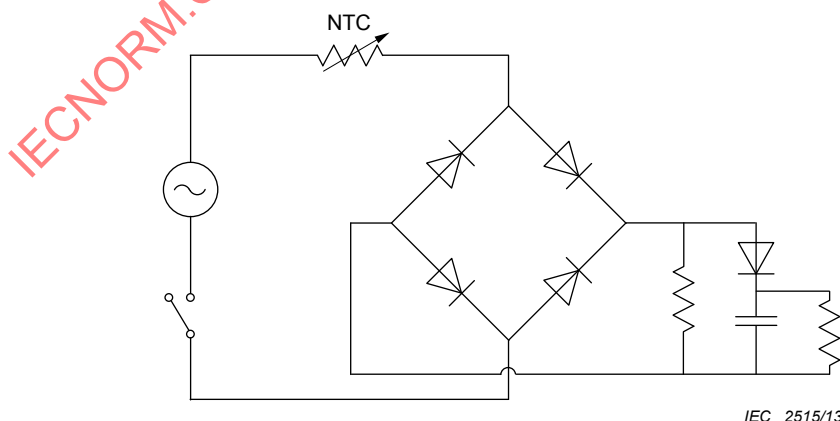
### J.17.18.7.2 Endurance

**J.17.18.7.2.1** The three **thermistor** samples that have been subjected to the overload test, J.17.18.7.1, 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.

- 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.
- Sensing** – A sensing **thermistor** shall be cycled between 25 °C  $\pm$  5 K and the maximum operating temperature.

**Table J.12 – Number of cycles for endurance test**

| Type of thermistor                                                                       | Number of cycles of operation |
|------------------------------------------------------------------------------------------|-------------------------------|
| <b>Inrush-current</b> limiter intended for use in a <b>functional safety</b> circuit     | 100 000                       |
| <b>Inrush-current</b> limiter not intended for use in a <b>functional safety</b> circuit | 6 000                         |
| Sensor intended for use in a <b>functional safety</b> circuit                            | 100 000                       |
| Sensor not intended for use in a <b>functional safety</b> circuit                        | 6 000                         |



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**Figure J.1 – Test circuit for inrush-current limiting thermistor endurance test**

## J.17.18.8 Cold operational cycling (for inrush current-limiting NTC thermistors only)

**J.17.18.8.1** Following the cycling specified in J.17.18.8.2, a **thermistor** shall comply with Table J.8.



**J.17.18.8.2** Three samples of a **thermistor** shall be subjected to 1 000 cycles of **operation** at **maximum voltage** ( $V_{\max}$ ) conducting **maximum current** ( $I_{\max}$ ), 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  $\pm 2$  K before each cycle.

## **J.20 Creepage distances, clearances and distances through insulation**

*Additional subclauses:*

### **J.20.1.14 Clearance**

**J.20.1.14.1 Clearance** between **live parts** connected electrically to the mains supply and **accessible surfaces** or parts shall comply with the requirements of 20.1.

**J.20.1.14.2 Clearance** between **live parts** providing **functional insulation** shall comply with the requirements of 20.1.

### **J.20.2.5 Creepage distance**

**J.20.2.5.1 Creepage distance** between **live parts** connected electrically to the mains supply and **accessible surfaces** or parts shall comply with the requirements of 20.2.

**J.20.2.5.2 Creepage distance** between **live parts** providing **functional insulation** shall comply with the requirements of 20.2.

## **J.24 Components**

**J.24.2.1** *Add the following:*

Subclause J.24.2.1 is applicable to **thermistors** previously tested under IEC 60738-1, IEC 60738-1-1 or IEC 60539.

## **J.27 Abnormal operation**

**J.27.1** Consideration of **fault** modes shall be made in accordance with Table H.24 for **thermistors** used in **protective controls**.

### Nominal voltages of supply systems for different modes of overvoltage control

**Table K.1 – Inherent control or equivalent protective control**

| Voltage line-to-neutral from nominal voltages a.c. or d.c. <sup>a</sup> | Nominal voltages presently used in the world                  |                                                       |                                            |                                              | Rated impulse voltage for equipment <sup>a</sup> |       |       |        |
|-------------------------------------------------------------------------|---------------------------------------------------------------|-------------------------------------------------------|--------------------------------------------|----------------------------------------------|--------------------------------------------------|-------|-------|--------|
|                                                                         | Three-phase four-wire systems with earthed neutral            | Three-phase three-wire systems unearthed              | Single-phase two-wire systems a.c. or d.c. | Single-phase three-wire systems a.c. or d.c. | Overvoltage category                             |       |       |        |
|                                                                         |                                                               |                                                       |                                            |                                              | I                                                | II    | III   | IV     |
| V                                                                       | V                                                             | V                                                     | V                                          | V                                            |                                                  |       |       |        |
| 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 <sup>b</sup><br>127 / 220                           | 115; 120; 127                                         | 110; 120                                   | 110 / 220<br>120 / 240 <sup>c</sup>          | 800                                              | 1 500 | 2 500 | 4 000  |
| 300                                                                     | 220 / 380<br>230 / 400<br>240 / 415<br>260 / 440<br>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<br>380 / 660<br>400 / 690<br>417 / 720<br>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 |

<sup>a</sup> These columns are taken from Annex F, Table F.1 of IEC 60664-1:2007 in which the **rated impulse voltage** values are specified. See 4.2.3 of IEC 60664-1:2007 for the definitions of protective **control** and inherent **control**.

<sup>b</sup> Practice in the USA and Canada.

<sup>c</sup> 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.

| Voltage line-to-neutral from nominal voltages a.c. or d.c. <sup>a</sup><br>V | Nominal voltages presently used in the world                  |                                                         |                                                 |                                                   | Rated impulse voltage for equipment <sup>a</sup><br>V |       |       |        |
|------------------------------------------------------------------------------|---------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------------|---------------------------------------------------|-------------------------------------------------------|-------|-------|--------|
|                                                                              | Three-phase four-wire systems with earthed neutral<br>V       | Three-phase three-wire systems unearthed<br>V           | Single-phase two-wire systems a.c. or d.c.<br>V | Single-phase three-wire systems a.c. or d.c.<br>V | Overvoltage category                                  |       |       |        |
|                                                                              |                                                               |                                                         |                                                 |                                                   | I                                                     | II    | III   | IV     |
| 50                                                                           |                                                               |                                                         | 12,5; 24; 25;<br>30; 42; 48                     | 30/60                                             | 330                                                   | 500   | 800   | 1 500  |
| 100                                                                          | 66 / 115                                                      | 66                                                      | 60                                              |                                                   | 500                                                   | 800   | 1 500 | 2 500  |
| 150                                                                          | 120 / 208 <sup>b</sup><br>127 / 220                           | 115; 120;<br>127                                        | 110; 120                                        | 110/220<br>120/240                                | 800                                                   | 1 500 | 2 500 | 4 000  |
| 300                                                                          | 220 / 380<br>230 / 400<br>240 / 415<br>260 / 440<br>277 / 480 | 220; 230;<br>240; 260;<br>277                           | 220                                             | 220/440                                           | 1 500                                                 | 2 500 | 4 000 | 6 000  |
| 600                                                                          | 347 / 600<br>380 / 660<br>400 / 690<br>417 / 720<br>480 / 830 | 347; 380;<br>400; 415;<br>440; 480;<br>500; 577;<br>600 | 480                                             | 480/960                                           | 2 500                                                 | 4 000 | 6 000 | 8 000  |
| 1 000                                                                        |                                                               | 660; 690;<br>720; 830;<br>1 000                         | 1 000                                           |                                                   | 4 000                                                 | 6 000 | 8 000 | 12 000 |

<sup>a</sup> These columns are taken from Annex F, Table F.1 of IEC 60664-1:2007 in which the **rated impulse voltage** values are specified. See 4.2.3 of IEC 60664-1:2007 for the definitions of protective **control** and inherent **control**.

<sup>b</sup> Practice in the USA and Canada.

## Annex L (normative)

### Overvoltage categories

**Overvoltage category** is a numeral characterizing a **transient overvoltage** condition.

The following information on **overvoltage categories** is based on IEC 60664-1. Part 2s 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**, unless the **control** or equipment application provides means of suppressing the transient voltage, in which case a lower category will apply.

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** can 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 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.

## Annex M (informative)

### Typical usage

**Table M.1 – Typical usage**

| Control situation                                                                                                                                                                                                                                                                                                                                                           | Overvoltage category |            |                |                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------|----------------|------------------------|
|                                                                                                                                                                                                                                                                                                                                                                             | I                    | II         | III            | IV                     |
| Special<br><b>Isolated limited secondary circuit</b><br>Transient limited supply                                                                                                                                                                                                                                                                                            | X<br>X               | X          | X              | X                      |
| Energy consuming utilization equipment<br><br>Integrated and <b>incorporated controls</b> in household appliances<br><br><b>Independently mounted controls</b> for fixed-wiring to energy consuming loads                                                                                                                                                                   |                      | X<br><br>X | <br><br>X      |                        |
| Other household and similar applications:<br><br><b>Controls</b> which are not integrated, incorporated, or for fixed-wiring to energy consuming loads<br><br><b>Controls</b> mounted at the origin of installation (i.e. service entrance equipment, electricity meters and primary overcurrent equipment)<br><br><b>Controls</b> covered by special part 2 considerations |                      |            | X<br><br><br>X | <br><br><br>X<br><br>X |

## Annex N (normative)

### Pollution degrees

#### N.1 Pollution

The **micro-environment** determines the effects of **pollution** on the insulation. The **macro-environment**, however, has to 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** may not be 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** may 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 standard.

#### N.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 P or Annex Q, 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.

## Annex P (normative)

### Printed circuit board coating performance test

**P.1** A coating intended to be used on a printed circuit board that has **creepage distances** in accordance with Clause 20, **pollution degree** 1, shall comply with the requirements of Annex P.

**P.2** A printed circuit board assembly that is used with a coating, including inks, solder resists and assembled components, is to 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.

**P.3** Electric strength of coating – A coating shall withstand the electric strength test of 13.2 for **functional insulation** at a test voltage determined from Table 12, based on the maximum **working voltage** supplied to the board assembly, after the conditioning of P.3.3 and P.3.4.

**P.3.1** Ten test samples shall be prepared with the minimum applicable **creepage distances** and the minimum coating thickness using the pattern shown in Figure P.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 is to be attached.

**P.3.2** Ageing test – Five samples of the coated board as described in P.3.1 shall be subjected to a temperature of  $130\text{ }^{\circ}\text{C} \pm 2\text{ K}$  for 1 000 h.

**P.3.3** 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  $(35 \pm 1)\text{ }^{\circ}\text{C}$  and  $(90 \pm 5)\%$  relative humidity. Immediately following removal from the test chamber, each sample is to be subjected to the electric strength test described in P.3.5 and P.3.6.

**P.3.4** Environmental cycle conditioning – Five of the samples of the coated board described in P.3.1 are to be subjected to three complete cycles of environmental conditioning as described in Table P.1. Immediately following the conditioning, each sample is to be subjected to the electric strength test described in P.3.5 and P.3.6.

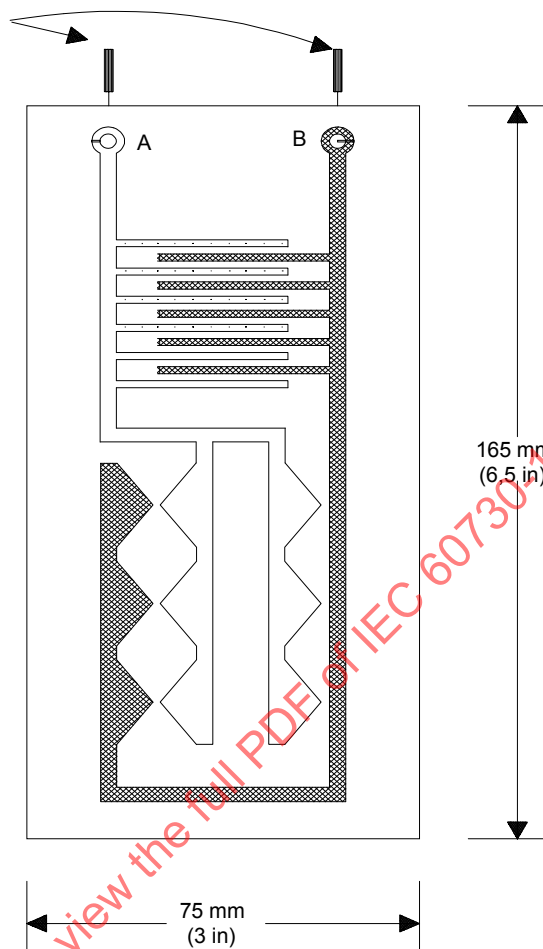
**P.3.5** After conditioning, the samples of the coated board as described in P.3.1 are to be provided with tight-fitting aluminium foil (representing an electrically conductive deposit along the surface of the coating) that covers the test pattern except for the insulated test lead wire and solder points.

**P.3.6** The voltage stress is to be applied according to Clause P.3 to each conditioned sample between leads A, B, and C individually and the common lead (see Figure P.1). No flashover or breakdown shall occur. Glow discharges without drop in voltage are neglected.

**Table P.1 – Environmental cycling conditions**

| For indoor applications                                                                                                                                                                 | For outdoor applications                                                                                                                                                                                                                        |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 24 h at $T_{\text{max}}$ ; followed by at least 96 h at $(35 \pm 2)\text{ }^{\circ}\text{C}$ , $(90 \pm 5)\%$ relative humidity; followed by 8 h at $(0 \pm 2)\text{ }^{\circ}\text{C}$ | A minimum of 24 h immersed at $(25 \pm 2)\text{ }^{\circ}\text{C}$ ; followed immediately by at least 96 h at $(35 \pm 2)\text{ }^{\circ}\text{C}$ , $(90 \pm 5)\%$ relative humidity; followed by 8 h at $(-35 \pm 2)\text{ }^{\circ}\text{C}$ |

High temperature  
(i.e. PTFE, Silicone, etc.)  
insulated test leads soldered  
to test pattern through  
the back of the board



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 P.1 – Test sample**



## Annex Q (normative)

### Printed circuit board coating performance test

**Q.1** A printed wiring board conforming with all of the requirements for type 1 coating as specified in IEC 60664-3 shall comply with the minimum **creepage distance** requirements of Clause 20 of this standard, **pollution degree** 1.

**Q.2** A printed wiring board conforming with all of the requirements for type 2 coating as specified in IEC 60664-3 shall comply with the minimum requirements for solid insulation as specified in 20.3 of this standard. The spacing between the conductors before the protection is applied shall not be less than the values as specified in Table 1 of IEC 60664-3:2003.

**Q.3** Actual printed boards representative of production samples or standard test boards according to Figures Q.1 and Q.2 may be used for the tests. Thirteen samples are required for type 1 tests, seventeen samples for type 2 tests.

**Q.4** *Compliance with the requirements for type 1 or type 2 coating shall be checked by the tests of Clause 5 of IEC 60664-3:2003, Amendment 1:2010.*

**Q.5** For the tests of Clause 5 of IEC 60664-3:2003, Amendment 1:2010, the test levels or conditions given in Table Q.1 apply:

**Table Q.1 – IEC 60664-3 test levels or conditions**

| IEC 60664-3:2003, subclause |                             | Test level of this standard               |
|-----------------------------|-----------------------------|-------------------------------------------|
| 5.7.1                       | Cold storage                | –25 °C                                    |
| 5.7.3                       | Rapid change of temperature | Degree of severity 2 (–25 °C to +125 °C)  |
| 5.7.4.2                     | Electromigration            | Not applicable unless specified in part 2 |
| 5.8.5                       | Partial discharge           | Not applicable unless specified in part 2 |

dimensions in millimetres

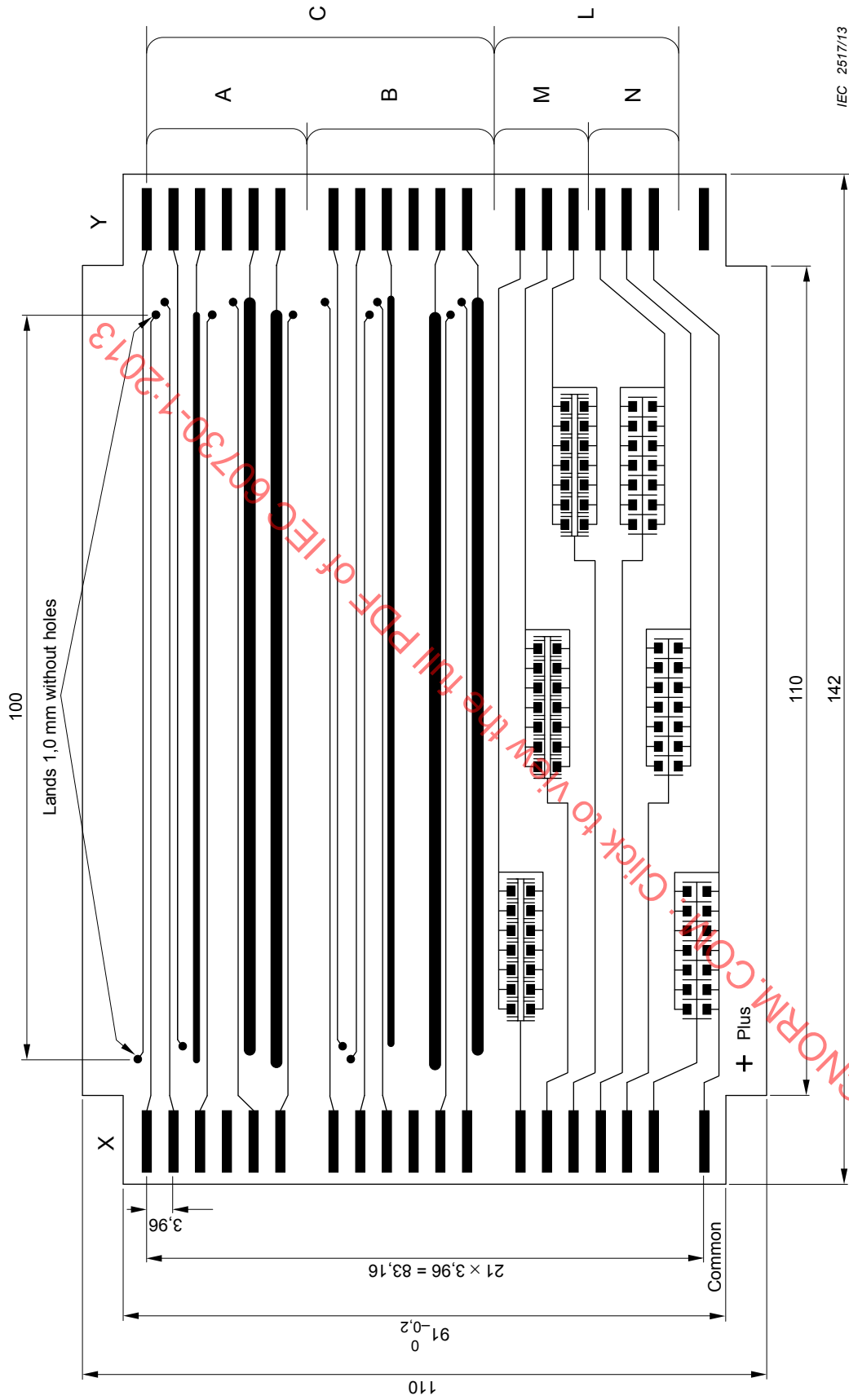
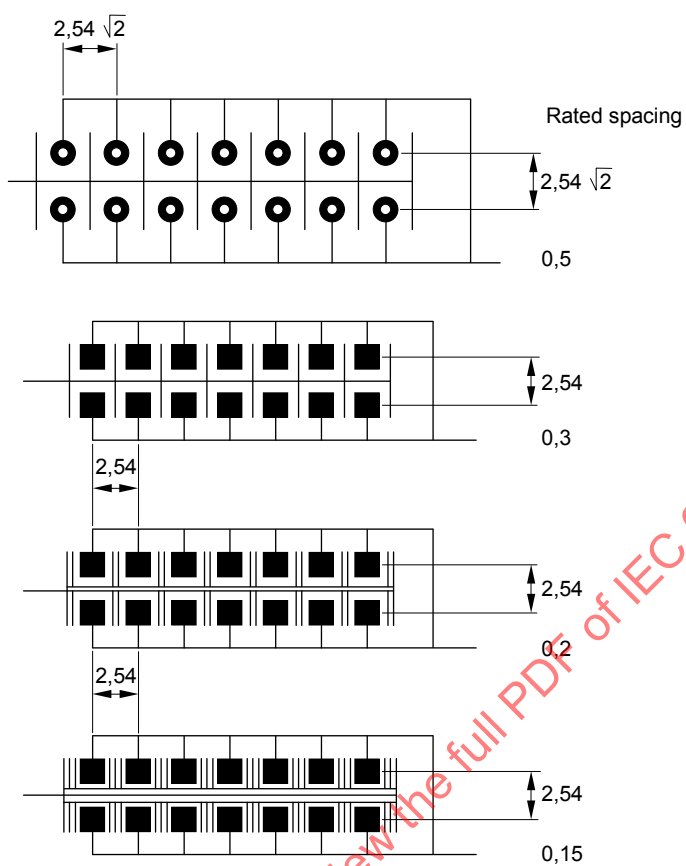


Figure Q.1 – Test sample

*Dimensions in millimetres*

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**Figure Q.2 – Examples of land configurations**  
(see also Figure Q.1)

## Annex R (informative)

### Explanatory notes for surge immunity test

#### R.1 Different source impedances

The selection of the source impedance of the generator depends on:

- the kind of cable/conductor/line (power supply a.c., power supply d.c., 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  $2\ \Omega$  represents the source impedance of the low voltage power supply network.

The generator with its effective output impedance of  $2\ \Omega$  is used.

The impedance of  $12\ \Omega$  ( $10\ \Omega + 2\ \Omega$ ) represents the source impedance of the low voltage power supply network and earth.

The generator with an additional resistor of  $10\ \Omega$  in series is used.

The impedance of  $42\ \Omega$  ( $40\ \Omega + 2\ \Omega$ ) represents the source impedance between all other lines and earth.

The generator with an additional resistor of  $40\ \Omega$  in series is used.

#### R.2 Application of the tests

Two different kinds of tests are to be distinguished: at equipment level and at **system** level.

##### R.2.1 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.

##### R.2.2 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.

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.

### R.3 Installation classification

#### R.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 may 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.

Surge may 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 may not exceed 4 kV.

Examples of the installation of electronic equipment in different areas are given in Figures R.1, R.2, and R.3.

### R.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

### R.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.

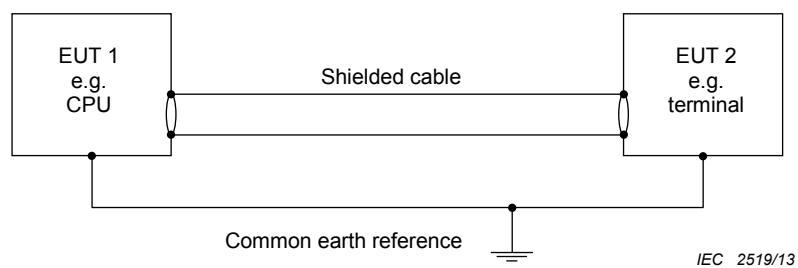


**Figure R.1 – Example of surge protection by shielding in buildings with common earth reference systems**

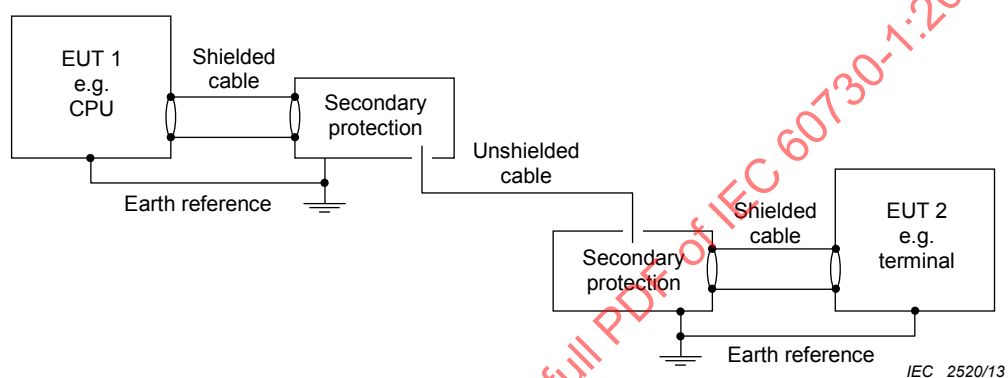
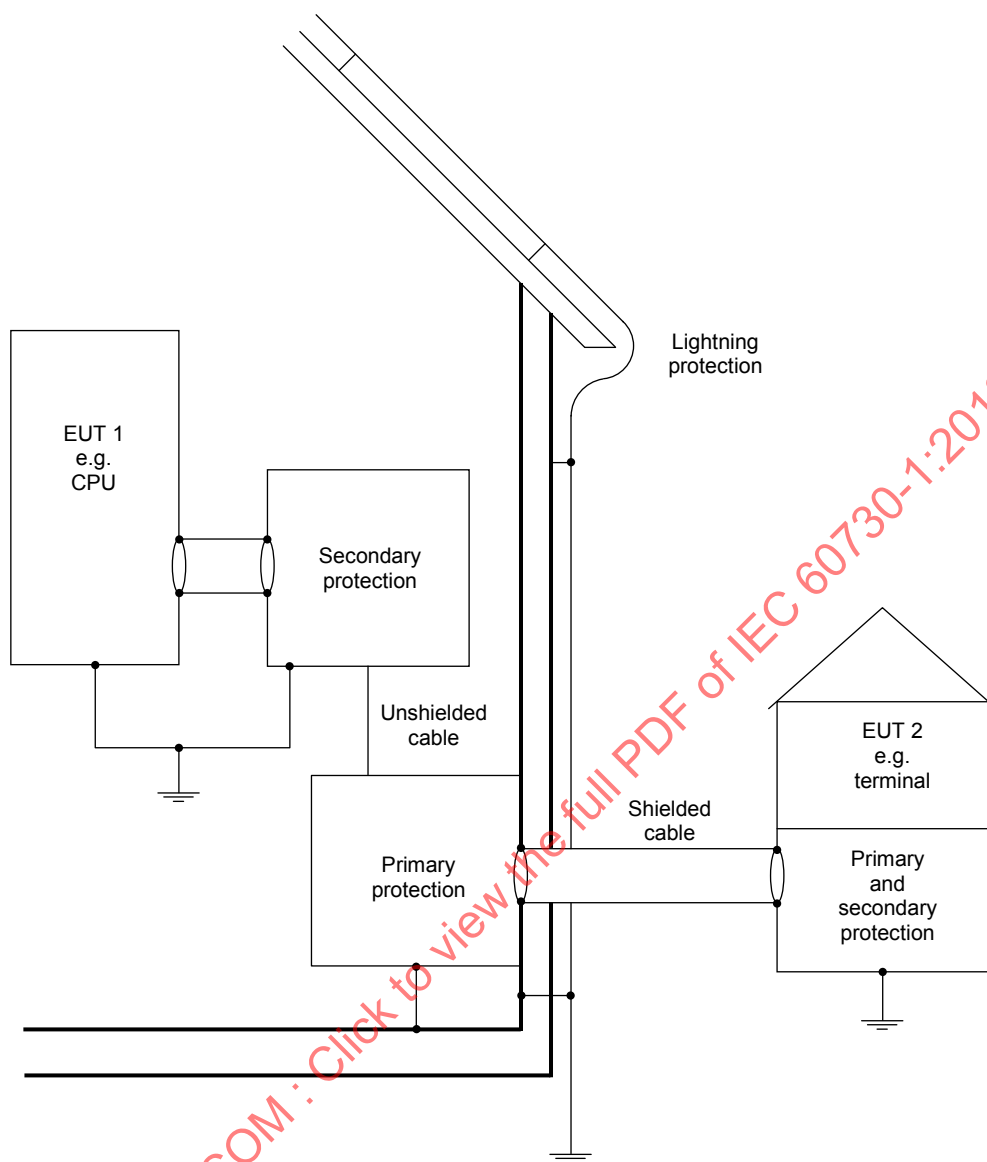


**Figure R.2 – Example of secondary surge protection in buildings with separate common earth reference systems**



IEC 2521/13

**Figure R.3 – Example of primary and secondary surge protection of indoor/outdoor equipment**



**Annex S**  
(informative)

**Guidance for applying Clause 20**

Guidance for applying Clause 20 is indicated in Figure S.1, Table S.1 and Table S.2.

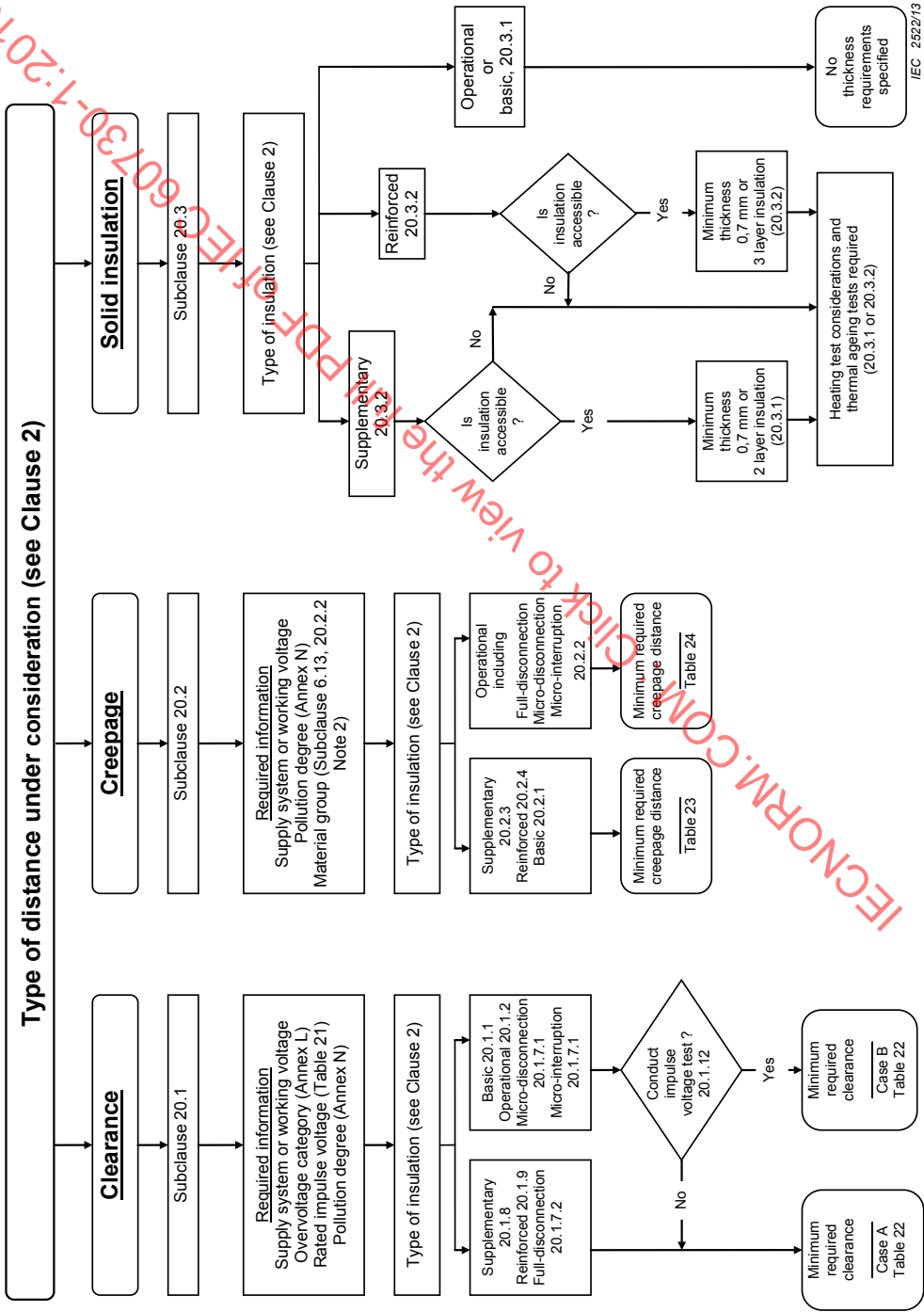


Figure S.1 – Guidance flowchart for application of requirements of Clause 20

**Table S.1 – Example A – Using Annex S guidance for applying Clause 20**

| Question                                                                                                     | Answer                                  | Instruction                                                                                                  |
|--------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------|
| Is the distance under consideration through air or across a surface?                                         | Through air                             | Follow <b>clearance</b> path of flow chart                                                                   |
| What is the <b>system</b> supply voltage, or for <b>functional insulation</b> , the <b>working voltage</b> ? | 230 V/400 V, 3-phase, 4 wire            | Record as a)                                                                                                 |
| What is the <b>overvoltage category</b> ? (refer to Annex L)                                                 | See category II                         | Record as b)                                                                                                 |
| What is the <b>rated impulse voltage</b> ?                                                                   | Determine from Table 21 using a) and b) | Record as c)                                                                                                 |
| What is the <b>pollution degree</b> ? (refer to Annex N)                                                     | <b>Pollution degree 2</b>               | Record as d)                                                                                                 |
| What is the type of insulation? (refer to definitions, etc.)                                                 | <b>Reinforced insulation</b>            | Refer to 20.1.9. For reinforced use case A and next higher impulse voltage step from Table 22. Record as e). |
| What is the limit for this distance?                                                                         | Refer to Table 22                       | Determine the limit using d) and e)                                                                          |
|                                                                                                              | <b>The limit is 3 mm</b>                |                                                                                                              |

**Table S.2 – Example B – Using Annex S guidance for applying Clause 20**

| Question                                                                                                     | Answer                       | Instruction                             |
|--------------------------------------------------------------------------------------------------------------|------------------------------|-----------------------------------------|
| Is the distance under consideration through air or across a surface?                                         | Across a surface             | Follow <b>creepage distance</b> path    |
| What is the <b>system</b> supply voltage, or for <b>functional insulation</b> , the <b>working voltage</b> ? | 230 V                        | Record as a)                            |
| What is the <b>pollution degree</b> ? (refer to Annex N)                                                     | <b>Pollution degree 2</b>    | Record as b)                            |
| What is the material group? (refer to 20.2.2, Note 2)                                                        | IIb)                         | Record as c)                            |
| What is the type of insulation? (refer to definitions, etc.)                                                 | <b>Functional insulation</b> | Refer to 20.2.2                         |
| What is the limit for this distance?                                                                         | Refer to Table 24            | Determine the limit using a), b) and c) |
|                                                                                                              | <b>The limit is 2,5 mm</b>   |                                         |

## Annex T (normative)

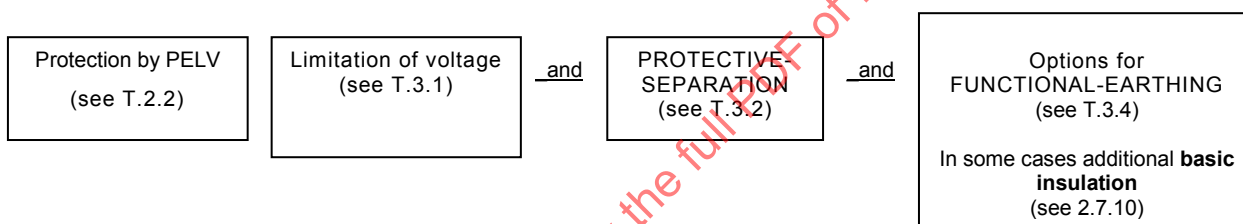
### Requirements for SELV and PELV

#### T.1 Overview of the requirements for SELV and PELV

##### T.1.1 Protection by SELV



##### T.1.2 Protection by PELV



(Adopted from IEC 61140)

NOTE The requirements of IEC 61140 for barriers were considered and included in the requirements of this standard including, but not limited to, Clauses 8, 11, 18, and 20.

#### T.2 Protection against electric shock by SELV or PELV

##### T.2.1 SELV

Protection against electric shock shall be provided by the following measures:

- limitation of voltage **ELV**, according to T.3.1 in a circuit (the **SELV-system**), and
- protective-separation, according to T.3.2, of the **SELV-system** from all circuits other than **SELV** and PELV, and
- simple-separation, according to T.3.3, 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 T.3.2.1 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** are given in Clause T.3.

### T.2.2 PELV

Protection against electric shock shall be provided by the following measures:

- limitation of voltage, **ELV** according to T.3.1 in a circuit which may be earthed and/or the **exposed-conductive-parts** of which may be earthed (the **PELV system**), and
- **protective separation** according to T.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 T.3.2.1 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** (T.3.4) 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 are given in Clause T.3.

### T.3 ELV, protective separation, simple separation, protective bonding as elements of SELV and PELV

**T.3.1** Limitation of voltage shall provide that the voltage between simultaneously **accessible parts** does not exceed relevant **ELV** limits as specified in 2.1.4 and as specified in 8.1.1.

**T.3.2** **Protective separation** between a **SELV/PELV**-circuit 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 T.3.2.1 with the protective screen being separated from each adjacent circuit by **basic insulation** rated for the highest adjacent circuit voltage (see also T.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**.

When the supply of **SELV** or **PELV** circuits is obtained from supply mains of higher voltages, it shall

- either be through a **safety isolating transformer**, or
- a converter with separate windings providing equivalent insulation and with requirements as below.

NOTE 1 The voltage limits are based on the assumption that the **safety isolating transformer** is supplied at the upper limit of its rated voltage.

NOTE 2 In Canada and the USA, parts connected to **ELV** supplied from a **safety isolating transformer** are at a voltage not exceeding 42,4 V peak or 30 V r.m.s. dry, or 21,2 V peak or 15 V r.m.s. when wet contact is likely to occur.

If a converter is used, and the **control** is declared

- IPX7 per 6.5.2, the **control** shall be declared to be subjected to second **fault** analysis (requirement 73 of Table 1) 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 H.8.1.10.

*Compliance is checked by inspection, measurement and when performing the appropriate test(s) in the order of this standard.*

**T.3.2.1** 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 9; and
- shall itself comply with the requirements of Clause 9.

**T.3.3** 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 current** values indicated in H.8.1.10 and H.11.2.5 for **protective impedance**.

#### **T.3.4 Protective bonding**

The requirements for protective bonding are those for protective earthing in Clause 9 of this standard.

For the installation of **controls** which consist of several component parts (sensing component, transmitters, central **control** unit, receivers, actors, 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.

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.

*This standard allows the use of **exposed-conductive-parts** as **internal conductors** of an internal **PELV** circuit for functional earthing under conditions specified in this Part 1 and for particular applications in the relevant part 2.*

## **Annex U** (normative)

### **Requirements for relays when used as controls in IEC 60335 appliances**

Annex U supplements or modifies the corresponding clauses of this standard.

NOTE These requirements were originally contained in IEC 60730-2-1 which has been withdrawn.<sup>6</sup>

#### **U.2 Terms and definitions**

##### **U.2.2 Definitions of types of control according to purpose**

###### **U.2.2.12**

###### **electrically operated control**

for the purpose of this annex, a relay is a **control** as defined in 2.2.12.

*Replace the first note to entry with the following new note to entry:*

NOTE An example is a relay, a current-operated relay, a voltage-operated relay, or a cycling replay.

#### **U.4 General notes on tests**

##### **U.4.3 Instructions for test**

###### **U.4.3.5 According to purpose**

*Additional subclause:*

**U.4.3.5.4** *If a relay incorporates a ventilation means, this should be broken out for the tests of Clauses 12 to 17, if so declared.*

#### **U.6 Classification**

##### **U.6.3 According to their purpose**

*Additional subclauses:*

**U.6.3.10.1** – relay

**U.6.3.10.2** – current operated relay

**U.6.3.10.3** – voltage operated relay

<sup>6</sup> IEC 60730-2-1:1989, *Automatic electrical controls for household and similar use – Part 2: Particular requirements for electrical controls for household appliances*

**U.6.6 According to method of connection***Additional subclauses:***U.6.6.6** – **control** for printed wiring board mounting**U.6.6.7** – **control** for printed wiring board mounting, contact connections via other than printed wiring board tracks**U.6.6.8** – plug-in relay**U.6.8 According to protection against electric shock***Additional subclauses:***U.6.8.5** For a relay: insulation between coil and contact circuits:**U.6.8.5.1** – of class 0;**U.6.8.5.2** – of class 0I;**U.6.8.5.3** – of class I;**U.6.8.5.4** – of class II;**U.6.8.5.5** – of class III.**U.6.8.6** For a relay: insulation between **live parts** and test function, **manual action actuating member**:**U.6.8.6.1** – of class 0;**U.6.8.6.2** – of class 0I;**U.6.8.6.3** – of class I;**U.6.8.6.4** – of class II;**U.6.8.6.5** – of class III.**U.7 Information***Replace rows 3, 4 and 88 of Table 1 as follows:*

| Information                                                 | Clause or subclause | Method |
|-------------------------------------------------------------|---------------------|--------|
| 3 Rated voltage for both coil and contacts, if different    | U.14, U.17          | C      |
| 4 Nature of supply for both coil and contacts, if different | U.14, U.17          | C      |
| 88 Maximum intended click rate                              | U.23                | D      |

**U.14 Heating***Replacement of subclause:***U.14.4** Tests shall be conducted under the following conditions:

- Coil voltage  $\times 0,9$  + contacts loaded or coil current  $\times 0,9$  + contacts loaded
- Coil voltage  $\times 1,1$  + contacts loaded or coil current  $\times 1,1$  + contacts loaded

- *Coil de-energised + contacts loaded (N.C. contacts).*
- *Relays shall be mounted as specified – printed wiring board connected relays shall be mounted to a printed wiring board if submitted with relays to be tested. If not available, relays shall be mounted to plain printed wiring board material, conductors of the appropriate size (according to Table 6) shall be soldered to printed wiring board pins.*

## **U.17 Endurance**

### **U.17.14 Evaluation of compliance**

*Replace the second list item as follows:*

- *the requirements of Clause 14, under the conditions stated by U.14.4, with regard to those items designated by Table 13, footnote a, that is, terminals, current carrying parts, and supporting surfaces are met.*

### **U.17.16 Test for particular purpose controls**

*Relays shall be endurance tested according to the following schedule:*

- *Ageing test of 17.6 if applicable*
- *Over-voltage test of **automatic action** of 17.7*
- *Test of **automatic action** at accelerated rate of 17.8*
- *Test of **automatic action** at slow rate of 17.9 if applicable*
- *Overvoltage test of **manual action** at accelerated speed of 17.10 if applicable*
- *Test of **manual action** at slow speed of 17.11 if applicable*
- *Test of **manual action** at high speed of 17.12 if applicable*
- *Test of **manual action** at accelerated speed of 17.13 if applicable*

## **U.20 Creepage distances, clearances and distances through solid insulation**

Assessment shall be conducted with relay energised, de-energised, and manually operated (if applicable).

## **U.23 Electromagnetic compatibility (EMC) requirements – Emission**

Consideration should be given as to whether EMC requirements are applicable to relays.

## **U.24 Components**

Relays incorporating electronic components shall be assessed according to Annex H.



## Annex V (normative)

### Requirements for controls powered by secondary batteries (rechargeable)

The following modifications to this standard are applicable for **controls** powered by batteries that can be recharged in the **control**.

#### V.4.3.2 According to rating

*Additional subclauses:*

**V.4.3.2.11 Operation** of the **control** is under the following conditions:

- the **control**, supplied by its fully charged battery, is operated as specified in this standard or the relevant part 2;
- the battery is charged, the battery being initially discharged to such an extent that the **control** cannot operate;
- 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. The **control** is operated as specified in the relevant part 2;
- 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.

#### V.7 Information

*Additional subclauses:*

##### V.7.4 Additional requirements for marking

**V.7.4.10** The instructions shall give information regarding charging of batteries.

#### V.8 Protection against electric shock

*Additional subclauses:*

**V.8.5** Battery operated **controls** shall be so designed that at a **user** accessible external point of disconnection of a d.c. mains supply,

- the maximum accessible voltage is less than or equal to the limits of a **SELV/PELV** circuit. (for example, due to stored charge on a battery in the **control** or a redundant d.c. mains supply for backup), and
- the available power is less than 15 W at the end of 5 s.

**V.8.5.1** *Verification is checked by the following test:*

*A test is conducted with the d.c. mains supply disconnected from a fully charged battery control. The voltage between the mains supply terminals is measured 1 s after disconnection of the mains supply. Then, a variable resistive load is connected to the input terminals where the d.c. mains supply is normally connected. The control is operated from its internal battery. The variable load is adjusted so that it draws maximum power through the circuit. The maximum power is recorded at the end of 5 s.*

*If the voltage and the power recorded are within the limits specified in V.8.5, the circuit is deemed to meet the intent of V.8.5.*

**V.11.13.4.4.3** *The battery used for the following tests is a fully charged rechargeable battery as provided with, or recommended by the manufacturer for use with, the equipment.*

**V.11.13.4.4.3.1** *Overcharging of a rechargeable battery. The battery is charged under each of the following conditions in turn.*

**V.11.13.4.4.3.1.1** *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.*

**V. 11.13.4.4.3.1.2** *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.*

**V.11.13.4.4.3.2** *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.*

**V.11.13.4.4.3.3** *Excessive discharging rate for 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.*

**V.11.13.4.4.3.4** *Compliance is in accordance with 11.13.4.4.4 and 11.13.4.5.*

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## COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

## DISPOSITIFS DE COMMANDE ÉLECTRIQUE AUTOMATIQUES –

## Partie 1: Exigences générales

## AVANT-PROPOS

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La Norme internationale CEI 60730-1 a été établie par le comité d'études 72 de la CEI: Commande électriques automatiques.

Cette cinquième édition annule et remplace la quatrième édition parue en 2010. Elle constitue une révision technique. Les principales modifications apportées par rapport à l'édition précédente sont les suivantes:

- modification du titre et du domaine d'application;
- révisions de l'Article H.26 sur la base des évolutions en termes de technologie et d'applications, et afin d'améliorer la cohérence et la présentation;
- modification du Tableau H.12 pour alignement avec la CISPR 22;
- révisions de l'Annexe J pour corrélation avec les modes de panne des thermistances, et exemption des thermistances utilisées conjointement avec les dispositifs de commande de type 1 en circuits TBTS de faible puissance à partir des essais spécifiés à l'Annexe J;
- nouvelles exigences concernant les dispositifs de commande alimentés par pile, et utilisation de piles dans les dispositifs de commande;

- révision concernant l'exclusion des pannes de relais;
- exigences nouvelles/mises à jour à l'Article 24, pour les alimentations en mode de commutation;
- révisions concernant les tolérances pour les organes de serrage sans vis conformes à la CEI 60999-1;
- nouvelles exigences concernant les fonctions de commande à distance;
- addition d'un diagramme de courant de fuite nouveau/mis à jour pour alignement du diagramme de l'Annexe E avec le diagramme de la CEI 60990;
- exigences mises à jour pour les dispositifs de commande sensibles à la température.

Le texte de cette norme est issu des documents suivants:

| FDIS        | Rapport de vote |
|-------------|-----------------|
| 72/899/FDIS | 72/928/RVD      |

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Une liste de toutes les parties de la CEI 60730, sous le titre général: *Dispositifs de commande électrique automatiques*, est disponible sur le site web de la CEI.

Afin de constituer une norme vraiment internationale pour couvrir les dispositifs de commande électrique automatiques à usage domestique et analogue, 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 commentaires concernant des pratiques nationales différentes (« dans certains pays...») sont contenus dans les paragraphes suivants:

|                                    |                                     |                                       |
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| 2.7.3                              | tableau b                           | 17.8.4.1                              |
| 2.14.2                             | 11.11.1.2                           | 17.10                                 |
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| 6.6.1                              | 11.11.1.4                           | 17.12.5                               |
| Tableau 1 (7.2), note de bas de    | 12.1.6                              | 18.1.6                                |
| tableau d                          | 12.3                                | 18.1.6.1                              |
| 7.4.3                              | Tableau 12 (13.2.1), note de bas de | 18.1.6.2                              |
| 7.4.3.2                            | tableau 14                          | 18.1.6.3                              |
| 8.1.1.1                            | 13.3.4                              | 18.4                                  |
| 8.4                                | 14.4                                | 19.2.4.1                              |
| 9.3.2                              | Tableau 13 (14.7.4), note de bas de | 19.2.5.1                              |
| 9.3.4                              | tableau f                           | 21.1                                  |
| 9.5.2                              | 15.1                                | 21.4                                  |
| Tableau 3 (10.1.4), note de bas de | 16.2.1                              | 27.2.3.1                              |
| tableau b                          | 17.1.3.1                            | Annexe C                              |
| 10.1.4.1                           | 17.2.2                              | Annexe D                              |
| 10.1.14                            | 17.2.3                              | H.26.10                               |
| 10.1.16                            | 17.2.3.1                            | Tableau H.18 (H.26.10.4)              |
| 10.1.16.1                          | Tableau 14 (17.2.5)                 | H.27.1.1.3                            |
| Tableau 6 (10.2.1), note de bas de | Tableau 15 (17.2.5)                 | Tableau K.1, note de bas de tableau b |
| tableau b                          | Tableau 16 (17.2.5)                 | Tableau K.2, note de bas de tableau b |
|                                    |                                     | T.3.2                                 |

Il est envisagé que dans la prochaine édition de la présente norme, il sera possible de supprimer les différences qui seront couvertes par de nouvelles normes de la CEI en préparation dans d'autres comités d'études.

La présente partie 1 est à utiliser 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.

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 la présente norme, 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**.

Afin de faciliter le rapprochement entre les parties 2 et la Partie 1, certains titres de tableau contiennent des références entre crochets aux numéros de tableau de la CEI 60730-1, édition 3.

Cette publication a été rédigée selon les Directives ISO/CEI, Partie 2.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de la CEI sous "<http://webstore.iec.ch>" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

Le contenu du corrigendum de septembre 2014 a été pris en considération dans cet exemplaire.

**IMPORTANT – Le logo "colour inside" qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.**

# DISPOSITIFS DE COMMANDE ÉLECTRIQUE AUTOMATIQUES –

## Partie 1: Exigences générales

### 1 Domaine d'application et références normatives

#### 1.1 Domaine d'application

En général, la présente Norme internationale s'applique aux **dispositifs de commande électrique** automatiques destinés à être utilisés dans, sur, ou avec des équipements à usage domestique et analogue. Les matériels peuvent utiliser l'électricité, le gaz, le pétrole, des combustibles solides, l'énergie thermique solaire, etc., ou une combinaison de ces sources d'énergie.

NOTE 1 Partout où il est utilisé dans la présente norme, le terme «matériel» signifie «matériel et équipement».

EXEMPLE 1 **Dispositifs de commande** pour les appareils entrant dans le domaine d'application de la CEI 60335.

La présente norme s'applique aux **dispositifs de commande** pour l'automatisation du bâtiment relevant du domaine d'application de l'ISO 16484.

La présente norme s'applique également aux **dispositifs de commande électriques** automatiques des équipements qui peuvent être utilisés par le public (les équipements destinés à être utilisés 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.

La présente norme est également applicable aux **dispositifs de commande** individuels 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.

EXEMPLE 3 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 entrant dans le domaine d'application de l'ISO 16484-2.

La présente norme s'applique également aux relais utilisés en tant que **dispositifs de commande** des appareils conformes à la CEI 60335. L'Annexe U contient des exigences supplémentaires relatives à la sécurité et aux **valeurs de fonctionnement** des relais utilisés en tant que **dispositifs de commande** des appareils conformes à la CEI 60335.

NOTE 2 Il est fait référence à ces exigences dans le domaine d'application de la CEI 61810-1.

NOTE 3 La présente norme est destinée à être utilisée pour les essais de tout relais autonome qui est censé être utilisé comme **dispositif de commande** d'un appareil conforme à la CEI 60335-1. Elle n'est censée ni être utilisée pour un autre relais autonome ni remplacer la série de normes CEI 61810.

La présente norme ne s'applique pas aux **dispositifs de commande électrique** automatiques prévus exclusivement pour des applications industrielles, sauf mention particulière dans la partie 2 ou la norme de l'équipement.

**1.1.1** La présente Norme internationale s'applique à la sécurité intrinsèque, aux **valeurs de fonctionnement**, aux **temps de fonctionnement** et aux **séquences de fonctionnement** dans la mesure où ils interviennent dans la sécurité du matériel, ainsi qu'aux essais des **dispositifs de commande électrique** automatiques utilisés dans ou avec du matériel.

La présente norme s'applique aux **dispositifs de commande** utilisant des **thermistances** (voir également Annexe J).

La présente norme s'applique également aux **systèmes** et **dispositifs de commande de sécurité fonctionnelle et de sécurité peu complexe**.

**1.1.2** La présente norme s'applique aux **dispositifs de commande électrique** automatiques 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.

**1.1.3** La présente norme s'applique aux relais de démarrage, qui constituent un type spécifique de **dispositif de commande électrique** automatique, prévus pour alimenter l'enroulement de démarrage d'un moteur. Ces **dispositifs de commande** peuvent faire partie intégrante du moteur ou constituer un élément séparé.

**1.1.4** La présente norme s'applique aux **dispositifs de commande manuelle** dans la mesure où ils font partie intégrale, électriquement et/ou mécaniquement, des **dispositifs de commande automatiques**.

NOTE Les exigences pour les dispositifs de commande manuelle ne faisant pas partie d'un **dispositif de commande automatique** sont contenues dans la CEI 61058-1.

**1.1.5** La présente norme s'applique à des **dispositifs de commande** à courant alternatif ou continu dont la tension assignée ne dépasse pas 690 V c.a. ou 600 V c.c.

**1.1.6** La présente norme 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 domestique appropriée ou déterminée par le fabricant doit s'appliquer.

**1.1.7** La présente norme s'applique également aux **dispositifs de commande** incorporant des **dispositifs électroniques** dont les exigences sont données à l'Annexe H.

**1.1.8** La présente norme s'applique également aux **dispositifs de commande** utilisant des **thermistances** CTN ou CTP, dont les exigences sont contenues à l'Annexe J.

## **1.2 Références normatives**

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

CEI 60038, *Tensions normales de la CEI*

CEI 60065:2001, *Appareils audio, vidéo et appareils électroniques analogues – Exigences de sécurité*<sup>1</sup>

Amendement 1:2005

Amendement 2:2010

<sup>1</sup> Il existe une édition consolidée 7.2:2011 comprenant la CEI 60065-1:2001 et ses Amendements 1:2005 et 2:2010.



CEI 60068-2-75, *Essais d'environnement – Partie 2-75: Essais – Essai Eh: Essais aux marteaux*

CEI 60085, *Isolation électrique – Évaluation et désignation thermiques*

CEI 60099-1, *Parafoudres – Partie 1: Parafoudres à résistance variable avec éclateurs pour réseaux à courant alternatif<sup>2</sup>*

CEI 60112:2003, *Méthode de détermination des indices de résistance et de tenue au cheminement des matériaux isolants solides<sup>3</sup>*  
*Amendement 1:2009*

IEC 60127-1, *Miniature fuses – Part 1: Definitions for miniature fuses and general requirements for miniature fuse-links* (disponible en anglais seulement)

CEI 60227-1, *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V – Partie 1: Exigences générales*

CEI 60245-1, *Conducteurs et câbles isolés au caoutchouc – Tension assignée au plus égale à 450/750 V – Partie 1: Exigences générales*

CEI 60269-1, *Fusibles basse tension – Partie 1: Exigences générales*

CEI 60335-1:2010 *Appareils électrodomestiques et analogues – Sécurité – Partie 1: Exigences générales*

CEI 60364 (toutes les parties), *Installations électriques à basse tension*

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* (disponible en anglais seulement)

IEC 60384-16, *Fixed capacitors for use in electronic equipment – Part 16: Sectional specification: Fixed metallized polypropylene film dielectric d.c. capacitors* (disponible en anglais seulement)

IEC 60384-17, *Fixed capacitors for use in electronic equipment – Part 17: Sectional specification: Fixed metallized polypropylene film dielectric a.c. and pulse capacitors* (disponible en anglais seulement)

CEI 60417 (toutes les parties), *Symboles graphiques utilisables sur le matériel*

CEI 60423, *Systèmes de conduits pour la gestion du câblage – Diamètres extérieurs des conduits pour installations électriques et filetages pour conduits et accessoires*

CEI 60529:1989, *Degrés de protection procurés par les enveloppes (Code IP)<sup>4</sup>*  
*Amendement 1:1999*

IEC 60539 (toutes les parties), *Directly heated negative temperature coefficient thermistors* (disponible en anglais seulement)

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<sup>2</sup> Retirée.

<sup>3</sup> Il existe une édition consolidée 4.1:2009 comprenant la CEI 60112:2003 et son Amendement 1:2009.

<sup>4</sup> Il existe une édition consolidée 2.1:2001 comprenant la CEI 60529:1989 et son Amendement 1:1999.



CEI 60664-1:2007, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 1: Principes, exigences et essais*

CEI 60664-3:2003, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 3: Utilisation de revêtement, d'empotage ou de moulage pour la protection contre la pollution*

Amendement 1:2010

CEI 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*

CEI 60695-2-10, *Essais relatifs aux risques du feu – Partie 2-10: Essais au fil incandescent/chauffant – Appareillage et méthode commune d'essai*

CEI 60695-2-11:2000, *Essais relatifs aux risques du feu – Partie 2-11: Essais au fil incandescent/chauffant – Méthode d'essai d'inflammabilité pour produits finis*

CEI 60695-10-2, *Essais relatifs aux risques du feu – Partie 10-2: Chaleurs anormales – Essai à la bille*

IEC 60738-1, *Thermistors – Thermistors – Directly heated positive temperature coefficient – Part 1: Generic specification* (disponible en anglais seulement)

IEC 60738-1-1, *Thermistors – Directly heated positive step-function temperature coefficient – Part 1-1: Blank detail specification – Current limiting application – Assessment level EZ* (disponible en anglais seulement)

CEI 60947-1:2007, *Appareillage à basse tension – Partie 1: Règles générales*

CEI 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*

CEI 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*

CEI 60999-1, *Dispositifs de connexion – Conducteurs électriques en cuivre – Prescriptions de sécurité pour organes de serrage à vis et sans vis – Partie 1: Prescriptions générales et particulières pour les organes de serrage pour les conducteurs de 0,2 mm<sup>2</sup> à 35 mm<sup>2</sup> (inclus)*

CEI 61000 (toutes les parties), *Compatibilité électromagnétique (CEM)*

CEI 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)*

CEI 61000-3-3:2008, *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 et non soumis à un raccordement conditionnel*

CEI 61000-4-2:2008, *Compatibilité électromagnétique (CEM) – Partie 4-2: Techniques d'essai et de mesure – Essai d'immunité aux décharges électrostatiques*

CEI 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*

CEI 61000-4-4, *Compatibilité électromagnétique (CEM) – Partie 4-4: Techniques d'essai et de mesure – Essais d'immunité aux transitoires électriques rapides en sèves*

CEI 61000-4-5, *Compatibilité électromagnétique (CEM) – Partie 4-5: Techniques d'essai et de mesure – Essai d'immunité aux ondes de choc*

CEI 61000-4-6, *Compatibilité électromagnétique (CEM) – Partie 4-6: Techniques d'essai et de mesure – Immunité aux perturbations conduites, induites par les champs radioélectriques*

CEI 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*

CEI 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*

CEI 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*  
Amendement 1:2009

CEI 61000-4-28, *Compatibilité électromagnétique (CEM) – Partie 4-28: Techniques d'essai et de mesure – Essai d'immunité à la variation de la fréquence d'alimentation*

CEI 61058-1, *Interrupteurs pour appareils – Partie 1: Règles générales*

CEI 61210, *Dispositifs de connexion – Bornes plates à connexion rapide pour conducteurs électriques en cuivre – Exigences de sécurité*

CEI 61249 (toutes les parties), *Matériaux pour circuits imprimés et autres structures d'interconnexion*

CEI 61558-2-6, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et produits analogues pour des tensions d'alimentation jusqu'à 1 100 V – Partie 2-6: Règles particulières et essais pour les transformateurs de sécurité et les blocs d'alimentation incorporant des transformateurs de sécurité*

CEI 61558-2-16, *Sécurité des transformateurs, bobines d'inductance, blocs d'alimentation et produits analogues pour des tensions d'alimentation jusqu'à 1 100 V – Partie 2-16: Règles particulières et essais pour les blocs d'alimentation à découpage et les transformateurs pour blocs d'alimentation à découpage*

CEI 61643-11, *Parafoudres basse tension – Partie 11: Parafoudres connectés aux systèmes basse tension – Exigences et méthodes d'essai*

CEI 62326 (toutes les parties), *Cartes imprimées*

CISPR 11, *Appareils industriels, scientifiques et médicaux – Caractéristiques de perturbations radioélectriques – Limites et méthodes de mesure*

CISPR 14-1:2005, *Compatibilité électromagnétique – Exigences pour les appareils électrodomestiques, outillages électriques et appareils analogues – Partie 1: Émission*<sup>5</sup>  
Amendement 1:2008

<sup>5</sup> Il existe une édition consolidée 5.1:2009 comprenant la CISPR 14-1:2005 et son Amendement 1:2008.

CISPR 22:2008, *Appareils de traitement de l'information – Caractéristiques des perturbations radioélectriques – Limites et méthodes de mesure*

ISO 16484-2, *Systèmes de gestion technique du bâtiment – Partie 2: Équipement*

## 2 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

Lorsque les termes «tension» et «courant» sont employés, ils impliquent les valeurs efficaces, sauf spécification contraire.

### 2.1 Définitions concernant les caractéristiques assignées de tension, courant, fréquence et puissance

#### 2.1.1

##### **tension, courant, fréquence et 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 de ligne.

#### 2.1.2

##### **plages assignées de tension, de courant, de fréquence ou de puissance**

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

#### 2.1.3

##### **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.

#### 2.1.4

##### **très basse tension**

##### **TBT**

tension nominale ne dépassant pas 50 V entre conducteurs et entre conducteurs et terre ou, dans le cas de montage triphasé, ne dépassant pas 50 V entre conducteurs de phase et 29 V entre conducteurs de phase et neutre

Note 1 à l'article: Ces valeurs sont dérivées de la CEI 60335-1:2010, Définition 3.4.1.

Note 2 à l'article: Dans la présente norme, les niveaux **TBT** à utiliser dans une application spécifique telle que spécifiée dans la norme d'application appropriée peuvent être déclarés pour les **dispositifs de commande** utilisés dans de telles applications, ou avec celles-ci, dans des conditions environnementales telles que spécifiées par la norme d'application.

### 2.1.5

#### **très basse tension de sécurité**

##### **TBTS**

tension nominale à utiliser dans un **réseau TBTS** ou dans un **réseau TBTP** entre conducteurs et entre conducteurs et terre ne dépassant pas 42 V entre conducteurs ou, dans le cas de montages triphasés, 24 V entre conducteurs et neutre, la tension à vide du circuit ne dépassant pas respectivement 50 V et 29 V, et qui est fournie par une pile ou lorsqu'elle est obtenue à partir d'une tension plus élevée est fournie par un **transformateur de sécurité** ou par un convertisseur à enroulements séparés

Note 1 à l'article: Les limites de la tension sont établies dans l'hypothèse d'un **transformateur de sécurité** alimenté à sa tension assignée.

Note 2 à l'article: Les convertisseurs à enroulements séparés fournissant une isolation équivalente sont traités dans la CEI 61558-2-6 et la CEI 61558-2-16.

Note 3 à l'article: Au Canada et aux États-Unis, la limite de la **très basse tension de sécurité** est de 30 V.

Note 4 à l'article: Voir aussi 2.1.20 **réseau TBTS** et 2.1.21 **réseau TBTP**.

### 2.1.6

#### **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**

### 2.1.7

#### **polarité identique**

relation existant entre deux **parties actives** de façon qu'une interconnexion de celles-ci permette à un courant de traverser une charge, le courant étant ainsi limité par la charge

### 2.1.8 Vacant

### 2.1.9

#### **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

### 2.1.10

#### **mode pilote**

classe de **fonctionnement** dans laquelle la charge électrique finale est commandée par un moyen auxiliaire tel qu'un relais ou un contacteur

### 2.1.11

#### **surtension transitoire**

surtension de courte durée, ne dépassant pas quelques millisecondes, oscillatoire ou non, généralement fortement amortie

[SOURCE: CEI 60050-604:1987, 604-03-13]

### 2.1.12

#### **tension assignée de choc**

tension de tenue au choc électrique assignée par le fabricant au matériel ou à une de ses parties, caractérisant la capacité de tenue spécifiée de son isolation aux surtensions

**2.1.13****catégorie de surtension**

chiffre caractérisant une condition de **surtension transitoire**

Note 1 à l'article: Les catégories de surtension I, II, III et IV sont utilisées. Voir Annexe L.

**2.1.14****partie conductrice accessible****masse dans une installation**

partie conductrice d'un matériel, susceptible d'être touchée, et qui n'est pas normalement sous tension 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: CEI 60050-195:1998, 195-06-10, modifiée – la Note 1 à l'article a été ajoutée.]

**2.1.15****écran (conducteur)****écran (conducteur) (US)**

partie conductrice qui enveloppe ou sépare des circuits électriques et/ou des conducteurs

[SOURCE: CEI 60050-195:1998, Amendement 1:2001, 195-02-38]

**2.1.16****écran de protection (électrique)****écran de protection (électrique) (US)**

**écran conducteur** utilisé pour séparer un circuit électrique et/ou des conducteurs des parties actives dangereuses

[SOURCE: CEI 60050-195:1998, Amendement 1:2001, 195-06-17]

**2.1.17****protection (électrique) par écran****protection (électrique) par écran (US)**

séparation de circuits électriques et/ou de conducteurs par rapport aux **parties actives dangereuses** par un **écran de protection électrique** relié au **réseau de liaisons équipotentielles** de protection et destiné à fournir une protection contre les chocs électriques

[SOURCE: CEI 60050-195:1998, Amendement 1:2001, 195-06-18]

**2.1.18****séparation simple**

séparation entre circuits ou entre un circuit et la terre par une **isolation principale**

[SOURCE: CEI 61140:2001, 3.23]

**2.1.19****séparation (électrique) de protection**

séparation entre deux circuits électriques au moyen:

- d'une **double isolation**, ou
- d'une **isolation principale** et d'une **protection électrique par écran**, ou
- d'une **isolation renforcée**

[SOURCE: CEI 60050-195:1998, Amendement 1:2001, 195-06-19]

### 2.1.20

#### **réseau TBTS**

réseau électrique dont la tension ne peut pas dépasser la valeur de la **TBT**

- dans des conditions normales, et
- dans des conditions de première **panne**, y compris les **pannes** à la terre dans d'autres circuits

[SOURCE: CEI 61140:2001, 3.26.1, modifiée – "défaut" a été changé en "panne".]

### 2.1.21

#### **réseau TBTP**

réseau électrique dont la tension ne peut pas dépasser la valeur **TBT**

- dans des conditions normales, et
- dans des conditions de première **panne**, à l'exception des **pannes** à la terre dans d'autres circuits

[SOURCE: CEI 61140:2001, 3.26.2, modifiée – "défaut" a été changé en "panne".]

## 2.2 Définitions des différents types de dispositifs de commande en fonction de l'application

### 2.2.1

#### **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 «**commande électrique**».

Note 2 à l'article: Au moins l'un de ces aspects doit être de nature électrique ou électronique.

### 2.2.2

#### **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

### 2.2.3

#### **dispositif de commande automatique**

**dispositif de commande** dont au moins l'une des phases opératoires n'est pas manuelle

### 2.2.4

#### **dispositif de commande sensible à une grandeur physique**

**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

### 2.2.5

#### **dispositif de commande à transmission thermique**

**dispositif de commande automatique** dans lequel la phase de **transmission** est effectuée par un **moteur primaire** thermique

### 2.2.6

#### **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

### 2.2.7

#### **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 normal** de **fonctionnement** de l'appareil.

### 2.2.8

#### **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: Normalement un coupe-circuit thermique produit une **action du type 2**.

### 2.2.9 Vacant

### 2.2.10

#### **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.

### 2.2.11

#### **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

### 2.2.12

#### **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** soit à **fonctionnement électrique** soit à **base de temps**, selon accord entre l'autorité responsable des essais et le fabricant.

### 2.2.13

#### **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 programmeur.

### 2.2.14

#### **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.



### 2.2.15

#### **dispositif de protection de moteur**

**dispositif de commande automatique** qui est spécialement prévu pour protéger les enroulements d'un moteur électrique contre les échauffements excessifs

### 2.2.16

#### **protecteur thermique**

**dispositif de commande automatique**, incorporé à un moteur ou monté sur un moteur, qui est spécialement prévu pour protéger le moteur contre les échauffements excessifs dus à un fonctionnement en surcharge et à une défaillance au démarrage

Note 1 à l'article: Le courant du moteur circule dans le **dispositif de commande** qui est sensible à la température et au courant du moteur.

Note 2 à l'article: Le **dispositif de commande** peut être réarmé (soit manuellement soit automatiquement) lorsque sa température baisse à la valeur de réarmement.

### 2.2.17

#### **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

### 2.2.18

#### **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.

### 2.2.19

#### **dispositif de commande de fonctionnement**

**dispositif de commande** qui démarre ou régule le matériel en **fonctionnement** normal

### 2.2.20

#### **dispositif de commande de protection**

**dispositif de commande** dont le **fonctionnement** est prévu pour éviter les situations dangereuses pendant un **fonctionnement** anormal du matériel

### 2.2.21

#### **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**.

### 2.2.22

#### **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.

### 2.2.23

#### **système**

**dispositif de commande**, capteurs de **commande** et actionneurs tels qu'appliqués à une application ou à des processus



## 2.3 Définitions concernant les fonctions des dispositifs de commande

### 2.3.1

#### **mise en marche**

cause initiale modifiant un aspect du **dispositif de commande** de telle manière que s'accomplissent la **transmission** et le **fonctionnement**

### 2.3.2

#### **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;
- c) **transmission** IR/RF; ou

toutes les combinaisons de a) à c) via Internet en utilisant, par exemple, des modems, des téléphones portables, etc.

### 2.3.3

#### **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

### 2.3.4

#### **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**

### 2.3.5

#### **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 à la vitesse 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.

### 2.3.6

#### **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 **action**

### 2.3.7

#### **action**

déplacement de l'**organe de manœuvre** du **dispositif de commande** effectué à la main, au pied ou de toute autre manière par l'**utilisateur**

### 2.3.8

#### **position repérée**

position à laquelle l'**organe de manœuvre** revient de lui-même si on le relâche après l'en avoir légèrement écarté

### 2.3.9

#### **position intermédiaire**

position stable d'un **organe de manœuvre** à proximité d'une **position repérée** correspondant à un **fonctionnement** intermédiaire du **dispositif de commande**

### 2.3.10

#### **grandeur de manœuvre**

caractéristique physique d'un milieu dont les variations ou la stabilité sont détectées

### 2.3.11

#### **valeur de fonctionnement**

valeur de la **grandeur de manœuvre** (température, pression, courant, etc.) à laquelle fonctionne le dispositif lors d'une élévation ou d'une baisse de la **grandeur de manœuvre**

### 2.3.12

#### **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**

### 2.3.13

#### **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**.

### 2.3.14

#### **valeur de réponse**

**valeur, temps ou séquence de fonctionnement** qui lie un **dispositif de commande** à un matériel particulier

### 2.3.15

#### **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

### 2.3.16

#### **courant de fuite**

tous les courants, y compris les courants à capacité couplée, qui peuvent circuler entre les surfaces conductrices accessibles d'un dispositif et la terre ou d'autres surfaces conductrices accessibles d'un dispositif

### 2.3.17

#### **réglage**

réglage mécanique d'une partie d'un **dispositif de commande** destiné à choisir une **valeur de fonctionnement**

### 2.3.18

#### **réglage par le fabricant du dispositif de commande**

tout **réglage** effectué par le **fabricant du dispositif** non destiné à être modifié par le **fabricant du matériel**, l'**installateur** ou l'

### 2.3.19

#### **réglage par le fabricant du matériel**

tout **réglage** effectué par le **fabricant du matériel** non destiné à être modifié par l'**installateur** ou l'

### 2.3.20

#### **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'

**2.3.21****réglage par l'utilisateur**

toute sélection d'une **valeur de fonctionnement** par une **manœuvre** effectuée par l'utilisateur

**2.3.22****point de consigne**

valeur sélectionnée par **réglage**

**2.3.23****point de consigne ajustable**

valeurs multiples, situées à l'intérieur d'une plage déclarée de valeurs, pouvant être sélectionnées par **réglage**

**2.3.24****cycle de fonctionnement**

toutes actions automatiques ou **manuelles** impliquées dans un **fonctionnement** du début à la fin d'un matériel commandé

**2.3.25****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

**2.3.26****différentielle de fonctionnement**

différence entre les valeurs supérieure et inférieure de la **valeur de fonctionnement**

**2.3.27****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

**2.3.28****différentielle fixe**

**différentielle de fonctionnement** dont le **réglage** du fabricant ne peut être modifié

**2.3.29****pression de travail maximale****pression assignée maximale**

trait maximal indiqué ou pression de travail maximale du système auquel le **dispositif de commande** ou certaines de ses parties peuvent être assujettis

**2.3.30****température maximale**

$T_{\max}$

température maximale ambiante continue à laquelle la **tête de commande** est prévue d'être exposée en **fonctionnement** normal

**2.3.31****fonction de commande à distance****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) via Internet en utilisant, par exemple, des modems, des téléphones portables, etc.

### 2.3.32

#### **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

## 2.4 Définitions relatives aux coupures et interruptions de circuit

Certains **dispositifs de commande** peuvent incorporer plusieurs types de coupure ou d'interruption de circuit.

### 2.4.1

#### **coupure sur tous les pôles**

pour les appareils monophasés à courant alternatif, et pour les appareils à courant continu, la déconnexion des deux conducteurs d'alimentation par une seule manœuvre ou, pour les appareils raccordés à plus de deux conducteurs d'alimentation, la déconnexion de tous les conducteurs d'alimentation excepté le conducteur de mise à la terre, par une seule manœuvre

Note 1 à l'article: Le conducteur de protection de mise à la terre n'est pas considéré comme un conducteur d'alimentation.

### 2.4.2

#### **coupure totale de circuit**

séparation des contacts de tous les pôles d'alimentation autres que celui de terre 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: Voir aussi l'Annexe H.

### 2.4.3

#### **microcoupure**

séparation adéquate des contacts d'au moins l'un des pôles d'alimentation pour fournir la sécurité 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 à une grandeur physique**, la fonction commandée par la coupure est franche et que, pour les **dispositifs de commande sensibles à une grandeur physique**, elle est sûre à l'intérieur des limites de la **grandeur de manœuvre** déclarée au point 36 du Tableau 1.

Note 3 à l'article: Voir aussi l'Annexe H.

### 2.4.4

#### **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** sur tous les pôles ou une **microcoupure**

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: Voir aussi l'Annexe H.

#### 2.4.5

##### **position ARRÊT**

position qui indique d'une manière visible ou implicite une **coupure totale** ou une **microcoupure** du circuit

2.4.6 Voir Annexe H.

### 2.5 Définitions des différents types de dispositifs de commande en fonction de la construction

#### 2.5.1

##### **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: Le matériel peut utiliser l'électricité, le gaz, le fuel, le charbon ou une combinaison de ces énergies.

Note 2 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).

#### 2.5.2

##### **dispositif de commande incorporé**

**dispositif de commande** destiné à être incorporé 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 4.3.1.1.

Note 2 à l'article: Le matériel peut utiliser l'électricité, le gaz, le fuel, le charbon ou une combinaison de ces énergies.

Note 3 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).

#### 2.5.3

##### **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 fiches 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**.

#### 2.5.4

##### **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.

#### 2.5.5

##### **dispositif de commande à montage indépendant**

**dispositif de commande** prévu pour être relié en permanence à un **câblage fixe**, loin 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 **fonctionnement** ou à l'intérieur de celui-ci, lorsque l'installation peut se faire par l'arrière.

### 2.5.6

#### **dispositif de commande à traction**

**dispositif de commande** destiné à être monté sur ou dans un matériel et actionné par un **cordon de traction**

2.5.7 à 2.5.10 Voir Annexe H.

### 2.5.11

#### **manœuvre à deux positions**

caractéristique séquentielle de deux mouvements distincts d'un **organe de manœuvre**

## 2.6 Définitions des types d'action automatique de dispositifs de commande d'après les procédures d'essai

### 2.6.1

#### **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 la présente norme

Note 1 à l'article: Une **action de type 1** fait l'objet de sous-classes comme spécifié en 6.4.

### 2.6.2

#### **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 la présente norme

Note 1 à l'article: Une **action de type 2** fait l'objet de sous-classes comme spécifié en 6.4.

## 2.7 Définitions concernant la protection contre les chocs électriques

### 2.7.1

#### **partie active**

partie conductrice prévue pour être mise sous tension en **usage normal**, comprenant le conducteur neutre mais, par convention, pas de conducteur PEN

#### 2.7.1.1

##### **partie active dangereuse**

**partie active** qui, dans certaines conditions d'influences externes, peut causer un choc électrique

### 2.7.2

#### **dispositif de commande de 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: Les **dispositifs de commande de classe 0** ne sont pas admis en Allemagne, Autriche, Belgique, Danemark, France, Royaume-Uni, Italie et en Norvège.

Note 3 à l'article: Une borne de terre est admise uniquement pour assurer la continuité ou le fonctionnement électrique (en tant que fonctions distinctes de la protection).

### 2.7.3

#### **dispositif de commande de classe 0I**

**dispositif intercalé dans un câble souple** ayant au moins une **isolation principale** en toutes ses parties et comportant une borne de terre, mais équipé d'un **câble souple fixé à demeure** sans conducteur de terre et d'une fiche de prise de courant sans contact de terre qui ne peut être introduite dans un socle ou une prise mobile avec contact de terre

Note 1 à l'article: Les **dispositifs de commande de classe 0I** ne sont pas admis en Allemagne, Autriche, Belgique, Danemark, France, Royaume-Uni, Italie et en Norvège.

Note 2 à l'article: Une borne de terre est admise uniquement pour assurer la continuité (en tant que fonctions distinctes de la protection).

### 2.7.4

#### **dispositif de commande de 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 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 la classe I** sont munis 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 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 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**.

### 2.7.5

#### **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 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 2.7.5.1 à 2.7.5.3.

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 terre.

#### 2.7.5.1

##### **dispositif de commande de la classe II à enveloppe isolante**

**dispositif de commande** ayant une enveloppe durable et pratiquement continue en matière isolante 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**

#### 2.7.5.2

##### **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 où on utilise une **isolation renforcée**, parce qu'une **double isolation** est manifestement irréalisable

#### 2.7.5.3

##### **dispositif de commande de la classe II à enveloppe isolante/enveloppe métallique**

**dispositif de commande** qui est une combinaison des types décrits en 2.7.5.1 et 2.7.5.2

Note 1 à l'article: L'enveloppe d'un **dispositif de la classe II** à enveloppe isolante peut faire partie ou constituer l'**isolation supplémentaire** ou **renforcée**. Un **dispositif à double isolation** complète et/ou **isolation renforcée** complète qui comporte une borne ou un contact de terre est considéré comme étant de la classe 0I ou I.

## 2.7.6

### **dispositif de commande de la classe III**

**dispositif de commande** reposant sur la limitation de la tension à des valeurs **TBT** comme disposition contre les chocs électriques pour la protection principale et

- sans mesures pour la protection en cas de **panne**;
- qui, pour l'alimentation, est seulement raccordé à un **réseau TBTS** ou à un **réseau 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 **panne** simple 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**

## 2.7.7

### **partie amovible**

partie qui peut être ôtée ou ouverte sans l'aide d'un **outil** et qui ne satisfait pas à l'essai de 11.11.1.5

## 2.7.8

### **partie accessible ou surface accessible**

toute partie ou surface qui peut être touchée avec le doigt d'épreuve de la Figure 2, lorsque le **dispositif de commande**, monté comme en **usage normal**, est débarrassé de toutes les **parties amovibles**

## 2.7.9

### **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)

Note 1 à l'article: Les abréviations utilisées de 2.7.9 à 2.7.12 ont les significations suivantes:

L **partie active**;

A **partie accessible** (surface conductrice ou isolante);

I **partie intermédiaire**.

## 2.7.10

### **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).

Note 2 à l'article: Cette isolation faisait partie antérieurement de l'isolation dite **fonctionnelle**.



**2.7.11****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).

**2.7.12****isolation renforcée**

isolation unique des **parties actives** assurant, dans les conditions spécifiées par la présente norme, un degré de protection contre les chocs électriques équivalent à une **double isolation** (L-(I)-A)

Note 1 à l'article: Cette isolation comprend une isolation entre des **parties actives** 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).

Note 2 à l'article: Le terme isolation unique 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**.

**2.7.13****double isolation**

isolation comprenant à la fois une **isolation principale** et une **isolation supplémentaire** (situation de la classe II)

**2.7.14** Voir Annexe H.**2.7.15****liaison équipotentielle**

mise en œuvre de liaisons électriques entre parties conductrices pour réaliser l'équipotentialité

Note 1 à l'article: L'efficacité de la **liaison équipotentielle** dépend de la fréquence du courant dans la liaison.

La **liaison équipotentielle** est utilisée pour raccorder toute partie conductrice d'un bâtiment ne faisant pas partie de l'installation électrique et susceptible d'introduire un potentiel électrique, généralement le potentiel électrique de la terre locale (élément conducteur étranger), et toute partie conductrice des **dispositifs de commande**, matériels ou composants dans l'installation susceptible d'être touchée et qui n'est normalement pas sous tension mais peut le devenir en cas de défaillance de l'**isolation principale** (**partie conductrice accessible**) à une **borne d'équipotentialité** principale en forme de barre, afin de porter ces parties au même potentiel. Les parties à connecter au **réseau de liaisons équipotentielles** comprennent par exemple les **conducteurs de protection**, les conducteurs **PE**, les conducteurs PEN, les conducteurs de mise à la terre, les bornes de mise à la terre de protection des **dispositifs de commande** ou matériels, toutes les parties conductrices dans un bâtiment, par exemple les conduites métalliques pour l'eau (de boisson et usée), les baignoires métalliques, les conduites du système de chauffage central, toute conduite intérieure de gaz (dont l'isolation des conduites de gaz extérieures est aussi exigée), les connecteurs de terre pour les antennes et réseaux de télécommunications, toutes les parties métalliques du bâtiment utilisées pour la construction comme les bétons armés d'acier, et les conducteurs de protection contre la foudre et, selon le système d'installation, l'électrode de terre. Les exigences pour la **liaison équipotentielle** peuvent être trouvées dans les normes de la CEI pour l'installation des bâtiments. Celles-ci peuvent être appropriées pour l'installation des **dispositifs de commande** qui comprennent plusieurs parties de composants (par exemple des capteurs, des actionneurs, des éléments de **commande** centrale, des éléments d'interfaces) raccordées en parallèle à l'installation fixe du bâtiment ou par l'intermédiaire de l'installation fixe du bâtiment.

[SOURCE: CEI 60050-195:1998, 195-01-10]

### 2.7.15.1

#### **liaison équipotentielle de protection**

**liaison équipotentielle** réalisée à des fins de sécurité (protection contre les chocs électriques)

Note 1 à l'article: La **liaison équipotentielle** fonctionnelle est définie dans le [VEI 195-01-16].

[SOURCE: CEI 60050-195:1998, 195-01-15, modifiée – (protection contre les chocs électriques) a été ajouté.]

## 2.8 Définitions concernant les éléments constituant des dispositifs de commande

### 2.8.1

#### **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 sensible**

### 2.8.2

#### **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**.

### 2.8.3

#### **organe de manœuvre**

partie qui est déplacée manuellement, soit 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 du dispositif par le fabricant de dispositifs** si ce moyen est convenablement immobilisé dans sa position initiale ou s'il nécessite un **outil** pour le **réglage par le fabricant de dispositifs**.

### 2.8.4

#### **liaison de manœuvre**

tout élément qui relie l'**organe de manœuvre** au mécanisme du **dispositif de commande**

### 2.8.5

#### **cordon de traction**

**organe de manœuvre** souple sur lequel une traction est exercée pour faire une **manœuvre**

### 2.8.6

#### **moteur primaire**

tout dispositif fournissant l'énergie mécanique nécessaire à 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**

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.

### 2.8.7

#### **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

### 2.8.8

#### **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 nécessiter d'**outil spécial**.

### 2.8.9

#### **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 nécessiter un **outil**, utilisé directement sur la partie (ou élément), ou encore utilisé pour accéder au moyen de retenue.

Note 2 à l'article: Comme exemples de parties qui ne sont pas considérées comme **parties (ou éléments) à fixation sans vis**, on peut citer:

- 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 normalisées;
- les socles de connecteur normalisés, 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.

## **2.9 Définitions concernant les différents types de bornes et connecteurs utilisés dans les dispositifs de commande**

### 2.9.1

#### **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 est appliquée soit directement par la vis, soit par l'intermédiaire d'une pièce de serrage qui transmet la pression de la vis (voir Figure 11).

### 2.9.2

#### **borne à vis**

borne dans laquelle le conducteur est serré sous la tête d'une 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 10).

### 2.9.3

#### **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 10).

### 2.9.4

#### **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 connexions nécessitant 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.

## 2.9.5

### **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

## 2.9.6

### **réceptacle**

partie femelle d'un **connecteur à languette** destinée à être fixée en permanence sur une âme conductrice ou un conducteur (voir Figure 16)

## 2.9.7

### **languette**

partie mâle d'un **connecteur à languette** (voir Figures 14 et 15)

## 2.9.8

### **languette inamovible**

**languette** fixée de manière permanente sur une âme conductrice ou sur un conducteur

## 2.9.9

### **languette fixe**

**languette** fixée de manière permanente sur un **dispositif de commande** ou en faisant partie intégrante

## 2.9.10

### **connexion**

pièce permettant la connexion d'un conducteur à un **dispositif de commande** de telle manière que son remplacement nécessite 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 nécessite un **outil spécial**. Le soudage électrique est un procédé spécial. La pose d'une cosse sur l'extrémité d'un conducteur est considérée comme une préparation spéciale.

## 2.9.11

### **connexion soudée**

**connexion** dans laquelle le conducteur est fixé mécaniquement et la continuité électrique est assurée par une soudure

## 2.9.12

### **borne à plaque**

borne dans laquelle l'âme d'un conducteur est serrée sous une plaque au moyen de deux ou plus de deux vis ou écrous (voir Figure 13a)

## 2.9.13

### **borne pour cosse et barrette**

**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 13b)

## 2.9.14

### **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 12).

### 2.9.15

#### **borne d'équipotentialité**

borne dont un matériel ou un dispositif est muni, et destinée à être connectée électriquement au **réseau de liaison équipotentielle**

[SOURCE: CEI 60050-195:1998, 195-02-32]

### 2.9.16

#### **borne d'équipotentialité de protection**

borne destinée à des fins d'**équipotentialité 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.

### 2.9.17

#### **conducteur de protection**

##### **PE**

conducteur prévu à des fins de sécurité, par exemple protection contre les chocs électriques

[SOURCE: CEI 60050-195:1998, 195-02-09 ]

## **2.10 Définitions concernant les modes de connexion aux dispositifs de commande**

### 2.10.1

#### **conducteur externe**

câble souple, cordon, âme conductrice ou conducteur dont une partie sort d'un **dispositif de commande intercalé**, 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.

### 2.10.2

#### **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 ou en fixant de façon appropriée les câbles aux murs ou autres surfaces.

### 2.10.3

#### **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.

### 2.10.4

#### **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**

## 2.10.5

### **câble souple non fixé à demeure**

conducteur externe souple qui est relié à un **dispositif de commande** ou à un appareil par l'intermédiaire d'un connecteur, un socle ou une prise mobile

## 2.10.6

### **câble souple fixé à demeure**

**conducteur externe** souple relié à ou monté sur un **dispositif de commande** par l'une des méthodes de 2.10.6.1 à 2.10.6.4

### 2.10.6.1

#### **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

### 2.10.6.2

#### **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.

### 2.10.6.3

#### **fixation de type Y**

moyen de fixation du câble souple d'alimentation tel que tout remplacement est prévu pour être réalisé par le fabricant, ses représentants pour l'entretien ou une personne qualifiée similaire

### 2.10.6.4

#### **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**

## 2.10.7

### **conducteur flottant**

#### **amorce**

conducteur(s) prévu(s) pour la connexion du **dispositif de commande**, une extrémité étant connectée de façon permanente au **dispositif de commande** par le **fabricant** du **dispositif de commande**

## 2.10.8

### **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.

## 2.10.9

### **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 **piles** 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.

## 2.11 Définitions concernant le fonctionnement des dispositifs à action du type 2

### 2.11.1

#### **tolérance de fabrication**

différence maximale entre les mesures de la **valeur de fonctionnement, de temps ou de 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 15 l'autorise.

### 2.11.2

#### **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 la présente norme

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 15 l'autorise.

## 2.12 Définitions concernant les exigences des lignes de fuite et distances dans l'air

### 2.12.1

#### **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 matière isolante

Note 1 à l'article: La méthode de mesure est détaillée à l'Annexe B et à la Figure 17.

### 2.12.2

#### **ligne de fuite**

plus court chemin le long d'une surface de matière isolante entre deux parties conductrices, ou entre une partie conductrice et une feuille métallique appliquée sur toute **surface accessible** en matière isolante

Note 1 à l'article: La méthode de mesure est détaillée à l'Annexe B et à la Figure 17.

### 2.12.3 Vacant

### 2.12.4 Vacant

### 2.12.5 Vacant

### 2.12.6 Vacant

### 2.12.7 Vacant

### 2.12.8

#### **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

## 2.12.9 Environnement

### 2.12.9.1

#### **macro-environnement**

**environnement** de la pièce ou de tout autre lieu dans lequel le matériel est installé ou utilisé

### 2.12.9.2

#### **microenvironnement**

**environnement** immédiat de l'isolation influençant particulièrement le dimensionnement des **lignes de fuite**

### 2.12.9.3

#### **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 N.

## 2.13 Définitions diverses

### 2.13.1

#### **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

### 2.13.2

#### **outil**

tournevis, pièce de monnaie ou tout autre objet permettant de tourner un écrou, une vis ou un élément analogue

### 2.13.3

#### **outil spécial**

**outil** qui ne se trouve pas normalement dans une maison, tel qu'une clé six pans

Note 1 à l'article: Les 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**.

### 2.13.4

#### **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.

### 2.13.5

#### **entretien par l'utilisateur**

#### **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

### 2.13.6

#### **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.

### 2.13.7

#### **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 de dispositifs de commande**.



**2.13.8****défaillance**

cessation de l'aptitude d'une entité à accomplir une fonction requise

[SOURCE: CEI 60050-191:1990, 191-04-01]

**2.13.9****panne**

état d'une entité inapte à accomplir une fonction requise, 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 logiciel.

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.

[SOURCE: CEI 60050-191:1990, 191-05 01]

**2.14 Définitions concernant le fabricant et l'utilisateur****2.14.1****fabricant de dispositifs de commande**

fabricant du **dispositif de commande**

**2.14.2****fabricant de matériel**

fabricant de matériel dans lequel, sur lequel ou avec lequel le **dispositif de commande** est utilisé

Note 1 à l'article: Au Canada et aux États-Unis, le **fabricant de matériel** est signalé comme l'OEM (**fabricant original du matériel**). L'OEM reçoit des **dispositifs de commande** du **fabricant de dispositifs de commande** pour intégration à ou incorporation dans le matériel.

**2.14.3****installateur**

personne qualifiée pour installer le **dispositif de commande** et peut-être le matériel associé

**2.14.4****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.

**2.14.5****dispositifs de commande ou systèmes de sécurité fonctionnelle peu complexe**

**système** ou **dispositif de commande** de sécurité dans lequel

- les modes de **défaillance** de chaque composant individuel sont bien définis;
- le comportement du **système** ou du **dispositif de commande** en cas de **panne** peut être totalement déterminé

**2.15 Définitions en rapport avec les thermistances**

Voir Annexe J.

## **2.16 Définitions relatives à la structure des dispositifs de commande utilisant des logiciels**

Voir Annexe H.

## **2.17 Définitions relatives à l'absence d'erreur pour les dispositifs de commande utilisant des logiciels**

Voir Annexe H.

## **2.18 Définitions relatives aux techniques de contrôle panne/erreur des dispositifs de commande utilisant des logiciels**

Voir Annexe H.

## **2.19 Définitions relatives aux essais de mémoire des dispositifs de commande utilisant des logiciels**

Voir Annexe H.

## **2.20 Définitions de la terminologie des logiciels – Généralités**

Voir Annexe H.

## **2.21 Vacant**

## **2.22 Définitions relatives aux classes de fonctions de commande**

Voir Annexe H.

## **2.23 Définitions relatives à la sécurité fonctionnelle**

Voir Annexe H.

## **2.24 Définitions liées à l'accès pour l'échange de données**

Voir Annexe H.

# **3 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 vérification de la conformité consiste, en général, à effectuer les essais spécifiés applicables de la présente norme et de la partie 2 appropriée.*

# **4 Généralités sur les essais**

*Les essais mentionnés dans cette norme sont des essais de type.*

NOTE 1 Si les résultats de l'un des essais spécifiés peuvent être déterminés sans aucun doute par évaluation, alors le ou les essais n'ont pas besoin d'être réalisés.

NOTE 2 Voir aussi l'Annexe H. Les exigences de l'Annexe H ne sont pas applicables aux **dispositifs de commande** non électroniques, à moins qu'elles ne soient spécifiées dans une partie 2 appropriée de la présente norme.

#### 4.1 Conditions d'essai

**4.1.1** Sauf spécification contraire dans la présente norme, 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.

**4.1.2** Si la température ambiante est susceptible d'influencer les résultats des essais, elle doit être maintenue à  $(20 \pm 5) ^\circ\text{C}$ , sauf que, en cas de doute, elle doit être maintenue à  $(23 \pm 2) ^\circ\text{C}$ , sauf spécification contraire dans un article particulier.

**4.1.3** 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.

**4.1.4** Sauf spécification contraire dans la présente norme, les essais sont effectués dans l'ordre des articles de la présente norme.

Voir aussi l'Annexe H.

**4.1.5** Pendant les essais de la présente norme, la **manœuvre** peut être effectuée, si besoin est, par l'équipement d'essai, à l'exception des essais à grande vitesse de 17.12.

**4.1.6** Pendant et pour les besoins des essais de la présente norme, autres que les essais de 17.12, 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.

**4.1.7** Les taux de variation de la température déclarés en 7.2 et utilisés dans l'Article 17 (soit  $\alpha_1$ ,  $\beta_1$ ,  $\alpha_2$  et  $\beta_2$ ) doivent avoir des tolérances d'essai de  $\pm 12 \text{ K/h}$ .

Pour d'autres grandeurs de manœuvre, les taux minimaux et maximaux de variation déclarés à l'exigence 37 du Tableau 1 et utilisés à l'Article 17 (soit  $\alpha_1$ ,  $\beta_1$ ,  $\alpha_2$  et  $\beta_2$ ) doivent avoir des tolérances d'essai telles que spécifiées dans la partie 2 appropriée.

**4.1.8** 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.

**4.1.9 à 4.1.11** Voir Annexe H.

#### 4.2 Échantillons requis

**4.2.1** Un seul échantillon est soumis aux essais des Articles 5 à 11 et 18 à 27, incluant les annexes y relatives. Un jeu de trois échantillons est soumis aux essais restants.

Si l'un des échantillons ne satisfait pas aux essais des Articles 12 à 17 inclus, l'essai qui a causé la non-conformité et tous ceux qui l'ont précédé qui peuvent avoir eu une influence sur le résultat de l'essai sont répétés sur un nouveau jeu d'échantillons identiques aux premiers, qui doivent alors tous satisfaire à ces essais.

Le fabricant peut soumettre, en même temps que le premier jeu d'échantillons d'essai, un ou plusieurs jeux supplémentaires à utiliser dans le cas où un échantillon du premier jeu ne satisferait pas aux essais. En pareil cas, l'autorité responsable des essais peut immédiatement procéder aux essais complémentaires sur le jeu de remplacement et le jeu n'est refusé que s'il se produit un autre cas de non-conformité. Si les jeux d'échantillons supplémentaires ne sont pas soumis en même temps, la non-conformité d'un échantillon peut entraîner le rejet de l'ensemble du lot.

NOTE Au Canada et aux États-Unis, seulement un échantillon est utilisé pour les essais des Articles 12 à 17 inclus et l'échantillon soumis à essai doit satisfaire aux essais.

#### 4.2.2 Vacant

**4.2.3** *Pour certains essais destructifs de la présente norme, des échantillons supplémentaires peuvent être nécessaires.*

**4.2.4** *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 l'autorité responsable des essais, on ne vérifie qu'une seule fois les exigences et essais communs à plusieurs parties 2, à moins que les essais communs puissent influencer les résultats de l'un quelconque des essais particuliers.

### 4.3 Instructions pour les essais

#### 4.3.1 Selon les échantillons soumis

**4.3.1.1** *Les **dispositifs de commande** qui sont soumis à l'essai dans un matériel ou avec un matériel, peuvent être soumis à essai soit dans le matériel ou avec le matériel, auquel cas ils sont classés d'après la charge spécifique déclarée, soit séparément, auquel cas ils peuvent être classés d'après, soit la charge spécifique déclarée, soit une charge résistive pure, ou encore d'après une charge résistive et inductive. Dans l'un ou l'autre des deux derniers 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.*

**4.3.1.2** *Pour tous les **dispositifs de commande** soumis à l'essai, que ce soit dans, sur ou avec un matériel, toutes autres informations correspondantes spécifiées en 7.2 peuvent être obtenues par examen et en effectuant des mesures sur le matériel soumis.*

**4.3.1.3** *Les **dispositifs de commande intégrés** sont classés d'après la charge spécifique déclarée et sont soumis à essai dans le matériel, ou partie de matériel, pour lequel ils sont prévus.*

**4.3.1.4** *Les **dispositifs de commande** qui ne sont pas présentés à l'essai dans ou avec un matériel sont soumis séparément aux essais.*

**4.3.1.5** *Les **dispositifs de commande** destinés à être utilisés avec des **câbles souples fixés à demeure** sont soumis à essai avec le câble approprié raccordé.*

#### 4.3.2 Selon les caractéristiques assignées

**4.3.2.1** *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*

**4.3.2.2** *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.*

**4.3.2.3** *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**.*

**4.3.2.4** *Lorsque les **dispositifs de commande** ont des valeurs assignées différentes en courant alternatif et continu, pour les essais des Articles 12, 13, 14 et 17, 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 L'autorité responsable des essais aura toute latitude pour fixer un nombre restreint d'essais à effectuer pour couvrir les diverses valeurs assignées déclarées.

**4.3.2.5** *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 4.3.2.7).*

**4.3.2.6** *Pour les **dispositifs de commande** pour lesquels plusieurs valeurs assignées de tension ou de courant sont déclarées ou marquées, les essais de l'Article 17 sont répétés pour chaque combinaison de tension et courant assignés.*

NOTE L'autorité responsable des essais aura toute latitude pour fixer un nombre restreint d'essais à effectuer pour couvrir les diverses valeurs assignées déclarées.

**4.3.2.7** *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.*

**4.3.2.8** *Les **dispositifs de commande** destinés à fonctionner avec une alimentation particulière sont soumis à essai avec cette alimentation.*

**4.3.2.9** *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 réseau d'alimentation prévu, indépendamment des caractéristiques assignées de tension indiquées pour l'équipement.*

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.

**4.3.2.10** *Les **dispositifs de commande** alimentés par piles rechargeables font l'objet d'essais supplémentaires conformément à l'Annexe V.*

**4.3.2.11** Voir Annexe J.

### **4.3.3 Selon la protection contre les chocs**

**4.3.3.1** *Si, dans les **dispositifs de commande des classes 0, 0I ou I**, ou dans les **dispositifs de commande** destinés à des matériels des classe 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**.*

**4.3.3.2** *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 munies d'une isolation conforme aux exigences pour un **dispositif de commande de la classe II** (voir 9.1.1).*

**4.3.3.3** *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 11.2.6.*

*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 TBTP de 11.2.6.*

NOTE Par définition (2.7.5), les **dispositifs de commande de la classe II** ne peuvent pas utiliser des circuits TBTP.

#### **4.3.4 Selon les variantes du fabricant**

**4.3.4.1** Les **dispositifs de commande** identiques mais qui peuvent être ajustés par le fabricant ou qui peuvent en cours de fabrication recevoir des composants ou des parties différentes auxquelles correspondent des **valeurs, des temps ou des séquences de fonctionnement** différentes sont, pour les besoins de la présente norme, 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, l'autorité responsable des essais 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.

**4.3.4.2** 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 peuvent être applicables aux différentes parties de la plage.

#### **4.3.5 Selon la fonction**

**4.3.5.1** Les **dispositifs de commande à plusieurs fonctions** doivent, selon 6.3, 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.

**4.3.5.2** De tels **dispositifs de commande** ne disposant pas d'une section appropriée de l'Article 17 doivent être soumis à essai suivant un processus décidé par accord entre le fabricant et l'autorité responsable des essais de sorte que les **valeurs, le temps et les séquences de fonctionnement** essentiels prévus soient soumis à essai.

**4.3.5.3** Tout **dispositif de commande** ayant une fonction qui n'est pas classée en 6.3, ou dans la partie 2 appropriée, peut être soumis à essai et approuvé suivant cette norme, sauf pour l'Article 17. Un programme d'essai pour l'Article 17 doit être basé dans la mesure du possible sur l'objectif de cet article et doit être décidé par accord entre le fabricant et l'autorité responsable des essais.

**4.3.5.4** Voir Annexe J.

### **5 Caractéristiques assignées**

#### **5.1 Tension assignée maximale**

La tension assignée maximale est 690 V.

#### **5.2 Vacant**

#### **5.3 Conformité**

La conformité de 5.1 et 5.2 est vérifiée par les exigences d'informations de l'Article 7.

## 6 Classification

Les **dispositifs de commande** sont classés:

### 6.1 Selon leur alimentation

#### 6.1.1 Dispositifs pour courant alternatif seulement

NOTE 1 Les **dispositifs** pour courant alternatif seulement ne peuvent être utilisés dans les circuits à courant continu que si le courant ne dépasse pas 10 % du courant alternatif assigné ou 0,1 A suivant la valeur la plus faible.

NOTE 2 Des essais supplémentaires peuvent être requis pour établir les valeurs assignées en courant continu.

#### 6.1.2 Dispositifs pour courant continu seulement.

#### 6.1.3 Dispositifs pour courants alternatif et continu.

#### 6.1.4 Dispositifs pour alimentation spécifique ou multiple.

#### 6.1.5 Dispositifs alimentés par pile.

### 6.2 Selon le type de charge associé à chaque circuit du dispositif de commande

Un **dispositif de commande** à plusieurs circuits ne nécessite pas d'avoir la même classification pour chaque circuit.

#### 6.2.1 Circuits pour charges pratiquement résistives dont le facteur de puissance n'est pas inférieur à 0,95.

NOTE 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.

#### 6.2.2 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).

NOTE 1 Comme exemple, on peut citer le circuit d'un ventilateur qui incorpore à la fois un élément chauffant et un moteur.

NOTE 2 Les circuits pour charges inductives seulement peuvent soit être classés conformément à 6.2.2, le fabricant déclarant que la charge résistive est égale à la charge inductive, soit être classés pour une charge spécifique déclarée.

#### 6.2.3 Circuits pour charges spécifiques déclarées.

NOTE Comme exemples, on peut citer les circuits qui commandent les lampes à filament de tungstène ou fluorescentes, des charges fortement inductives dont le facteur de puissance est inférieur à 0,6, des charges capacitatives et des contacts destinés à ne travailler qu'à vide.

#### 6.2.4 Circuits pour courant inférieur à 20 mA.

NOTE Comme exemples, on peut citer les circuits de commande des voyants au néon ou des lampes de signalisation.

#### 6.2.5 Circuits pour moteurs alternatifs, dont les caractéristiques de charge sont définies dans la déclaration du fabricant du **dispositif de commande**.

#### 6.2.6 Circuit pour auxiliaires.



### 6.3 Selon leurs fonctions

Un **dispositif de commande** peut être classé pour plusieurs fonctions, auquel cas il est dit **dispositif de commande** multifonction.

NOTE Toute **action manuelle** d'un **dispositif de commande automatique** ou une **action manuelle** distincte faisant partie intégrale d'un **dispositif de commande automatique** n'est pas classée suivant 6.3.

- 6.3.1 – thermostat;
- 6.3.2 – limiteur de température;
- 6.3.3 – coupe-circuit thermique;
- 6.3.4 Vacant
- 6.3.5 – régulateur d'énergie;
- 6.3.6 – minuterie;
- 6.3.7 – minuterie cyclique;
- 6.3.8 – dispositif de commande manuelle;
- 6.3.9 – **dispositif de commande sensible** (autre que les dispositifs classés de 6.3.1 à 6.3.4);
- 6.3.10 – **dispositif de commande à fonctionnement électrique**;
- 6.3.11 – **dispositif de protection de moteur**;
- 6.3.11.1 – **protecteur thermique**;
- 6.3.12 – électrovanne;
- 6.3.13 – **mécanisme à fonctionnement électrique**;
- 6.3.14 – **dispositif de commande de protection**;
- 6.3.15 – **dispositif de commande de fonctionnement**.

NOTE Des classifications complémentaires peuvent être données dans les parties 2 adéquates.

### 6.4 Selon les caractéristiques du fonctionnement automatique

- 6.4.1 – **action de type 1**;
- 6.4.2 – **action de type 2**;

**6.4.3** Les **actions de type 1** et les **actions de type 2** sont de plus classées suivant une ou plusieurs caractéristiques de construction ou de fonctionnement suivantes:

NOTE 1 Ces classifications supplémentaires ne sont applicables que si les déclarations correspondantes sont faites et tous les essais appropriés satisfaits.



NOTE 2 Une action comportant plus d'une caractéristique peut être classée par une combinaison des lettres appropriées, par exemple type 1.C.L ou type 2.A.E.

NOTE 3 Une **action manuelle** n'est pas classée selon 6.4.3.

- 6.4.3.1 – **fonctionnement** se traduisant par une **coupure totale de circuit** (type 1.A ou 2.A);
- 6.4.3.2 – **fonctionnement** se traduisant par une **microcoupure** (type 1.B ou 2.B);
- 6.4.3.3 – **fonctionnement** se traduisant par une **micro-interruption** (type 1.C ou 2.C);
- 6.4.3.4 – mécanisme à **déclenchement libre** ne pouvant être, même momentanément, réarmé en présence d'une **panne** (type 1.D ou 2.D);
- 6.4.3.5 – mécanisme à **déclenchement libre** n'empêchant pas l'ouverture ou le maintien fermé de ses contacts tant que la **panne** persiste (type 1.E ou 2.E);

NOTE Un exemple est un **dispositif sensible** au courant qui est tenu de, ou peut, être réenclenché momentanément pour détecter si le courant de **panne** persiste.

- 6.4.3.6 – action d'un dispositif qui ne peut être réenclenchée qu'à l'aide d'un **outil** (type 1.F ou 2.F);
- 6.4.3.7 – action d'un dispositif qui n'est pas destinée à être réenclenchée dans les conditions de charge électrique (type 1.G ou 2.G);
- 6.4.3.8 – un mécanisme à **déclenchement libre** dans lequel l'ouverture des contacts ne peut être empêchée, et qui peut être remis à la position fermé après rétablissement des conditions de **fonctionnement** normal si le moyen de réarmement est maintenu en position réarmement (type 1.H ou 2.H);
- 6.4.3.9 – un 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 (type 1.J ou 2.J);
- 6.4.3.10 – pour les actions de détection, 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** (type 1.K ou 2.K);
- 6.4.3.11 – une action qui ne nécessite pas de source d'énergie auxiliaire externe d'alimentation électrique pour le **fonctionnement** envisagé (type 1.L ou 2.L);
- 6.4.3.12 – une action qui fonctionne après une période de vieillissement déclarée (type 1.M ou 2.M).

6.4.3.13 Voir Annexe H.

## 6.5 Selon le degré de protection et le degré de pollution

6.5.1 Selon les degrés de protection procurés par les enveloppes contre la pénétration de corps solides et de poussières (voir CEI 60529):

IP0X, IP1X, IP2X, IP3X, IP4X, IP5X, IP6X.

6.5.2 Selon le degré de protection procuré par les enveloppes contre les effets nuisibles dus à la pénétration de l'eau (voir CEI 60529):

IPX0, IPX1, IPX2, IPX3, IPX4, IPX5, IPX6, IPX7, IPX8.

NOTE 1 Un **dispositif de commande** destiné à être utilisé dans un **environnement** particulier peut être utilisé dans un **environnement** différent à condition que l'appareil soit muni d'une protection complémentaire appropriée, si elle est prévue.

NOTE 2 Combinaisons préférentielles de degrés de protection selon 6.5.1 et 6.5.2:

| Premier chiffre caractéristique<br>Protection contre la pénétration des corps étrangers | Deuxième chiffre caractéristique<br>Protection contre la pénétration d'eau |      |   |      |      |      |   |      |      |
|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------|---|------|------|------|---|------|------|
|                                                                                         | 0                                                                          | 1    | 2 | 3    | 4    | 5    | 6 | 7    | 8    |
| 0                                                                                       | IP00                                                                       |      |   |      |      |      |   |      |      |
| 1                                                                                       |                                                                            |      |   |      |      |      |   |      |      |
| 2                                                                                       | IP20                                                                       | IP21 |   |      |      |      |   |      |      |
| 3                                                                                       |                                                                            |      |   |      |      |      |   |      |      |
| 4                                                                                       |                                                                            | IP41 |   | IP43 | IP44 |      |   |      |      |
| 5                                                                                       |                                                                            |      |   |      | IP54 | IP55 |   |      |      |
| 6                                                                                       |                                                                            |      |   |      |      | IP65 |   | IP67 | IP68 |

**6.5.3** Selon le ou les **degrés de pollution** pour le ou lesquels le **dispositif de commande** est déclaré. Voir Annexe N.

NOTE Il est possible que, si un **dispositif de commande** est monté selon la déclaration du fabricant, différentes parties du **dispositif de commande** soient dans des **macro-environnements** ayant des **degrés de pollution** différents.

## 6.6 Selon le mode de connexion

**6.6.1** **Dispositif** comportant au moins une borne destinée à être reliée à un **câblage fixe**.

NOTE Au Canada et aux États-Unis, les **conducteurs flottants** sont admis.

**6.6.2** **Dispositif** comportant au moins une borne destinée au raccordement d'un câble souple.

Un **dispositif de commande** peut être classé selon 6.6.1 et 6.6.2.

**6.6.3** **Dispositif** sans borne destinée à la connexion de **conducteurs externes**.

Ce type de **dispositif** n'est destiné qu'au raccordement de **conducteurs** intégrés ou **internes**.

**6.6.4** **Dispositif** destiné à la connexion de **pile primaire**.

**6.6.5** **Dispositif** destiné à la connexion de **pile secondaire (cellule rechargeable)**.

## 6.7 Selon les limites de température ambiante imposées à la tête de commande

**6.7.1** **Dispositif** dont la **tête de commande** est utilisable à une température ambiante se situant entre une valeur minimale ( $T_{\min}$ ) de 0 °C et une valeur maximale ( $T_{\max}$ ) de 55 °C.

**6.7.2** **Dispositif** dont la **tête de commande** est destinée à fonctionner à une température ambiante ayant une valeur maximale ( $T_{\max}$ ) autre que 55 °C, mais non inférieure à 30 °C, ou une valeur minimale ( $T_{\min}$ ) inférieure à 0 °C, ou les deux.

NOTE Les valeurs préférentielles pour  $T_{\max}$  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.

Des valeurs différentes de ces valeurs préférentielles sont possibles.

## 6.8 Selon la protection contre les chocs électriques

### 6.8.1 Dispositifs de commande intégrés:

NOTE Un **dispositif de commande intégré** n'est pas classé, mais est rattaché à la classe du matériel dont il fait partie.

### 6.8.2 Dispositifs de commande incorporés à utiliser dans:

6.8.2.1 – du matériel de la classe 0;

6.8.2.2 – du matériel de la classe 0I;

6.8.2.3 – du matériel de la classe I;

6.8.2.4 – du matériel de la classe II;

6.8.2.5 – du matériel de la classe III.

NOTE 1 Pour la coordination des classes 0, I, II et III de matériels électriques, voir la CEI 61140 et pour les mesures de protection dans l'installation électrique, voir la CEI 60364.

NOTE 2 Un **dispositif de commande** destiné à être incorporé dans un matériel d'une classe particulière peut aussi être utilisé pour une classe différente si les dispositions appropriées sont prises dans le matériel.

### 6.8.3 Dispositifs de commande intercalés dans un câble souple, dispositifs de commande séparés ou dispositifs de commande à montage indépendant:

6.8.3.1 – de classe 0;

6.8.3.2 – de classe 0I;

6.8.3.3 – de classe I;

6.8.3.4 – de classe II;

6.8.3.5 – de classe III.

NOTE 1 Pour la coordination des classes 0, I, II et III de matériels électriques, voir la CEI 61140 et pour les mesures de protection dans l'installation électrique, voir la CEI 60364.

NOTE 2 Un **dispositif de commande** destiné à être incorporé dans un matériel d'une classe particulière peut aussi être utilisé pour une classe différente si les dispositions appropriées sont prises dans le matériel.

### 6.8.4 Dispositifs de commande utilisant la TBTS ou la TBTP pour la protection contre les chocs électriques

6.8.4.1 **Dispositifs de commande** utilisant un ou plusieurs circuits **TBTS**, et le cas échéant, les informations déclarées dans le Tableau 1, exigence 86

6.8.4.2 **Dispositifs de commande** utilisant un ou plusieurs circuits **TBTP**, et le cas échéant, les informations déclarées dans le Tableau 1, exigence 86

## 6.9 Selon le type de coupure ou d'interruption du circuit:

- 6.9.1 – **coupure totale**;
- 6.9.2 – **microcoupure**;
- 6.9.3 – **micro-interruption**;
- 6.9.4 – **coupure sur tous les pôles**;
- 6.9.5 – Voir Annexe H.

NOTE 1 Certaines normes particulières du matériel peuvent exiger une **coupure totale**, d'autres peuvent autoriser une **coupure totale** ou une **microcoupure** et, pour certaines normes particulières, une **micro-interruption** est suffisante.

NOTE 2 Les diverses fonctions d'un même **dispositif** peuvent se traduire par des types différents de coupure ou d'interruption de circuit.

## 6.10 Selon le nombre de cycles de manœuvre (M) pour chaque action manuelle

Les valeurs préférentielles sont:

- 6.10.1 – 100 000 cycles;
- 6.10.2 – 30 000 cycles;
- 6.10.3 – 10 000 cycles;
- 6.10.4 – 6 000 cycles;
- 6.10.5 – 3 000 cycles <sup>1)</sup>;
- 6.10.6 – 300 cycles <sup>1)</sup>;
- 6.10.7 – 30 cycles <sup>1)</sup>.

<sup>1)</sup> Ces valeurs ne sont applicables qu'à des actions de **commande** réservées à certains types de matériel et à des applications telles que les **dispositifs** à prises de tension multiples, les **dispositifs** à position été/hiver pour chauffe-eau et lorsque la norme particulière le permet explicitement.

NOTE Pour les **dispositifs** à plusieurs **actions manuelles**, une valeur différente peut être déclarée pour chacune. Pour les **dispositifs** à plusieurs **positions ARRÊT**, on considère que chaque déplacement d'une **position ARRÊT** à la suivante constitue un cycle de **manœuvre**.

## 6.11 Selon le nombre de cycles automatiques (A) pour chaque action automatique

Les valeurs préférentielles sont:

- 6.11.1 – 300 000 cycles;
- 6.11.2 – 200 000 cycles;
- 6.11.3 – 100 000 cycles;
- 6.11.4 – 30 000 cycles;
- 6.11.5 – 20 000 cycles;
- 6.11.6 – 10 000 cycles;
- 6.11.7 – 6 000 cycles;
- 6.11.8 – 3 000 cycles <sup>1)</sup>;
- 6.11.9 – 1 000 cycles <sup>1)</sup>.

**6.11.10** – 300 cycles<sup>2)</sup>;

**6.11.11** – 30 cycles<sup>2)4)</sup>;

**6.11.12** – 1 cycle<sup>3)</sup>.

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 nécessitant le remplacement d'un élément après chaque **fonctionnement**.

4) Ne peut être réarmé qu'au cours de l'**entretien opéré par le fabricant**.

NOTE Pour les **dispositifs** à plusieurs **actions automatiques**, une valeur différente peut être déclarée pour chaque action.

## **6.12 Selon les limitations de température applicables à la surface de montage du dispositif de commande**

**6.12.2 Dispositif** pour montage sur une surface dont la température ne dépasse pas de plus de 20 K la température ambiante classée comme en 6.7.

**6.12.2 Dispositif** pour montage sur une surface dont la température dépasse de plus de 20 K la température ambiante classée comme en 6.7.

NOTE C'est par exemple le cas d'un **dispositif de commande** qui est monté sur le compresseur d'un réfrigérateur, la surface de montage étant à 150 °C alors que l'**élément sensible** est à –10 °C et que la température ambiante n'est que de 30 °C.

## **6.13 Selon la valeur de l'indice de résistance au cheminement (IRC) du matériau isolant employé**

**6.13.1** – matériau du groupe de matériaux IIIb ayant un IRC de 100 et au-dessus, jusqu'à 175 exclu;

**6.13.2** – matériau du groupe de matériaux IIIa ayant un IRC de 175 et au-dessus, jusqu'à 400 exclu;

**6.13.3** – matériau du groupe de matériaux II ayant un IRC de 400 et au-dessus, jusqu'à 600 exclu;

**6.13.4** – matériau du groupe de matériaux I ayant un IRC de 600 et au-dessus.

## **6.14 Selon la période des contraintes électriques auxquelles sont soumises les parties isolantes qui portent des parties actives et entre des parties actives et des éléments métalliques mis à la terre**

**6.14.1** – période courte;

**6.14.2** – période longue.

NOTE On considère que la période des contraintes électriques est longue lorsque le **dispositif de commande** est incorporé à un matériel à service continu; et également lorsque le côté amont d'un **dispositif de commande** incorporé à tout autre matériel n'est pas habituellement isolé du réseau par l'enlèvement d'une fiche de branchement ou par le **fonctionnement** d'un **dispositif de commande** fournissant une **coupure totale**.

## **6.15 Selon la construction**

**6.15.1** – **dispositif de commande intégré**;

- 6.15.2** – **dispositif de commande incorporé;**
- 6.15.3** – **dispositif de commande intercalé dans un câble souple;**
- 6.15.4** – **dispositif de commande séparé;**
- 6.15.5** – **dispositif de commande à montage indépendant pour:**
  - 6.15.5.1** – montage en surface;
  - 6.15.5.2** – montage encastré;
  - 6.15.5.3** – montage sur un panneau.
- 6.15.6** Voir Annexe J.

**6.16 Selon les exigences de vieillissement (Y) du matériel dans ou avec lequel le dispositif de commande est destiné à fonctionner**

- 6.16.1** – 60 000 h;
- 6.16.2** – 30 000 h;
- 6.16.3** – 10 000 h;
- 6.16.4** – 3 000 h;
- 6.16.5** – 300 h;
- 6.16.6** – 15 h.

NOTE Les **dispositifs de commande** qui fonctionnent pendant les essais d'échauffement ou d'endurance de la norme du matériel ne sont pas classés selon 6.16.6.

**6.17 Selon l'utilisation de la thermistance**

Voir Annexe J.

**6.18 Selon les classes de fonctions de commande**

Voir Annexe H.

## **7 Information**

### **7.1 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** puisse être monté et utilisé d'une manière telle qu'il satisfasse aux exigences de la présente norme; et
- les essais correspondants puissent être effectués pour déterminer la conformité aux exigences de la présente norme.

## 7.2 Méthodes pour fournir les informations

**7.2.1** Les informations doivent être présentées en utilisant une ou plusieurs des méthodes suivantes. Les informations spécifiées pour les **dispositifs de commande** et la méthode appropriée pour fournir ces informations doivent suivre les dispositions du Tableau 1.

NOTE 1 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** même, sauf que, dans le cas d'un **dispositif de commande intégré**, 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**.

NOTE 2 Les informations données par le marquage (C) peuvent également être comprises dans la documentation (D).

- Documentation (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** doit être accompagné par ce genre d'informations. Les notices d'instructions ainsi que les autres documents spécifiés dans la présente norme doivent être rédigés dans la ou les langues officielles du pays dans lequel le **dispositif** est destiné à être vendu.

Pour les **dispositifs de commande** destinés à être exclusivement livrés au **fabricant du matériel**, les notices d'instruction peuvent être remplacées par un dépliant, de la correspondance technique ou un schéma, etc. Il n'est pas nécessaire que chaque dispositif soit accompagné d'un document de ce genre.

- Déclaration (X) – ces informations doivent être fournies à l'autorité responsable des essais en fonction d'accords passés entre cette autorité et le fabricant. Elles peuvent être présentées, par exemple, sous forme de marquage apposé sur le **dispositif**, de dépliant, de correspondance technique ou de schémas, ou encore, dans le cas d'un **dispositif** soumis sur, dans ou avec un matériel, sous forme de mesures et d'examen du matériel soumis. Il convient de fournir également ces informations au **fabricant du matériel**, selon le cas.

**7.2.2** Les informations présentées comme requises au titre du marquage (C) ou de la documentation (D) doivent également être fournies à l'autorité responsable des essais sous une forme convenue si cette autorité l'exige.

**7.2.3** Pour les **dispositifs de commande** soumis dans, sur ou avec un matériel, l'exigence de documentation (D) est remplacée par une exigence de déclaration (X).

**7.2.4** Pour un **dispositif de commande intégré** qui fait partie d'un **dispositif** plus complexe, le marquage relatif au **dispositif de commande intégré** peut être compris dans le marquage du **dispositif** plus complexe.

**7.2.5** L'exigence de documentation (D) est considérée comme satisfaite si l'information nécessaire a été fournie par marquage (C).

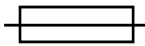
**7.2.5.1** L'exigence de déclaration (X) est considérée comme satisfaite si l'information nécessaire a été fournie soit par la documentation (D) soit par marquage (C).

**7.2.6** A l'exception des cas prévus en 7.4, 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 seules marques obligatoires 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). Pour les **dispositifs de commande incorporés** déclarés au point 50, se reporter aux explications contenues dans la documentation (D) selon 7.2.1.

**7.2.7** 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** doit être marqué uniquement de la **référence unique de type** et du nom du fabricant ou de sa marque de fabrique. Les autres marquages nécessaires doivent figurer dans la documentation (D).

**7.2.8** Il est permis d'apposer des marquages supplémentaires, à condition qu'ils ne risquent pas d'engendrer des malentendus.

**7.2.9** Les symboles utilisés doivent être les suivants:

|                                                                 |                                                                                       |                                                                                                                                                                                                                                                  |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ampères.....                                                    | A                                                                                     |                                                                                                                                                                                                                                                  |
| Volts .....                                                     | V                                                                                     |                                                                                                                                                                                                                                                  |
| Watts .....                                                     | W                                                                                     |                                                                                                                                                                                                                                                  |
| Volts-ampères .....                                             | VA                                                                                    |                                                                                                                                                                                                                                                  |
| Courant alternatif (monophasé) .....                            | ~                                                                                     | CEI 60417-5032<br>(2002-10)                                                                                                                                                                                                                      |
| Courant alternatif (triphasé).....                              | 3~                                                                                    |                                                                                                                                                                                                                                                  |
| Courant alternatif (triphasé avec neutre) .....                 | 3N~                                                                                   |                                                                                                                                                                                                                                                  |
| Courant continu.....                                            | — — —                                                                                 | CEI 60417-5031<br>(2002-10)                                                                                                                                                                                                                      |
| Construction de classe II .....                                 |   | CEI 60417-5172<br>(2003-02)                                                                                                                                                                                                                      |
| <b>Dispositif de commande de classe III</b> .....               |  | CEI 60417-5180<br>(2003-02)                                                                                                                                                                                                                      |
| Limites de température ambiante de la <b>tête de commande T</b> |                                                                                       | (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.....        |  | CEI 60417-5016 (2002-10)                                                                                                                                                                                                                         |
| Fréquence .....                                                 | Hz                                                                                    |                                                                                                                                                                                                                                                  |
| Borne de terre .....                                            |  | CEI 60417-5019<br>(2006-08)                                                                                                                                                                                                                      |
| Mise à la terre fonctionnelle .....                             |  | CEI 60417-5018<br>(2011-07)                                                                                                                                                                                                                      |

Pour l'identification du degré de protection procuré par l'enveloppe, les symboles de 6.5 doivent être utilisés.

NOTE 1 Les informations sur la tension et le courant assignés peut 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) A 250 V ~ ou 16 (3) / 250 ~ ou  $\frac{16 (3)}{250} \sim$



NOTE 2 Exemples de la façon de fournir des informations concernant les limites de température d'un **dispositif**:

– 20T 30 (soit moins 20 °C jusqu'à plus 30 °C);

– T85 (soit 0 °C jusqu'à 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 (7.2 de l'édition 3) – Information requise  
et méthodes pour fournir les informations (1 sur 4)**

| Information                                                                                                                                                                                             | Article ou paragraphe                 | Méthode |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|---------|
| 1 Nom du fabricant ou sa marque de fabrique                                                                                                                                                             | 7.2.6                                 | C       |
| 2 <b>Référence unique de type</b> <sup>a</sup>                                                                                                                                                          | 2.11.1,<br>2.13.1, 7.2.6              | C       |
| 3 Tension assignée ou plage de tensions assignées, en volts (V)                                                                                                                                         | 2.12, 4.3.2<br>14.4,                  | C       |
| 4 Type d'alimentation, sauf si le <b>dispositif de commande</b> peut fonctionner indifféremment en courant alternatif ou continu, ou si les caractéristiques assignées sont les mêmes dans les deux cas | 4.3.2, 6.1                            | C       |
| 5 Fréquence si elle n'est pas comprise dans la plage de 50 Hz à 60 Hz inclus                                                                                                                            | 4.3.2                                 | C       |
| 6 Fonction du <b>dispositif de commande</b>                                                                                                                                                             | 2.2, 4.2.4, 4.3.5,<br>6.3, 17.16      | D       |
| 6a Construction du <b>dispositif de commande</b> et si celui-ci est électronique                                                                                                                        | 6.15, Annexe<br>H, H.2.5.7            | D       |
| 7 Le type de charge contrôlé par chaque circuit <sup>b</sup>                                                                                                                                            | 6.2, 14, 17,<br>23.1.1                | C       |
| 15 Degré de protection procurée par l'enveloppe <sup>c</sup>                                                                                                                                            | 6.5.1, 6.5.2<br>11.5                  | C       |
| 17 Bornes susceptibles d'être reliées à des <b>conducteurs externes</b> , de phase, de neutre, ou indifféremment à l'un ou l'autre                                                                      | 6.6, 7.4.2<br>7.4.3                   | C       |
| 18 Bornes de <b>conducteurs externes</b> prévues pour une gamme de dimensions de conducteur plus étendue que celles qui figurent dans le Tableau 3                                                      | 10.1                                  | D       |
| 19 Pour les <b>bornes sans vis</b> , moyen de connexion et de déconnexion des conducteurs <sup>d</sup>                                                                                                  | 10                                    | D       |
| 20 Détail des conducteurs spéciaux destinés à être reliés aux bornes prévues pour les <b>conducteurs internes</b>                                                                                       | 10.2.1                                | D       |
| 21 Température maximale des bornes pour <b>conducteurs internes</b> et bornes pour <b>conducteurs externes</b> de <b>dispositifs de commandes intégrés</b> et incorporés, si supérieure à 85 °C         | 14                                    | X       |
| 22 Limites de température applicables à la <b>tête de commande</b> si $T_{\min}$ est inférieure à 0 °C ou $T_{\max}$ autre que 55 °C                                                                    | 6.7, 14.5<br>14.7, 17.3               | C       |
| 23 Limites de la température des surfaces de montage ( $T_s$ )                                                                                                                                          | 6.12.2, 14.1,<br>17.3                 | C       |
| 24 Classification du <b>dispositif</b> selon la protection contre les chocs électriques                                                                                                                 | 6.8                                   | X       |
| 25 Pour les <b>dispositifs de classe II</b> , symbole de la construction de classe II                                                                                                                   | 7.3                                   | C       |
| 26 Nombre de cycles de <b>manœuvre</b> (M) pour chaque <b>action manuelle</b>                                                                                                                           | 6.10, 17.10,<br>17.11                 | X       |
| 27 Nombre de cycles automatiques (A) pour chaque <b>action automatique</b>                                                                                                                              | 6.11, 17.8,<br>17.9                   | X       |
| 28 Période de vieillissement (Y) pour <b>dispositifs de commande</b> avec action de type 1M ou 2M                                                                                                       | 6.16, 17.6                            | X       |
| 29 Pour chaque circuit, type de coupure ou d'interruption                                                                                                                                               | 2.4.1, 2.4.2,<br>2.4.3, 2.4.4,<br>6.9 | X       |

Tableau 1 (2 sur 4)

| Information                                                                                                                                                                                                                                                                                                                  | Article ou paragraphe                                                                    | Méthode |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|---------|
| 30 IRC des matériaux isolants utilisés                                                                                                                                                                                                                                                                                       | 6.13, Tableau 23, Note de bas de tableau b, Tableau 24, Note de bas de tableau d, 21.2.7 | X       |
| 31 Méthode de montage du <b>dispositif</b> <sup>e</sup>                                                                                                                                                                                                                                                                      | 11.6                                                                                     | D       |
| 31a Méthode de mise à la terre du <b>dispositif de commande</b>                                                                                                                                                                                                                                                              | 7.4.3, 9, 9.1.1, 9.1.2                                                                   | D       |
| 32 Type de fixation des <b>câbles souples fixés à demeure</b> <sup>f</sup>                                                                                                                                                                                                                                                   | 10.1, 11.7                                                                               | D       |
| 33 Condition de transport prévue du <b>dispositif de commande</b> <sup>g</sup>                                                                                                                                                                                                                                               | 16.1                                                                                     | X       |
| 34 Détail de toute limitation du <b>temps de fonctionnement</b> <sup>h</sup>                                                                                                                                                                                                                                                 | 14, 17                                                                                   | D       |
| 35 Période de contraintes électriques dans les parties isolantes                                                                                                                                                                                                                                                             | 6.14                                                                                     | X       |
| 36 Limites de la <b>grandeur de manœuvre</b> pour tout <b>élément sensible</b> au-dessus desquelles une <b>microcoupure</b> est sûre (voir aussi l'Article H.7, point 36)                                                                                                                                                    | 11.3.2                                                                                   | X       |
| 37 Pente minimale ou maximale de variation de la grandeur de manœuvre, ou fréquence cyclique minimale ou maximale dans le cas d'un <b>dispositif de commande sensible</b> <sup>i</sup>                                                                                                                                       | 4.1.7, 15, 17                                                                            | X       |
| 38 Valeurs de dépassement de la <b>grandeur de manœuvre</b> nécessaires au bon fonctionnement ou utilisables pour les essais, pour les <b>dispositifs de commande sensibles</b>                                                                                                                                              | 17                                                                                       | X       |
| 39 <b>Action de type 1</b> ou <b>de type 2</b>                                                                                                                                                                                                                                                                               | 6.4                                                                                      | D       |
| 40 Caractéristiques complémentaires pour <b>action de type 1</b> ou <b>de type 2</b>                                                                                                                                                                                                                                         | 6.4.3, 11.4                                                                              | D       |
| 41 <b>Tolérance de fabrication</b> et condition d'essai correspondante                                                                                                                                                                                                                                                       | 2.11.1, 11.4.3, 15, 17.14                                                                | X       |
| 42 <b>Dérive</b>                                                                                                                                                                                                                                                                                                             | 2.11.2, 11.4.3, 15, 16.2.4                                                               | X       |
| 43 Caractéristiques de réenclenchement pour action de coupe-circuit <sup>j</sup>                                                                                                                                                                                                                                             | 6.4                                                                                      | D       |
| 44 Si le <b>dispositif de commande</b> est destiné à être tenu à la main ou à être incorporé à un matériel tenu à la main                                                                                                                                                                                                    |                                                                                          | X       |
| 45 Limitation éventuelle du nombre et de la répartition des <b>réceptacles</b> de connecteurs à languette pouvant être montés                                                                                                                                                                                                | 10.2.4.4                                                                                 | D       |
| 46 Toute <b>action de type 2</b> doit être conçue de manière à confiner la <b>tolérance de fabrication</b> et la <b>dérive</b> de sa <b>valeur de fonctionnement</b> , de son <b>temps de fonctionnement</b> ou de sa <b>séquence de fonctionnement</b> dans la limite déclarée dans les exigences 41, 42 et 46 du Tableau 1 | 11.4.3                                                                                   | D       |
| 47 Extension de tout <b>élément sensible</b>                                                                                                                                                                                                                                                                                 | 2.8.1                                                                                    | D       |
| 48 <b>Valeur(s) de fonctionnement</b> ou <b>temps de fonctionnement</b>                                                                                                                                                                                                                                                      | 2.3.11, 2.3.12, 6.4.3.10, 11, 14, 15.6, 17                                               | D       |
| 49 <b>Degré de pollution du dispositif de commande</b>                                                                                                                                                                                                                                                                       | 6.5.3                                                                                    | D       |
| 50 <b>Dispositif de commande</b> prévu pour livraison exclusive au <b>fabricant de matériel</b>                                                                                                                                                                                                                              | 7.2.1, 7.2.6                                                                             | X       |
| 51 Températures de l'essai au fil incandescent                                                                                                                                                                                                                                                                               | 21.2.1, 21.2.2, 21.2.3 et 21.2.4                                                         | X       |
| 52 à 60 Voir Annexe H                                                                                                                                                                                                                                                                                                        |                                                                                          |         |
| 61 à 65 Voir Annexe J                                                                                                                                                                                                                                                                                                        |                                                                                          |         |
| 66 à 74 Voir Annexe H                                                                                                                                                                                                                                                                                                        |                                                                                          |         |

Tableau 1 (3 sur 4)

| Information                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Article ou paragraphe                | Méthode |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|---------|
| 75 <b>Tension assignée de choc</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2.1.12, 20.1                         | D       |
| 76 Type de revêtement de la plaque de circuit                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Annexe P ou Annexe Q                 | X       |
| 77 Température pour l'essai à la bille                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 21.2.1, 21.2.2, 21.2.3 et 21.2.4     | D       |
| 78 Couple maximal déclaré sur manchon simple utilisant des matériaux thermoplastiques                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Tableau 20, Note de bas de tableau a | D       |
| 79 <b>Degré de pollution</b> dans le <b>microenvironnement</b> de la <b>ligne de fuite</b> ou <b>distance dans l'air</b> , si plus propre que celui du <b>dispositif de commande</b> , et comment il est conçu                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Tableau H.24                         | D       |
| 80 <b>Tension assignée de choc</b> pour la <b>ligne de fuite</b> ou <b>distance dans l'air</b> , si différente de celle du <b>dispositif de commande</b> , et comment elle est réalisée                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Tableau H.24                         | D       |
| 81 Les valeurs prévues pour les tolérances des distances pour lesquelles l'exclusion du mode de <b>panne</b> «court» est revendiquée                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Tableau H.24                         | D       |
| 82 Voir Annexe J                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                      |         |
| 85 Pour les <b>dispositifs de classe III</b> , symbole de la construction de classe III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 7.4.6                                | C       |
| 86 Pour les circuits <b>TBTS</b> ou <b>TBTP</b> , les limites <b>TBT</b> réalisées                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | 2.1.5, T.3.2                         | D       |
| 87 Pour la tension accessible des circuits <b>TBTS</b> ou <b>TBTP</b> , si elle diffère de 8.1.1, la norme de produit à laquelle il est fait référence pour l'application de la <b>commande</b> , dans laquelle norme le(s) niveau(x) <b>TBTS</b> ou <b>TBTP</b> accessibles est (sont) donné(s)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 2.1.4, 6.8.4.1, 6.8.4.2, 8.1.1       | D       |
| 88 Voir Annexe U                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                      |         |
| 89 Essais et groupes d'émission tels que déclarés selon la CISPR 11                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 23.2, H.23.1.2                       | X       |
| 90 Les essais d'immunité pour les <b>dispositifs de commande de protection</b> destinés à être utilisés avec les appareils relevant de la CEI 60335                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | Tableau H.13                         | X       |
| 91 à 94 Voir Annexe H                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                      |         |
| 95 Courant de court-circuit maximal comme déclaré                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | 11.3.5.2.1 b)                        | D       |
| <p><sup>a</sup> La <b>référence unique de type</b> doit être telle que le fait de la citer en entier permette de commander au fabricant un <b>dispositif</b> de remplacement parfaitement interchangeable avec l'original du point de vue de ses caractéristiques électriques, mécaniques, dimensionnelles et fonctionnelles.</p> <p>Cette référence peut comprendre une référence de série avec d'autres marques et indications, comme une tension assignée ou une température ambiante, l'ensemble de ces données constituant la <b>référence unique de type</b>.</p> <p><sup>b</sup> Pour les <b>dispositifs de commande</b> qui comportent plus d'un seul circuit, l'intensité applicable à chaque circuit et à chaque borne. En cas de différences d'un circuit à l'autre, on doit préciser 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 17.2.</p> <p><sup>c</sup> L'exigence de marquage (C) ne s'applique pas aux <b>dispositifs de commande</b> ou à leurs parties classées IP00, IP10, IP20, IP30 et IP40.</p> <p><sup>d</sup> Au Canada et aux États-Unis, le marquage (C) est exigé pour le mode de connexion et de déconnexion des <b>bornes sans vis</b> à câbler sur place.</p> |                                      |         |

**Tableau 1 (4 sur 4)**

- <sup>e</sup> 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** à pose encastrée. Afin de s'assurer qu'après encastrement les conditions spécifiées dans la présente norme sont respectées, la notice d'instructions doit comprendre les précisions appropriées concernant:
- les dimensions de l'emplacement destiné au **dispositif**;
  - les dimensions et la position des moyens de support et de fixation du **dispositif** à l'intérieur de cet emplacement;
  - un espace minimal entre les différentes parties du **dispositif** et les parties de l'emplacement qui l'entourent;
  - les dimensions minimales des ouvertures de ventilation et la disposition correcte de celle-ci;
  - le raccordement du **dispositif** à l'alimentation et l'interconnexion des éléments constitutifs 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 au Tableau 13, 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 de bas de tableau a du Tableau 13).
- 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 requis pour cette partie de l'installation fixe.
- <sup>f</sup> Les **dispositifs de commande intercalés dans un câble souple, séparés et à montage indépendant**, munis de **câbles 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 ne peut être remplacé que par le fabricant ou son agent agréé" (Y).
- <sup>g</sup> La méthode d'emballage n'a pas à être déclarée.
- <sup>h</sup> 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.
- <sup>i</sup>  $\alpha_1$  = pente ascendante minimale  
 $\beta_1$  = pente descendante minimale
- Les pentes ( $\alpha_1$  et  $\beta_1$ ) de la variation de la **grandeur de manœuvre** sont celles qui correspondent à un **usage normal**.
- $\alpha_2$  = pente ascendante maximale (applicable uniquement aux **actions du type 2**)  
 $\beta_2$  = pente descendante maximale (applicable uniquement aux **actions du type 2**).
- Aux fins d'essais, les valeurs de  $\alpha_1$  et de  $\beta_1$  doivent être conformes aux valeurs déclarées sans pouvoir être inférieures aux limites données pour les **actions du type 1** ou du **type 2** dans les parties 2 appropriées. Les valeurs de  $\alpha_2$  et  $\beta_2$  ne sont données que pour les essais; elles peuvent être remplacées par la déclaration d'une valeur cyclique maximale. Dans le cadre de la présente norme, 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                           |
| Éclairement          | lux/s                          |
| Vitesse              | mm/s <sup>2</sup>              |
| Niveau liquide       | mm/s                           |
| Courant              | A/s                            |
| Humidité             | %/s                            |
| Débit d'air          | m <sup>3</sup> /s <sup>2</sup> |
- \* Lors de l'utilisation d'autres grandeurs de manœuvre, ces grandeurs doivent être exprimées en unités SI.
- <sup>j</sup> 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**.
- <sup>k</sup> Vacant
- <sup>l</sup> Vacant
- <sup>m</sup> à <sup>t</sup> Voir Annexe H.

### 7.3 Symbole de classe II

**7.3.1** Le symbole de construction de la classe II ne doit être utilisé que pour les **dispositifs de commande** classés selon les dispositions de 6.8.3.4.

**7.3.2** 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.

**7.3.2.1** 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.

**7.3.2.2** Les **dispositifs de commande** fournissant une protection contre les chocs électriques telle que requise 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, CEI 60417-5172 (2003-02), mais doivent être considérés comme des **dispositifs de commande de classe I**.

### 7.4 Exigences supplémentaires de marquage

**7.4.1** Le marquage spécifié sur le **dispositif de commande** doit être de préférence apposé sur le corps du **dispositif**, mais peut être placé sur des **parties non amovibles** du dispositif.

Le marquage spécifié doit être lisible et durable.

*La conformité est vérifiée par examen et par les essais de l'Annexe A.*

**7.4.2** 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.*

**7.4.3** Les bornes à relier exclusivement à un **conducteur externe** de neutre doivent être signalées par la lettre "N".

NOTE Au Royaume-Uni, les bornes prévues exclusivement pour recevoir un **conducteur actif externe** doivent être marquées avec la lettre L.

**7.4.3.1** Les bornes de terre destinées aux conducteurs externes de terre 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, CEI 60417-5019 (2006-08);
- pour la terre fonctionnelle, par le symbole de terre pour la terre de fonctionnelle, CEI 60417-5018 (2011-07).

**7.4.3.2** 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.*

NOTE 1 Au Canada et aux États-Unis, les bornes destinées au raccordement de conducteurs d'alimentation mis à la terre doivent être réalisées de manière à présenter une extrémité de couleur blanche ou gris naturel et doivent être repérables par rapport aux autres parties.

NOTE 2 Au Canada et aux États-Unis, les vis serre-fil destinées au raccordement des conducteurs de terre des équipements doivent avoir une tête fendue ou hexagonale de couleur verte. Les connecteurs à pression de fil servant au raccordement des conducteurs de terre doivent être identifiés par un marquage TERRE ou par marquage sur un schéma de câblage apposé sur le **dispositif de commande**. Les vis serre-fil ou les connecteurs à pression de fil doivent être placés de façon qu'ils ne soient pas susceptibles d'être enlevés lors des opérations d'**entretien** des **dispositifs**.

NOTE 3 En ce qui concerne 7.4.2 à 7.4.3.2 inclus, au Canada et aux États-Unis, les règles d'installation exigent des marquages complémentaires ou autres.

NOTE 4 Au Royaume-Uni, la lettre L ne doit pas être utilisée, sauf comme indiqué en 7.4.3 ci-dessus.

**7.4.4** Les **dispositifs de commande** destinés à être réglés par l'**utilisateur** ou par le **fabricant du 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 "+" ou "-" est suffisante.

Les **dispositifs de commande** destinés à être réglés par le **fabricant du matériel** ou son **installateur** doivent être accompagnés d'une documentation (D) indiquant la méthode appropriée pour bloquer en position de **réglage**.

**7.4.5** 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**.

**7.4.6** Les **dispositifs de commande** destinés à être reliés uniquement à des **réseaux TBTS** doivent être marqués du symbole graphique CEI 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 que requise pour les **dispositifs de commande de classe III** 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 III, CEI 60417-5180 (2003-02).

**7.4.7** Si un équipement 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 expression analogue:

**ATTENTION**  
**RISQUE D'EXPLOSION SI LA PILE EST REMPLACÉE PAR UN TYPE INCORRECT**  
**ÉLIMINER LES PILES USAGEES CONFORMEMENT AUX INSTRUCTIONS**

**7.4.8** 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.

**7.4.9** 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 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.

**7.4.10** Voir Annexe V.

## 8 Protection contre les chocs électriques

### 8.1 Exigences générales

**8.1.1** 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 **capot** 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 circuits **TBTS** ou les circuits TBTP alimentés sous une tension ne dépassant pas 24 V ne sont pas considérés comme étant des **parties actives dangereuses**.

Si les circuits **TBTS** ou TBTP alimentés à une tension dépassant 24 V sont accessibles, le courant entre la (les) **partie(s) accessible(s)** et un pôle quelconque de la source d'alimentation des circuits **TBTS** ou TBTP doit être conforme à H.8.1.10.1.

**8.1.1.1** Il est permis de spécifier à une valeur différente la tension des circuits **TBTS** ou TBTP considérés comme n'étant pas dangereux

- 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

- si le fabricant déclare l'application, la norme de produit régissant l'application, et le niveau de tension pour les circuits **TBTS** ou TBTP accessibles considérés comme non dangereux par la norme d'application (Tableau 1, exigence 86).



NOTE Au Canada et aux États-Unis, les parties raccordées à la **TBT** issue d'un **transformateur de sécurité** sous une tension ne dépassant pas 42,4 V crête ou 30 V efficaces en conditions sèches, ou 21,2 V crête ou 15 V efficaces lorsque un contact humide est susceptible de se produire ne sont pas considérées comme étant des **parties actives dangereuses**.

**8.1.2** Pour les **dispositifs de commande de la classe II** et les **dispositifs** destinés au matériel de la classe II, cette exigence s'applique également à tout contact accidentel avec des parties métalliques séparées des **parties actives dangereuses** par une **isolation principale** seulement.

**8.1.3** 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 requise contre les contacts accidentels avec des **parties actives dangereuses**.

NOTE Les matières de remplissage autodurcissables peuvent être touchées sans danger.

**8.1.4** Pour les **dispositifs de commande de la classe II** et les **dispositifs** 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**.

**8.1.5** Les **dispositifs de commande de la classe II** et les **dispositifs** 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 spécifié 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 munis d'une gaine métallique.

**8.1.6** Pour les **dispositifs de commande intégrés et incorporés**, les essais de 8.1.9 à 8.1.9.5 inclus ne s'appliquent qu'aux parties accessibles lorsque le **dispositif** est monté dans une position conforme aux déclarations du fabricant et lorsque toutes ses **parties amovibles** ont été enlevées.

**8.1.7** Pour les **dispositifs de commande intercalés dans un câble souple** et les **dispositifs de commande séparés**, les essais de 8.1.9 à 8.1.9.5 inclus sont effectués avec des câbles souples de la section nominale la plus petite ou la plus grande spécifiée en 10.1.4 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.

**8.1.8** Pour les **dispositifs de commande à montage indépendant**, l'essai est effectué, le **dispositif** étant monté comme en **usage normal** et muni d'un câble souple ayant la section nominale la plus faible ou la plus grande spécifiée en 10.1.4, 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.

**8.1.9** La conformité aux spécifications de 8.1.1 à 8.1.8 inclus est vérifiée par examen et par les essais suivants:

Le doigt d'épreuve normalisé de la Figure 2 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 2 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 2 peut entrer sans forcer, l'essai avec ce dernier doigt est répété. Un contact éventuel est décelé électriquement.*

NOTE Pour déceler les contacts indésirables, on peut utiliser une lampe avec une tension d'au moins 40 V.

**8.1.9.1** *Le doigt d'épreuve normalisé doit être conçu de façon que chacune des parties articulées puisse être tournée de 90°, par rapport à l'axe du doigt, dans une seule et même direction.*

**8.1.9.2** *Les trous des parties isolantes 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 1, appliquée sans forcer dans toutes les positions possibles.*

**8.1.9.3** *Il ne doit pas être possible de toucher ni avec le doigt ni avec la broche d'épreuve des **parties actives dangereuses**.*

**8.1.9.4** *Pour les **dispositifs de commande** comportant des parties à **double isolation**, il ne doit pas être possible de toucher avec le doigt d'épreuve les parties métalliques séparées des **parties actives dangereuses** uniquement par une **isolation principale**.*

**8.1.9.5** *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**, 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**.*

**8.1.10** Voir Annexe H.

**8.1.11** Entre des circuits de la classe III et des circuits connectés au réseau ou à la terre, l'isolation externe du **transformateur d'isolement 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.

**8.1.12** Une **partie active** doit être considérée dangereuse si elle dépasse les valeurs spécifiées en 8.1.1 et elle n'est pas séparée de la source par une **impédance de protection** conforme à H.8.1.40 et n'est pas un conducteur PEN ou n'appartient pas au **réseau de liaison équipotentielle**.

**8.1.13** 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 détachable même si les instructions spécifient qu'il est nécessaire de la retirer.

## **8.2 Organes de manœuvre et liaisons de manœuvre**

**8.2.1** Un **organe de manœuvre** ne doit pas être sous tension.

**8.2.2** Une **liaison de manœuvre** ne doit pas être sous tension 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 à 8.2.1 et 8.2.2 est vérifiée par examen et par les essais de 8.1.*

NOTE On considère qu'un **organe de manœuvre** isolé est convenablement fixé lorsqu'on ne peut l'enlever qu'en le cassant, en le coupant ou après l'avoir sérieusement endommagé.

**8.2.3** Pour les **dispositifs de commande** autres que ceux de la classe III ou destinés à des appareils autres que ceux de la classe III, les poignées et autres **organes de manœuvre** destinés à être tenus à la main en **usage normal** doivent être en matière isolante ou recouverts de façon appropriée de matière isolante. S'ils sont en métal, leurs **parties accessibles** doivent être séparées des **organes de manœuvre** ou du moyen de fixation par une **isolation supplémentaire** au cas où ces derniers présenteraient un risque quelconque de devenir actifs 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 appareils fixes, cette exigence ne s'applique pas sous réserve que ces parties soient:

- ou reliées de façon fiable à une borne de terre ou un contact de terre; ou
- séparées des **parties actives dangereuses** par des parties métalliques mises à la terre.

*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.

### **8.3 Condensateurs**

**8.3.1** 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. Pour les **dispositifs de commande**, destinés aux 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** est monté conformément aux déclarations du fabricant. Les enveloppes métalliques des condensateurs doivent être séparées par une **isolation supplémentaire** des parties métalliques accessibles et des parties métalliques qui sont susceptibles d'être en contact avec des parties métalliques accessibles lorsque le **dispositif** est monté conformément aux déclarations du fabricant.

*La conformité est vérifiée par examen et d'après les exigences relatives à l'**isolation supplémentaire** aux Articles 13 et 20.*

**8.3.2** 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.

*La conformité est vérifiée par l'essai suivant de 8.3.2.1 à 8.3.2.4 inclus, effectué 10 fois.*

**8.3.2.1** Le **dispositif** est alimenté sous la tension assignée ou sous la limite supérieure de la plage de tensions assignées.

**8.3.2.2** L'**organe de manœuvre** éventuel est alors mis dans la position «ARRÊT», si elle existe, et le **dispositif** est séparé de la source d'alimentation en retirant la fiche du socle.

**8.3.2.3** Au bout de 1 s, la tension entre les broches de la fiche est mesurée.

**8.3.2.4** Cette tension mesurée ne doit pas dépasser 34 V crête. Cet essai n'est effectué que si la capacité du condensateur dépasse 0,1  $\mu$ F.

## 8.4 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 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.*

NOTE 1 Au Canada et aux États-Unis, la disposition des **parties actives dangereuses** et la position du **couvercle** doivent être telles que le fait d'enlever ou de replacer le **couvercle** n'expose aucune personne à un **danger** de choc électrique.

NOTE 2 Au Canada et aux États-Unis, les **parties actives dangereuses** et les parties mobiles dangereuses doivent être disposées, protégées ou enfermées de manière à réduire au minimum les risques qu'elles présentent pour le personnel d'entretien et de réparation procédant à des opérations de remplacement d'ampoules, de tubes électroniques ou de fusibles, de lubrification des pièces, ou d'autres **fonctionnements** analogues effectués pendant la **maintenance par l'utilisateur** ou les **entretiens**.

## 8.5 Voir Annexe V.

## 9 Dispositions en vue de la mise à la terre de protection

### 9.1 Exigences générales

**9.1.1** Les parties métalliques accessibles, autres que des **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 mises sous tension en cas de **panne** d'isolement, doivent être reliées en permanence et de façon sûre à une borne de terre ou à une connexion de terre placée à l'intérieur du **dispositif**, ou au contact de terre d'un socle de connecteur.

NOTE 1 La phrase "reliées en permanence et de façon sûre à une borne de terre" est synonyme du terme mise à la terre.

NOTE 2 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 terre, une **connexion** de terre ou un contact de terre ne sont pas considérées comme des parties susceptibles d'être mises sous tension en cas de **panne** d'isolement.

NOTE 3 Les exigences des **organes de manœuvre** sont spécifiées en 8.2.3.

**9.1.2** Les parties métalliques accessibles, autres que des **organes de manœuvre**, des **dispositifs de commande incorporés** et intégrés destinés aux appareils de la classe 0I et de la classe I qui peuvent être mises sous tension en cas de **panne** d'isolement, doivent comporter une disposition en vue de mise à la terre.

NOTE 1 Les **dispositifs de commande intégrés** et **incorporés** peuvent être mis à la terre par leurs éléments 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 de l'appareil, si le fabricant a spécifié cette méthode de mise à la terre dans ses déclarations.

NOTE 2 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 terre, une **connexion** de terre ou un contact de terre ne sont pas considérées comme des parties susceptibles d'être mises sous tension en cas de **panne** d'isolement.

NOTE 3 Les exigences des **organes de manœuvre** sont spécifiées en 8.2.3.

**9.1.3** Les bornes de terre, les **connexions** de terre et les contacts de terre ne doivent pas être reliés électriquement à une borne de neutre quelconque.

La conformité à 9.1.1 à 9.1.3 est vérifiée par examen.

## 9.2 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.

## 9.3 Connexions de terre appropriées

### 9.3.1 Exigences générales

La connexion entre une borne de terre, une **connexion** de terre ou un contact de terre et les parties devant y être reliées, doit être de faible résistance.

La conformité est vérifiée par l'essai suivant:

- On fait passer 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, de la borne de terre, de la **connexion** de terre ou du contact de terre à successivement chacune des parties métalliques accessibles.
- La chute de tension est mesurée entre la borne de terre, la **connexion** de terre ou le contact de 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  $\Omega$ . L'essai est poursuivi jusqu'à l'établissement de conditions stables.

NOTE 1 On prend soin que la résistance de contact entre l'extrémité de la sonde de mesure et la partie métallique en essai 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.

### 9.3.2 Câblage fixe et fixations du type X et du type M

Les bornes de terre pour le raccordement d'un **câblage fixe** ou des **câbles souples fixés à demeure** ayant des fixations du type X et du type M doivent satisfaire aux exigences de 10.1.

NOTE 1 Au Canada et aux États-Unis, une borne plate à connexion rapide, ayant les dimensions indiquées dans le Tableau 2 peut être utilisée comme borne de terre non accessible à condition d'avoir des moyens additionnels pour empêcher le déplacement en cours d'utilisation et d'être utilisée dans un circuit ayant un dispositif de protection comme spécifié dans le tableau.

NOTE 2 Au Canada, en Chine et aux États-Unis, un fil de mise à la terre d'un **câblage fixe** ou d'un câble souple d'alimentation ne doit pas être terminé par une borne à connexion rapide.

**Tableau 2 (9.3.2 de l'édition 3) – Dimensions de la borne de connexion rapide (Canada et États-Unis)**

| Dimensions nominales<br>mm |           |          | Caractéristique assignée<br>du dispositif de protection<br>du circuit<br>A |
|----------------------------|-----------|----------|----------------------------------------------------------------------------|
| Largeur                    | Épaisseur | Longueur |                                                                            |
| 4,8                        | 0,5       | 6,4      | 20 ou moins                                                                |
| 4,8                        | 0,8       | 6,4      | 20 ou moins                                                                |
| 5,2                        | 0,8       | 6,4      | 20 ou moins                                                                |
| 6,3                        | 0,8       | 8,0      | 60 ou moins                                                                |

### 9.3.3 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 terre sans vis de type unité de serrage conformes à la CEI 60998-2-2 ou à la CEI 60998-2-3 ou sans vis de type unité de serrage conformes à la CEI 60999-1.

### 9.3.4 Dimensions des bornes de terre accessibles

Les bornes de terre accessibles en **usage normal** doivent permettre le raccordement des conducteurs ayant des sections nominales comprises entre 2,5 mm<sup>2</sup> et 6 mm<sup>2</sup> et il ne doit pas être possible de les desserrer sans l'aide d'un **outil**.

NOTE Au Canada et aux États-Unis, des conducteurs d'autres sections nominales sont autorisés.

### 9.3.5 Dimensions des bornes de terre non accessibles

Les bornes de terre non accessibles en **usage normal** pour **conducteurs externes** doivent avoir une section égale ou supérieure à celle qui est requise pour les bornes actives correspondantes.

### 9.3.6 Verrouillage des bornes de terre

Les organes de serrage des bornes de terre pour **conducteurs externes** doivent être protégés efficacement contre un desserrage accidentel.

*La conformité aux spécifications de 9.3.2 à 9.3.6 inclus est vérifiée par examen, par essai manuel et par les essais applicables de 10.1.*

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**.

## 9.4 Résistance à la corrosion

Toutes les parties de la borne de terre doivent être résistantes à la corrosion résultant du contact entre ces parties et le cuivre du conducteur de terre ou de tout autre métal en contact avec ces parties.

### 9.4.1 Matériaux

Le corps de la borne de 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.

### 9.4.2 Armatures ou enveloppes en aluminium

Si le corps de la borne de 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 résultant du contact entre le cuivre et l'aluminium ou ses alliages.

*La conformité à 9.4, 9.4.1 et 9.4.2 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.

## 9.5 Autres exigences

### 9.5.1 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.*

### 9.5.2 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 terre tel qu'il ne soit pas nécessaire de le débrancher pour effectuer ces essais, **réglages** ou opérations d'**entretien**.

*La conformité est vérifiée par examen.*

NOTE 1 C'est, par exemple, le cas des **dispositifs de commande** thermosensibles, ou de dégivrage des réfrigérateurs.

NOTE 2 Dans les pays membres du CENELEC, 9.5.2 n'est pas applicable.

## 10 Bornes et connexions

Voir aussi l'Article 20, troisième alinéa.

### 10.1 Bornes et connexions pour conducteurs externes en cuivre

**10.1.1** 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 10.1.3 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.

**10.1.1.1** Les bornes ou **connexions** pour des **câbles souples fixés à demeure** ayant des **fixations du type Y** et du **type Z** peuvent nécessiter l'emploi d'un **outil spécial** pour la connexion ou la déconnexion, mais doivent satisfaire aux exigences applicables aux bornes et **connexions** pour **conducteurs internes**.

*La conformité à 10.1.1 et 10.1.1.1 est vérifiée par examen et par essai.*

NOTE 1 Les bornes à vis conformes à la CEI 60998-2-1, les **bornes sans vis** conformes à la CEI 60998-2-2 ou à la CEI 60998-2-3 et les organes de serrage conformes à la CEI 60999-1 sont considérés comme des dispositifs efficaces.

NOTE 2 Les connecteurs à languette sont considérés comme nécessitant l'emploi d'un **outil spécial**.

**10.1.2** 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 1 Provisoirement, les filetages SI, BA et Filetages unifiés sont considérés comme étant aussi efficaces que le filetage métrique ISO.

NOTE 2 Un essai d'équivalence d'efficacité est à l'étude. En attendant qu'il soit agréé, toutes les valeurs de couple applicables à des filetages autres qu'ISO (métriques), SI, BA, et Filetages unifiés sont augmentées de 20 %.

### 10.1.3 Connexions soudées, brasées, serties ou analogues

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 10.2.2 et 10.2.3.

*La conformité est vérifiée par examen.*

NOTE En général, les normes particulières du matériel limitent l'utilisation de telles connexions.

**10.1.4** 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 3.

*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.*

**Tableau 3 (10.1.4 de l'édition 3) – Sections minimales des conducteurs**

| Courant circulant dans la borne <sup>a</sup><br>A                                                                                                                                                                                                                                                                                   | Sections nominales <sup>b</sup><br>mm <sup>2</sup> |                               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------|
|                                                                                                                                                                                                                                                                                                                                     | Conducteurs pour câbles souples                    | Conducteurs pour câblage fixe |
| Jusqu'à 6 inclus <sup>c</sup>                                                                                                                                                                                                                                                                                                       | 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                       |
| <sup>a</sup> Des exigences pour les applications supérieures à 63 A sont à l'étude.<br><sup>b</sup> Aux États-Unis, d'autres sections de conducteurs sont applicables.<br><sup>c</sup> Les sections nominales spécifiées ne s'appliquent pas aux bornes des circuits <b>TBTS</b> ou <b>TBTP</b> dont le courant ne dépasse pas 3 A. |                                                    |                               |

**10.1.4.1** Si une borne est prévue pour une gamme plus étendue de dimensions de conducteurs pour **câblage fixe** ou pour câbles souples que celles indiquées aux colonnes 2 et 3 du Tableau 3, cette précision doit figurer dans les déclarations du fabricant.

NOTE 1 Au Canada et aux États-Unis, les **lignes de fuites** et **distances dans l'air** entre les bornes déclarées comme **conducteurs externes** du **câblage fixe** et entre de telles bornes, autres que les bornes de mise à la terre, et les pièces métalliques adjacentes doivent répondre aux exigences de l'Article 20 et, de plus, quand elles sont mesurées selon la Note 2 de 10.1.4.1, elles doivent être au moins de

- 6,4 mm pour les tensions assignées ne dépassant pas 250 V;
- 8,0 mm pour les tensions assignées supérieures à 250 V mais ne dépassant pas 400 V;

- 9,6 mm pour les tensions assignées supérieures à 400 V.

NOTE 2 Au Canada et aux États-Unis, la mesure des **lignes de fuite** et des **distances dans l'air** aux bornes est effectuée deux fois, une fois avec des conducteurs de la plus grande section utilisable et une fois sans conducteur.

**10.1.5** Les bornes pour un **câblage fixe** ou pour les **câbles 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 20.

*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 10.1.4, le conducteur étant déplacé à chaque desserrage. Pour les parties filetées, le couple de serrage maximal appliqué est soit celui indiqué dans le Tableau 20, soit le couple spécifié à la figure applicable (voir Figures 10 à 13 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 de la présente norme.

NOTE 2 Pour éviter le desserrage des bornes, on peut utiliser deux vis de fixation, une vis dans un évidement ou tout autre moyen approprié.

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 de l'appareil; 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 spécifiées dans la présente norme.

**10.1.6** 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 que pour les **bornes sans vis** destinées à des circuits dont le courant ne dépasse pas 2 A, l'une des surfaces de serrage peut être en matière non métallique.

*La conformité est vérifiée par examen de la borne et des conducteurs après l'essai de 10.1.5.*

NOTE On considère comme excessivement endommagés des conducteurs présentant des entailles profondes ou du cisaillement.

**10.1.7** Les bornes pour un **câblage fixe** ou pour les **câbles fixés à demeure** ayant des **fixations du type X** ne doivent pas exiger une préparation spéciale des conducteurs pour réaliser une connexion correcte.

**10.1.7.1** 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.

**10.1.8** Les bornes pour un **câblage fixe** ou pour les **câbles 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.

**10.1.8.1** La conformité est vérifiée par l'essai suivant.

**10.1.8.2** Les bornes sont équipées des conducteurs prévus selon l'utilisation de la borne, conformément au Tableau 4. Les âmes des conducteurs pour **câblage fixe** sont redressées avant d'être introduites dans les bornes.

**10.1.8.3** 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 20.

**10.1.8.4** 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 4 (10.1.8 de l'édition 3) – Conducteurs de borne**

| Courant circulant dans la borne <sup>a</sup><br>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                      |
| <sup>a</sup> Des exigences pour les applications supérieures à 63 A sont à l'étude. |                               |                                                                                          |                               |

**10.1.9** Les bornes doivent être conçues de façon à serrer le conducteur de façon fiable.

La conformité est vérifiée par l'essai suivant.

**10.1.9.1** Les bornes sont équipées de conducteurs de la plus petite et de la plus grande section nominale spécifiée en 10.1.4, 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 20. Chaque conducteur est ensuite soumis à une traction dont la valeur est donnée par le Tableau 5, appliquée sans secousse pendant 1 min dans l'axe du logement du conducteur.

**10.1.9.2** Normalement, la force de traction est exercée directement sur le 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.

**10.1.9.3** Pendant l'essai, le conducteur ne doit pas se déplacer dans la borne de façon notable.

**Tableau 5 (10.1.9 de l'édition 3) – Valeurs d'essai de traction du conducteur**

| Courant circulant dans la borne <sup>a</sup><br>A                                                                                                                                | Force de traction<br>N                      |                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-------------------------------------------|
|                                                                                                                                                                                  | Bornes pour conducteurs pour câbles souples | Bornes pour conducteurs pour câblage fixe |
| Jusqu'à 3 inclus                                                                                                                                                                 | 20 <sup>b</sup>                             | 20 <sup>b</sup>                           |
| 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                                       |
| <sup>a</sup> Des exigences pour les applications supérieures à 63 A sont à l'étude.                                                                                              |                                             |                                           |
| <sup>b</sup> Applicable seulement aux circuits <b>TBTS</b> ou <b>TBTP</b> et aux autres applications pour lesquelles les caractéristiques des conducteurs ne sont pas précisées. |                                             |                                           |

**10.1.10** 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 14.*

**10.1.11** Les bornes doivent être disposées de façon que chacun des conducteurs d'un **câblage fixe** ou câble souple puisse être raccordé raisonnablement près des autres conducteurs du même câble, sauf si une raison technique valable s'y oppose.

*La conformité est vérifiée par examen.*

**10.1.12** 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 la classe II** ou 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**.

*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 10.1.4 est dépouillée de son enveloppe isolante sur une longueur de 8 mm. Un brin du conducteur est décâblé et les autres brins sont introduits

*complètement et serrés dans la borne. Le brin décablé est plié, sans déchirer l'enveloppe isolante, dans toutes les directions possibles, mais sans angles vifs le long de cloisons.*

- *Le brin décablé 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 la classe II** ou destinés au matériel de la classe II, aucune partie métallique séparée des parties actives par une **isolation supplémentaire** seulement.*
- *Le brin décablé d'un conducteur relié à une borne de terre ne doit toucher aucune **partie active**.*
- *Le brin décablé 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**.*

**10.1.13** Les bornes doivent être conçues de manière que la continuité du circuit ne soit pas maintenue par une pression de contact transmise par une matière isolante autre que céramique ou une autre matière isolante 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 17.*

NOTE Pour de telles applications, les matières isolantes sont jugées sur leur stabilité dimensionnelle dans la plage de températures pour laquelle le **dispositif de commande** est prévu.

**10.1.14** Les vis et autres parties filetées des bornes doivent être en métal.

*La conformité est vérifiée par examen.*

NOTE Au Canada et aux États-Unis, les normes nationales exigent que, lorsque les vis sont utilisées pour des conducteurs de diamètre égal ou inférieur à 2,5 mm, la connexion doit comporter des pinces ou des vis de serrage avec les plaques des bornes ayant des cosses tournées vers le haut, ou analogue, pour maintenir les fils en place. Les épaisseurs des plaques des bornes sont de 1,27 mm (0,050 in) pour des dimensions de fil supérieures à 1,6 mm (# 14 AWG) et de 0,76 mm minimum (0,030 in) pour des dimensions de fil inférieures ou égales à 1,6 mm. Les vis des bornes ne doivent pas être plus petites que #8 Unifié, sauf qu'une vis de # 6 Unifié peut être utilisée pour le raccordement d'un fil de 1,29 mm (# 16), d'un fil de 1,02 mm (# 18) ou d'un seul fil de 1,6 mm (#14).

**10.1.15** 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 11 et pour les **bornes à capot taraudé** par la distance minimale spécifiée à la Figure 12.*

NOTE Au Canada et États-Unis, les Paragraphes 10.1.16 et 10.1.16.1 s'appliquent:

#### **10.1.16 Conducteurs flottants (amorces)**

Au Canada et aux États-Unis, où des **conducteurs flottants (amorces)** peuvent être utilisés pour des connexions de raccordement de **dispositifs de commande à montage indépendant**, les conducteurs de connexion ne doivent pas être plus petits que 0,82 mm<sup>2</sup>. L'isolation doit être d'au moins 0,8 mm d'épaisseur, si elle est en thermoplastique, ou d'au moins 0,8 mm d'épaisseur si elle est en caoutchouc, avec un guidage thermoplastique de 0,8 mm d'épaisseur.

Les conducteurs doivent avoir une longueur minimale de 150 mm et doivent être disposés de façon à être inaccessibles lorsqu'ils sont installés conformément aux pratiques de câblages nationales. En complément, la connexion terminale du **dispositif de commande** d'un tel conducteur, si elle est placée dans la même boîte de câblage, ne doit pas être d'une construction à borne filetée à moins que le dispositif de connexion soit rendu inutilisable pour la connexion d'un **conducteur externe**.

La construction à borne filetée peut ne pas être rendue inutilisable si l'extrémité à connecter du conducteur est isolée, et qu'un marquage sur le dispositif indique clairement l'usage prévu du conducteur.

La conformité est vérifiée par examen.

**10.1.16.1** Au Canada et aux États-Unis, les **conducteurs flottants** doivent être munis d'un renforcement pour éviter que la contrainte soit transmise à la borne, aux épissures (par exemple pour des connexions torsadées) ou au câblage interne.

La conformité est vérifiée par examen et en appliquant une traction de 44 N sur les conducteurs pendant 1 min.

Pendant l'essai, le conducteur ne doit pas être endommagé et ne pas s'être déplacé longitudinalement de plus de 2 mm.

## 10.2 Bornes et connexions pour conducteurs internes

### 10.2.1 Connexion des conducteurs

Les bornes et **connexions** pour conducteurs internes doivent permettre le raccordement de conducteurs ayant des sections nominales indiquées par le Tableau 6.

**Tableau 6 (10.2.1 de l'édition 3) – Sections nominales des conducteurs**

| Courant circulant dans la borne ou connexion <sup>a</sup><br>A | Section nominale <sup>b</sup> minimale du conducteur<br>mm <sup>2</sup> |
|----------------------------------------------------------------|-------------------------------------------------------------------------|
| Jusqu'à 3 inclus                                               | – <sup>c</sup>                                                          |
| 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                                                                      |

<sup>a</sup> Des exigences pour les applications supérieures à 63 A sont à l'étude.

<sup>b</sup> Aux États-Unis, d'autres sections de conducteurs sont applicables.

<sup>c</sup> Aucun minimum n'est spécifié, mais le fabricant doit déclarer la section à utiliser pour les essais.

NOTE Les exigences de 10.2.1 ne s'appliquent pas aux bornes de dispositifs qui ne sont pas destinées à recevoir des conducteurs normalisés sans préparation spéciale, ni aux bornes qui, par leur conception et leur destination, ne peuvent recevoir des conducteurs normalisés, ni aux bornes qui sont spécialement conçues pour recevoir des conducteurs de section différente et qui sont destinées exclusivement à certains types d'appareils. Par exemple, un **thermostat** destiné à être incorporé dans le tissu d'une couverture chauffante.

### 10.2.2 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.*

### 10.2.3 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 20, 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.

#### 10.2.4 Connecteurs à languette, bornes sans vis plate

**10.2.4.1** Les **languettes** faisant partie intégrante d'un **dispositif de commande** doivent satisfaire aux exigences dimensionnelles de la Figure 14 ou 15.

*La conformité est vérifiée par des mesures.*

Des **languettes** de dimensions autres que celles indiquées à la Figure 14 ou 15 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** normalisé (voir Figure 16).

Pour les dimensions des Figures 14, 15 et 16, les dimensions physiques de la CEI 61210 peuvent être utilisées comme alternative. Les exigences de performances de la CEI 61210 ne sont pas applicables.

Des **languettes** assurant un détrompage des **réceptacles** selon leur polarité peuvent être utilisées (Figure 16).

**10.2.4.2** Les **languettes** faisant partie d'un **dispositif de commande** doivent être en matériau et revêtement appropriés à la température maximale des **languettes** indiquée au Tableau 7. Des matériaux et des revêtements différents de ceux qui sont spécifiés dans le tableau peuvent être employés à condition que leurs caractéristiques électriques et mécaniques soient au moins équivalentes, particulièrement sur le plan de la résistance à la corrosion et de la robustesse mécanique.

**Tableau 7 (10.2.4.2 de l'édition 3) – Matériau des languettes et de leur revêtement**

| Matériau et revêtement des languettes            | Température maximale des languettes<br>°C |
|--------------------------------------------------|-------------------------------------------|
| Cuivre nu                                        | 155                                       |
| Laiton nu                                        | 210                                       |
| Cuivre recouvert d'étain et alliages de cuivre   | 160                                       |
| Cuivre recouvert de nickel et alliages de cuivre | 185                                       |
| Cuivre recouvert d'argent et alliages de cuivre  | 205                                       |
| Acier recouvert de nickel                        | 400                                       |
| Acier inoxydable                                 | 400                                       |

*La conformité est vérifiée en mesurant la température atteinte pendant les essais de l'Article 14.*

NOTE Les températures indiquées correspondent à un régime continu. Des températures momentanément plus élevées sont possibles, par exemple lors d'un échauffement excessif mais temporaire d'un **dispositif de commande thermosensible**.

**10.2.4.3** 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 à la présente norme.

*La conformité est vérifiée par l'application, sans secousses, des forces de traction axiales égales à celles indiquées dans le Tableau 8. Ces forces ne doivent causer ni déplacement ni dommages notables.*

**Tableau 8 (10.2.4.3 de l'édition 3) – Valeurs des forces de traction axiales pour l'insertion et l'enlèvement de languette**

| Taille de la languette<br>(voir Figure 16)                                                                                                                               | Force de poussée <sup>a</sup><br>N | Force de traction <sup>a</sup><br>N |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|-------------------------------------|
| 2,8                                                                                                                                                                      | 50                                 | 40                                  |
| 4,8                                                                                                                                                                      | 60                                 | 50                                  |
| 6,3                                                                                                                                                                      | 80                                 | 70                                  |
| 9,5                                                                                                                                                                      | 100                                | 100                                 |
| <sup>a</sup> Les valeurs données dans le tableau sont des valeurs maximales admissibles pour l'insertion et l'enlèvement d'un <b>réceptacle</b> d'une <b>languette</b> . |                                    |                                     |

**10.2.4.4** Les **languettes** faisant partie intégrante d'un **dispositif de commande** doivent être suffisamment espacées pour permettre l'engagement des **réceptacles** appropriés.

Pour les dimensions des Figures 14, 15 et 16, les dimensions physiques de la CEI 61210 peuvent être utilisées comme alternative. Les exigences de performances de la CEI 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 20.*

NOTE Aux **languettes** conformes à la Figure 14 ou 15 correspondent les **réceptacles** de la Figure 16.

### 10.3 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 10 mais les exigences appropriées des autres articles peuvent s'appliquer.

## 11 Exigences de construction

### 11.1 Matériaux

#### 11.1.1 Matières isolantes – Imprégnées

Le bois, le coton, la soie, le papier ordinaire et les matières fibreuses ou hygroscopiques analogues ne doivent pas être utilisés comme isolant, sauf s'ils sont imprégnés.

*La conformité est vérifiée par examen.*

NOTE Une matière isolante est considérée comme imprégnée si un isolant approprié remplit pratiquement les interstices entre les fibres de la matière.

### 11.1.2 Parties transportant le courant

Pour les pièces 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 et analyse du matériau.*

### 11.1.3 Câbles souples fixés à demeure

**11.1.3.1** 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.

**11.1.3.2** 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 terre.

*La conformité à 11.1.3.1 et 11.1.3.2 est vérifiée par examen.*

## 11.2 Protection contre les chocs électriques

### 11.2.1 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.

**11.2.1.1** 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.

### 11.2.2 Dérogation à la double isolation ou isolation renforcée

Les **dispositifs de commande de la classe II** et les **dispositifs** 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 20. 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 20.

*La conformité est vérifiée par examen, par mesure et/ou par essai manuel.*

*Dans le cadre de cette exigence:*

– on ne s'attend pas à ce que deux fixations indépendantes se desserrent 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 17 et 18 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 maintenus 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 conducteurs câblés, 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 l'un(e) quelconque des vis ou écrous est desserré(e).

### 11.2.3 Conducteurs intégrés

**11.2.3.1** 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 20.

**11.2.3.2** 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 11.2.3.1 et 11.2.3.2 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 la CEI, 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 13.

### 11.2.4 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 la CEI 60227-1 ou dans la CEI 60245-1.

*La conformité est vérifiée par examen et, si nécessaire, par des essais portant sur les gaines des câbles souples, conformément à la CEI 60227-1 ou à la CEI 60245-1.*

### 11.2.5 Impédance de protection

Voir Annexe H.

### 11.2.6 Protection contre les chocs électriques par l'utilisation de la TBTS ou de la TBTP

Voir Annexe T.

### 11.2.7 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 dédiés qui ne peuvent pas être montés sur ou interconnectés avec d'autres systèmes de raccordement.

*La conformité est vérifiée par examen.*

### 11.3 Manœuvre et fonctionnement

#### 11.3.1 Coupure totale

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 20. 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 13 et 20, si nécessaire.*

#### 11.3.2 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 13, 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 au Tableau 1, exigence 36, ou de la température de la **tête de commande** entre les limites déclarées au Tableau 1, exigence 22, ne doit pas provoquer un **fonctionnement** qui réduirait la séparation des contacts de façon que les exigences de l'Article 13 ne soient plus satisfaites.

*La conformité est vérifiée par examen et, si nécessaire, par les essais de l'Article 13, exécutés aux limites de température déclarées.*

#### 11.3.3 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.

*La conformité est vérifiée par examen.*

NOTE 1 Cette exigence exclut par exemple les boutons de réarmement montés dans une position telle qu'ils puissent être réenclenchés en poussant le **dispositif de commande** contre un mur ou en poussant un meuble contre le **dispositif**.

NOTE 2 Cette exigence ne s'applique pas aux **dispositifs de commande** à réarmement manuel avec actions à **déclenchement libre**.

#### 11.3.4 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.*

### 11.3.5 Contacts – Généralités

**11.3.5.1** 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 11.3.7.

**11.3.5.2** 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.

#### 11.3.5.2.1 Dispositions pour prévenir les erreurs de cause commune

Des mesures doivent être prises pour assurer la protection contre les **défaillances** de deux (au moins) éléments de commutation, 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 commutateur permettant de commander le courant de court-circuit. Ce commutateur étant ouvert, le **dispositif de commande** est connecté comme indiqué en H.27.1.1.2 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 95).*

**11.3.5.2.1.1** Un court-circuit est appliqué entre les bornes de sortie de sécurité du **dispositif de commande** en fermant le commutateur.

*L'essai est réalisé pendant 1 h ou à travers le commutateur en l'absence de courant.*

*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 le commutateur fermé.*

*L'essai est répété à l'aide du même échantillon ou sur un échantillon différent, le commutateur étant maintenu en position fermée avant la première séquence de démarrage.*

**11.3.5.2.1.2** 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 H.27.1.1.3 et à l'Article 15.*

*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.*

### **11.3.6 Contacts pour coupure totale et microcoupure**

Les contacts produisant une **coupure totale** 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 14 et, dans le cas d'une position ouverte, par application des exigences de l'Article 13 concernant les **microcoupures**. Cependant, lorsque l'**organe de manœuvre** peut occuper une **position intermédiaire** voisine d'une **position repérée** déclarée pour une **coupure totale**, les essais des Articles 13 et 20 concernant les **coupures totales** sont applicables à cette **position intermédiaire**.*

### **11.3.7 Exclusions pour 11.3.5 et 11.3.6**

Les exigences de 11.3.5 et 11.3.6 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**.

**11.3.7.1** *La conformité est vérifiée par examen et, si nécessaire, par l'essai de 11.3.7.2.*

**11.3.7.2** *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.*

### **11.3.8 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**.

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**.

### **11.3.9 Dispositif de commande à cordon de traction**

Les **dispositifs de commande à cordon de traction** doivent être conçus de façon qu'après une manœuvre du **dispositif** 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.*

NOTE 1 Les **dispositifs de commande à cordon de 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 2 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 peuvent être données.

## 11.4 Actions

### 11.4.1 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 toute(s) autre(s) action(s).

*La conformité est vérifiée par examen et, si nécessaire, par des essais après avoir rendu toutes les autres actions inopérantes.*

### 11.4.2 Réglage par le fabricant

Une **action de type 2** pour laquelle un **réglage** par le fabricant de sa **valeur de fonctionnement**, de son **temps de fonctionnement** ou de sa **séquence de fonctionnement** a été prévu, 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.*

### 11.4.3 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 les exigences 41 et 42 du Tableau 1.

*La conformité est vérifiée par les essais des Articles 15 à 17 inclus.*

### 11.4.4 Action de type 1.A ou 2.A

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**.

*La conformité est vérifiée par les essais de l'Article 13 et les exigences appropriées de l'Article 20.*

### 11.4.5 Action de type 1.B ou 2.B

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 13 et les exigences appropriées de l'Article 20.*

#### 11.4.6 Action de type 1.C ou 2.C

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 20.*

#### 11.4.7 Action de type 1.D ou 2.D

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 réenclenchement 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.*

#### 11.4.8 Action de type 1.E ou 2.E

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 réenclenchement 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.

*La conformité est vérifiée par examen et par essai.*

#### 11.4.9 Action de type 1.F ou 2.F

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 réenclenché qu'à l'aide d'un **outil**.

*La conformité est vérifiée par examen et par essai.*

NOTE Cette exigence est considérée comme satisfaite si le montage dans l'appareil est tel qu'un **outil** soit nécessaire pour accéder au **dispositif de commande**.

#### 11.4.10 Action de type 1.G ou 2.G

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 à sa tension assignée et à son courant assigné.*

#### 11.4.11 Action de type 1.H ou 2.H

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  $-35\text{ °C}$  avec le mécanisme de réarmement en position normale.

*La conformité est vérifiée par examen et par essai.*

#### 11.4.12 Action de type 1.J ou 2.J

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  $-35^{\circ}\text{C}$ .

*La conformité est vérifiée par examen et par essai.*

#### 11.4.13 Action de type 1.K ou 2.K

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, temps ou séquence de fonctionnement** déclaré ne soit dépassé.

NOTE L'essai est spécifié dans la partie 2 appropriée.

#### 11.4.14 Action de type 1.L ou 2.L

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.*

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.

#### 11.4.15 Action de type 1.M ou 2.M

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 17.6.*

11.4.16 Voir Annexe H.

11.4.17 Voir Annexe J.

### 11.5 Ouvertures dans les enveloppes

Les trous d'écoulement éventuels doivent avoir une section minimale de  $20\text{ mm}^2$ ; une section maximale de  $40\text{ mm}^2$  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 12.

NOTE 2 Les **dispositifs de commande** classés IPX7 peuvent comporter un moyen pour ouvrir un trou d'écoulement.

NOTE 3 Aux États-Unis, il existe des exigences supplémentaires pour les ouvertures dans les enveloppes destinées à la ventilation, au drainage, au montage de composants, au jeu autour d'un cadran, d'un bouton, d'un levier, d'un tube capillaire ou analogue.

## 11.6 Montage des dispositifs de commande

**11.6.1** 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 de la présente norme.

**11.6.2** 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 à la présente norme. Si un démontage ou démontage partiel est nécessaire au bon fonctionnement du **dispositif**, les exigences des Articles 8, 13 et 20 doivent être satisfaites avant et après un tel démontage.

*La conformité à 11.6.1 et 11.6.2 est vérifiée par examen et par un essai manuel.*

NOTE On considère que 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 l'**organe de manœuvre**, satisfont à cette exigence à condition que le serrage de l'écrou nécessite 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**.

### 11.6.3 Montage de dispositifs de commande à montage indépendant

**11.6.3.1** 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, ou
- être prévus pour montage en saillie sur une surface plane.

**11.6.3.2** 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 la CEI 60423.

**11.6.3.3** Les **dispositifs de commande à montage indépendant** pour montage en saillie, utilisés en installation enterrée (câblage caché) sans boîte de sortie doivent être pourvus de trous convenables à l'arrière du **dispositif de commande**, permettant une installation et une connexion faciles aux bornes.

**11.6.3.4** Les **dispositifs de commande à montage indépendant** pour montage en saillie, utilisés en câblage exposé, doivent être pourvus d'entrées de câble ou de conduit, de parois défonçables ou de presse-étoupe qui permettent la connexion de modèles appropriés de câble ou de conduits répondant aux normes CEI les concernant.

**11.6.3.5** 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 **capot** (ou le **dispositif de commande**) est retiré.

**11.6.3.6** 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**.



**11.6.3.7** 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 empêcheront le contact avec le câblage installé dans la boîte.

*La conformité à 11.6.3.1 à 11.6.3.7 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.

## **11.7 Fixation des câbles**

### **11.7.1 Flexion**

**11.7.1.1** 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**.

**11.7.1.2** *La conformité est vérifiée en soumettant le **dispositif de commande** équipé du câble ou du jeu de câbles prévu à l'essai suivant.*

**11.7.1.2.1** *Le **dispositif de commande** est monté dans l'appareil d'essai de flexion représenté à la Figure 9. L'axe d'oscillation est choisi de façon que le poids qui est fixé au câble et le câble lui-même aient un mouvement latéral d'amplitude minimale au cours de l'essai.*

*Les échantillons de dispositifs de commande à câble méplat sont montés de manière que le grand axe de la section du câble soit parallèle à l'axe d'oscillation. Chaque câble souple passant par l'ouverture d'entrée est lesté avec un poids de 1 kg. On fait circuler dans chaque âme conductrice soumise à l'essai un courant égal à celui qu'elle conduit lorsque le **dispositif** 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.*

**11.7.1.2.2** *Après cet essai, l'échantillon ne doit présenter aucune détérioration au sens de la présente norme. 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.*

**11.7.1.2.3** *Il est admis qu'un maximum de 10 % du nombre total des conducteurs de câble souple doit s'être rompu.*

### **11.7.2 Dispositifs d'arrêt de traction et de torsion**

**11.7.2.1** 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.



**11.7.2.2** Les dispositifs d'arrêt de traction et de torsion pour les **dispositifs de commande de la classe II** doivent être en matière isolante 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**.

**11.7.2.3** Les dispositifs d'arrêt de traction et de torsion pour **dispositifs de commande** autres que ceux de la classe II doivent être en matière isolante, ou munis d'une enveloppe isolante, si un **panne** d'isolation 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 11.7.1.

**11.7.2.4** 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 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;
- pour les **fixations du type X** et du **type M**, le remplacement du câble ne nécessite pas d'**outil spécial**;
- pour les **fixations du type X**, ils soient efficaces pour les différents types de câbles 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.

**11.7.2.5** Pour les **fixations** autres que celles 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.

**11.7.2.6** Les presse-étoupe 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 qu'ils ne soient prévus des moyens permettant le serrage de tous les types et toutes les sections de câble mentionnés en 10.1.4.

**11.7.2.7** 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** 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.

**11.7.2.8** La conformité aux spécifications de 11.7.2.1 à 11.7.2.7 inclus est vérifiée par examen et par les essais de 11.7.2.9 à 11.7.2.15 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.

**11.7.2.9** Le **dispositif de commande** est muni 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 19.1.

**11.7.2.10** Après cette préparation, il ne doit pas être possible de repousser le câble à l'intérieur du dispositif au point que le câble ou les parties internes puissent être endommagés, ou que les parties internes du **dispositif** soient gênées de façon que la conformité à la présente norme soit affectée.

**11.7.2.11** Le câble est ensuite soumis à des tractions dont la valeur et le nombre sont indiqués dans le Tableau 9. Les tractions sont appliquées dans la direction la plus défavorable, sans secousse, chaque fois pendant 1 s.

**11.7.2.12** Immédiatement après, le câble est soumis pendant 1 min à un couple de torsion dont la valeur est indiquée dans le Tableau 9.

**Tableau 9 (11.7.2 de l'édition 3) – Valeurs de couple de torsion et de traction**

| Dispositif de commande                                                                           | Force de traction <sup>a</sup><br>N | Couple de torsion <sup>a</sup><br>Nm | Nombre de tractions <sup>a</sup> |
|--------------------------------------------------------------------------------------------------|-------------------------------------|--------------------------------------|----------------------------------|
| <b>Dispositifs de commande séparés et dispositifs de commande à montage indépendant:</b>         |                                     |                                      |                                  |
| 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                               |
| <b>Dispositifs intercalés dans un câble souple:</b> (à l'exclusion des dispositifs séparés)      | 90                                  | 0,25                                 | 100                              |
| <sup>a</sup> Certaines normes particulières du matériel peuvent imposer des valeurs différentes. |                                     |                                      |                                  |

**11.7.2.13** 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 10.1.4, puis avec le câble le plus voisin 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.

**11.7.2.14** Pendant les essais, le câble ne doit pas être endommagé. Après les essais, on ne doit pas constater un déplacement longitudinal du câble de plus de 2 mm, 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 20.

**11.7.2.15** Pour mesurer le déplacement longitudinal on fait avant les essais une marque 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, on mesure le déplacement de la marque sur le câble par rapport au dispositif d'arrêt de traction et de torsion, le câble étant maintenu tendu.

## **11.8 Dimensions des câbles souples fixés à demeure**

**11.8.1** Les **câbles souples fixés à demeure** ne doivent pas être plus légers que les câbles sous gaine ordinaire de caoutchouc (désignation CEI 60245 53) ou les câbles sous gaine légère de polychlorure de vinyle (désignation CEI 60227 53). L'utilisation d'un câble souple plus léger 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.

**11.8.2** 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 10.

**Tableau 10 (11.8.2 de l'édition 3) – Valeurs du conducteur de câble minimal**

| <b>Courant dans le circuit applicable<sup>a</sup></b><br>A | <b>Sections nominales<sup>b</sup></b><br>mm <sup>2</sup> |
|------------------------------------------------------------|----------------------------------------------------------|
| Jusqu'à 6 inclus <sup>c</sup>                              | 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                                                       |

<sup>a</sup> Des exigences pour les applications supérieures à 63 A sont à l'étude.

<sup>b</sup> Aux États-Unis, d'autres sections de conducteurs sont applicables.

<sup>c</sup> Les sections inférieures à 0,75 mm<sup>2</sup> sont admises pour les **dispositifs de la classe III** ou si la norme particulière du matériel ou d'installation autorise de telles sections.

*La conformité est vérifiée par examen.*

**11.8.3** 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 **capots** 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 **capot**.

*La conformité est vérifiée par examen et par un essai de montage de la plus forte section de conducteur mentionnée en 10.1.4.*

## **11.9 Entrées**

**11.9.1** Les entrées de câbles souples externes doivent être conçues et profilées ou doivent être munies de traversées de telle façon que le revêtement du câble puisse être introduit sans **risque** de détérioration.

**11.9.1.1** Les entrées de conduit et les parties 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 20.

*La conformité est vérifiée par examen.*

**11.9.2** En l'absence d'une traversée, l'entrée du câble doit être en matière isolante.

**11.9.3** Lorsque l'entrée est équipée d'une traversée, celle-ci doit être en matière isolante 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.

**11.9.4** 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 11.9.1 à 11.9.4 inclus est vérifiée par examen et par un essai manuel.*

**11.9.5** 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 entrées défonçables ou des presse-étoupe qui permettent la connexion du conduit, du câble ou du câble souple appropriés.

## **11.10 Socles de connecteurs et prises**

**11.10.1** 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.*

**11.10.2** Les **dispositifs de commande intercalés dans un câble souple** munis 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**, des socles ou des prises en **usage normal**.

*La conformité est vérifiée par examen.*

**11.10.3** 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.

Si des **dispositifs de commande intercalés dans un câble souple** munis 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 pourvu 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 27.5.

La partie socle-prise de courant du **dispositif de commande** doit être conforme à la norme appropriée pour le système de prise et socle de prise de courant. La partie **commande** doit être conforme à la présente norme.

NOTE Cet article n'est pas applicable au Canada et aux États-Unis.

*La conformité est vérifiée par examen et par les essais basés sur les circuits spécifiés pour le système de socles de connecteurs.*

## **11.11 Exigences pendant le montage et les opérations de maintenance et d'entretien**

### **11.11.1 Capots et leurs fixations**

**11.11.1.1** Pour les **dispositifs de commande autres qu'intégrés**, le fait d'enlever un **capot** ou un **couvercle**, incluant le **capot** du compartiment de pile, prévu pour être enlevé lors du montage ou pendant les opérations de **maintenance** et d'**entretien** du **dispositif** ou de l'appareil **par l'utilisateur** ne doit pas changer les **réglages** initiaux si cela risque d'affecter la conformité à la présente norme.

**11.11.1.2** La fixation de ces **capots** 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 à la présente norme. La fixation des **capots** 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 11.11.1.1 et 11.11.1.2 est vérifiée par examen.*

NOTE 1 Au Canada et aux États-Unis, un **capot** fixé sans vis démontable sans l'aide d'un **outil** et qui donne accès à des **parties actives** doit subir les essais suivants:

Un **capot** ne doit pas se décrocher sous l'effet d'une traction directe de 60 N. Pour cet essai, le **capot** est saisi en deux points convenablement choisis. L'essai doit être effectué avant et après 10 démontages et remontages du **capot**.

Un **capot** doit résister à des chocs de 1,35 Nm sur toutes ses faces accessibles (un choc par face) sans déplacement et sans dommages pour les parties internes du **dispositif de commande** ni perturbation de son fonctionnement à la suite de l'essai. Le rayon de la bille à employer pour cet essai doit être d'au moins 25,4 mm.

NOTE 2 Au Canada et aux États-Unis, la continuité électrique de circuits de mise à la terre pour des **capots** fixés sans vis doit être conforme aux exigences de 9.3 et 9.5.

#### **11.11.1.3 Capots des enveloppes**

NOTE Au Canada et aux États-Unis, il y a des exigences supplémentaires pour les portes et les **capots** des enveloppes permettant l'accès aux fusibles ou à n'importe quel dispositif de protection contre les surcharges dont le fonctionnement normal exige le remplacement, ou s'il est nécessaire d'ouvrir le **capot** en rapport avec le **fonctionnement** normal du dispositif de protection contre les surcharges.

#### **11.11.1.4 Vitre recouvrant une ouverture**

NOTE Au Canada et aux États-Unis, il y a des exigences supplémentaires pour les matériaux en verre ou similaires recouvrant une ouverture d'observation.

#### **11.11.1.5 Parties non détachables**

Les parties non détachables fournissant le degré de protection nécessaire contre les chocs électriques, l'humidité ou le contact avec les pièces 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 de 11.11.1.5.1 à 11.11.1.5.3.*

**11.11.1.5.1** *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.

**11.11.1.5.2** *Pour les essais de 11.11.1.5.3, 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** ait fonctionné dans les conditions spécifiées à l'Article 14.*

**11.11.1.5.3** Une force est appliquée sans secousse dans la direction la plus défavorable pendant 10 s, aux zones du **capot** ou de la pièce susceptibles d'être faibles. La force à appliquer doit être comme suit:

- Force de poussée 50 N
- Force de traction:
  - 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

La force de poussée est appliquée au moyen d'un doigt d'essai rigide aux dimensions semblables à celles du doigt d'essai normalisé de la Figure 2.

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 a) ou de b) est exécuté, l'ongle d'essai de la Figure 3 est inséré dans toutes les ouvertures ou jointures avec une force de 10 N. L'ongle d'essai 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'essai de la Figure 3 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 **capot** 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'essai 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.

**11.11.1.5.4** Pendant et après les essais de 11.11.1.5.3, les pièces ne doivent pas se séparer et doivent rester en position verrouillée, sinon elles sont jugées être des **pièces amovibles**.

**11.11.1.6** Un **capot**, 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 **capot** qui peut être entourée par la paume de la main. L'essai est effectué avant et après 10 démontages et remontages.

## 11.11.2 Moyens de fixation du capot

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 munies de rondelles serrantes de carton ou d'une matière analogue. Voir 19.1.5.



### 11.11.3 Organe de manœuvre

**11.11.3.1** 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.

**11.11.3.2** Si les limites supérieure et inférieure de la plage de **réglage** à la disposition du fabricant ou de 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**.

**11.11.3.3** 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** quelconque à **action de type 2** est utilisé pour indiquer l'état du **dispositif**, il ne doit pas être possible de monter cet **organe de manœuvre** dans une position incorrecte.

*La conformité aux spécifications de 11.11.3.1 à 11.11.3.3 inclus est vérifiée par examen et, pour les **organes de manœuvre** qui ne nécessitent pas d'**outil** pour leur démontage, par l'essai de 18.9.*

NOTE Des normes particulières du matériel peuvent exiger qu'il soit impossible de monter d'une manière incorrecte l'**organe de manœuvre** qui est utilisé pour indiquer l'état du **dispositif**.

### 11.11.4 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 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** 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.

### 11.11.5 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 si on ne peut l'enlever qu'en le cassant ou le coupant, ou s'il est serré.

### 11.11.6 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.*

### 11.11.7 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.*

## **11.12 Dispositifs de commande utilisant des logiciels**

Voir Annexe H.

## **11.13 Dispositifs de commande de protection et éléments constituant des systèmes de commande de protection**

### **11.13.1 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 appareils 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.

Les **dispositifs de commande de fonctionnement** ne doivent pas être utilisés comme des **dispositifs de commande de protection**.

*La conformité est vérifiée par les essais appropriés spécifiés dans la présente norme et dans la partie 2 concernée.*

### **11.13.2 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.

### **11.13.3 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.

### **11.13.4 Piles**

**11.13.4.1** 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 **panne** simple 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**.

**11.13.4.2** 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 (voir l'Annexe V); 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 (voir l'Annexe V), 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 2); ou
  - être intrinsèquement protégées pour empêcher d'engendrer un **danger** au sens de la norme.

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.

**11.13.4.3** 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 éventuelle fuite de liquide 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.

**11.13.4.3.1** Si un bac support de piles est exigé, sa capacité doit être au moins égale au volume de l'électrolyte de tous 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.

**11.13.4.4** La conformité aux spécifications de 11.13.4.1 à 11.13.4.3.1 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 11.13.4.4.1 à 11.13.4.4.4 et 11.13.4.5. 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. La pile utilisée pour les essais suivants est une pile non rechargeable neuve ou fournie ou recommandée par le fabricant pour utilisation avec le **dispositif de commande**.*

**11.13.4.4.1** 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 au minimum 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.

**11.13.4.4.2** Régime de décharge excessif. 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.

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.

**11.13.4.4.3** Voir Annexe V.

**11.13.4.4** Ces essais ne doivent 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**.

**11.13.4.5** À l'issue des essais, l'équipement est soumis aux essais de rigidité diélectrique de 13.2.

## 12 Résistance à l'humidité et à la poussière

### 12.1 Protection contre la pénétration de l'eau et de la poussière

**12.1.1** 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 lorsqu'ils sont montés ou utilisés de la manière déclarée.

**12.1.2** La vérification de la conformité consiste d'abord à préparer le **dispositif de commande** de la manière indiquée de 12.1.3 à 12.1.6, puis à effectuer l'essai approprié spécifié dans la CEI 60529. Immédiatement après l'essai approprié, le **dispositif** doit satisfaire à l'essai diélectrique de 13.2 et un examen doit montrer que l'eau qui pourrait avoir pénétré dans le **dispositif** ne peut avoir de conséquences néfastes: 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 20.

**12.1.3** 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.

**12.1.4** Les **dispositifs de commande** munis de **câbles souples amovibles** sont équipés d'un socle de connecteur et d'un câble souple appropriés; les **dispositifs de commande** munis de **câbles souples fixés à demeure** ayant des **fixations du type X** sont équipés des conducteurs appropriés de la plus petite section spécifiée en 10.1.4. Les **dispositifs de commande** munis de **câbles souples fixés à demeure** ayant des **fixations du type M**, du **type Y** ou du **type Z** sont soumis à essai avec les câbles déclarés dans les instructions du fabricant ou livrés avec les échantillons.

**12.1.5** Les **parties amovibles** sont enlevées et soumises, s'il y a lieu, en même temps que la partie principale, aux essais correspondants.

**12.1.6** Les bagues d'étanchéité des presse-étoupe 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  $(70 \pm 2) ^\circ\text{C}$ .

NOTE Aux États-Unis, il existe des exigences supplémentaires relatives aux joints, presse-étoupe et pâtes d'étanchéité utilisés pour éviter l'entrée néfaste d'eau et aux produits adhésifs utilisés pour la fixation desdits joints à une enveloppe ou **couvercle** sur des **dispositifs** destinés à être installés dans des endroits où ils sont exposés à la pluie, et fonctionnant à ou en dessous de  $60 ^\circ\text{C}$ .

**12.1.6.1** Vacant

**12.1.6.2** Immédiatement après le traitement de vieillissement, les pièces 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-étoupe et les autres moyens d'assurer l'étanchéité sont alors serrés avec un couple égal aux deux tiers de celui donné dans le Tableau 20.

## 12.2 Protection contre les conditions d'humidité

**12.2.1** Tous les **dispositifs de commande** doivent résister aux conditions d'humidité susceptibles de se produire en **usage normal**.

Voir aussi l'Annexe J.

**12.2.2** La conformité est vérifiée par la séquence d'essais décrite en 12.2.3 après l'épreuve hygroscopique décrite de 12.2.5 à 12.2.9 inclus.

**12.2.3** 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 13.2 est effectué immédiatement après l'épreuve hygroscopique. Pour les **dispositifs de commande incorporés** et intégrés, l'essai de 13.2 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.

**12.2.4** Le **dispositif de commande** ne doit présenter aucun dommage qui compromettrait la conformité à la présente norme.

**12.2.5** Les entrées de conducteurs, s'il en existe, et les trous d'écoulement sont laissés ouverts. Si un **dispositif** classé IPX7 comporte un trou d'écoulement, ce dernier est ouvert.

**12.2.6** Les **parties amovibles** sont enlevées et soumises, s'il y a lieu, en même temps que la partie principale à l'épreuve hygroscopique.

**12.2.7** Avant d'être placé dans l'enceinte humide, l'échantillon est porté à une température comprise entre  $t$  et  $(t + 4)^\circ\text{C}$ . 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**.

**12.2.8** 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, à 1 K près, à une valeur appropriée ( $t$ ) comprise entre 20 °C et 30 °C.

**12.2.9** Après ce traitement, les essais de l'Article 13 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 éventuelles.

NOTE 1 Pour porter l'échantillon à la température spécifiée, on peut, dans la plupart des cas, le laisser séjourner à cette température pendant 4 h au moins avant l'épreuve hygroscopique.

NOTE 2 Une humidité relative comprise entre 91 % et 95 % peut être obtenue en plaçant dans l'enceinte humide une solution saturée dans l'eau de sulfate de sodium ( $\text{Na}_2\text{SO}_4$ ) ou de nitrate de potassium ( $\text{KNO}_3$ ) cette solution ayant une surface de contact avec l'air suffisamment étendue. Il est important de veiller à ce que l'échantillon en essai ne soit pas soumis à la condensation ou à d'autres agents de contamination de la solution saline ou d'une partie quelconque de l'appareil d'essai.

NOTE 3 Les conditions imposées pour l'enceinte humide exigent un brassage constant de l'air à l'intérieur et, en général, une isolation thermique de l'enceinte.

**12.3** 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 12.3.1 à 12.3.7 inclus avant de subir les autres essais de l'Article 12.

Les **dispositifs de commande de la classe III** ne sont pas soumis aux essais de ces paragraphes.

NOTE Dans les pays membres du CENELEC, 12.3 n'est pas applicable.

**12.3.1** 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.

**12.3.2** Le **courant de fuite** est mesuré entre les parties indiquées en 13.3.1.

**12.3.3** Les circuits de mesure pour les **dispositifs de commande** utilisant différentes sources d'alimentation sont décrits dans les figures mentionnées ci-dessous.

- pour un **dispositif de commande** monophasé de tension assignée ne dépassant pas 250 V, ou pour un **dispositif de commande** triphasé utilisé comme un **dispositif de commande** monophasé, s'il est de la **classe II**, voir Figure 25; s'il est d'une classe autre que la **classe II**, voir Figure 26;
- pour un **dispositif de commande** monophasé de tension assignée dépassant 250 V, ou pour un **dispositif de commande** triphasé inapte à être utilisé comme un **dispositif de commande** monophasé, s'il est de la **classe II**, voir Figure 27; s'il s'agit d'un **dispositif de commande** d'une classe autre que la **classe II**, voir Figure 28;
- pour un **dispositif de commande** diphasé de tension assignée ne dépassant pas 250 V et d'une classe autre que la **classe II**, voir Figure 29 ou 30, selon l'usage.

Les **dispositifs de commande** pour les matériels monophasés de tension assignée supérieure à 250 V doivent être reliés à deux conducteurs de phase, le conducteur de phase restant n'étant pas utilisé.

Un circuit de mesure approprié est présenté à l'Annexe E.

**12.3.4** Pendant les mesures, tous les circuits de **commande** doivent être fermés. Cependant, pour les **dispositifs de commande** soumis à essai conformément aux Figures 26, 29 et 30, les **courants de fuite** doivent être vérifiés avec l'interrupteur S1 en position ouverte et en position fermée.

Il est admis de court-circuiter des points de contact pour simuler des circuits fermés.

**12.3.5** Le circuit de mesure doit avoir une impédance totale de  $(1\,750 \pm 250) \, \Omega$  et doit être shunté par un condensateur tel que la constante de temps du circuit soit de  $(225 \pm 15) \, \mu s$ .

**12.3.6** Le circuit de mesure ne doit pas avoir une erreur de mesure dépassant 5 % pour un courant de fuite indiqué de 0,75 mA et doit avoir une précision de 5 % pour toutes les fréquences de la gamme 20 Hz à 5 kHz.

**12.3.7** Le **courant de fuite** maximal, après stabilisation de la température du **dispositif de commande**, ne doit pas dépasser les valeurs données en 13.3.4.

## 13 Résistance d'isolement et rigidité diélectrique

### 13.1 Résistance d'isolement

La résistance d'isolement des **dispositifs de commande** intercalés dans un câble souple, **séparés** et à **montage indépendant** doit être adéquate.

**13.1.1** La conformité est vérifiée par l'essai de 13.1.2 à 13.1.4 inclus. Cet essai est effectué lorsqu'il est spécifié à l'Article 12.

**13.1.2** Lorsqu'on mesure l'**isolation renforcée** ou l'**isolation supplémentaire** des parties autres que métalliques, chaque surface appropriée de l'isolation est recouverte d'une feuille métallique de manière à fournir une électrode pour l'essai.

**13.1.3** On mesure la résistance d'isolement sous une tension continue de 500 V environ, la mesure étant effectuée après 1 min d'application de la tension.

**13.1.4** La résistance d'isolement ne doit pas être inférieure à celle indiquée dans le Tableau 11.

**Tableau 11 (13.1 de l'édition 3) – Résistance d'isolement minimum**

| Isolation à soumettre à essai | Résistance d'isolement<br>MΩ |
|-------------------------------|------------------------------|
| Isolation fonctionnelle       | –                            |
| Isolation principale          | 2                            |
| Isolation supplémentaire      | 5                            |
| Isolation renforcée           | 7                            |

### 13.2 Rigidité diélectrique

La rigidité diélectrique de tous les **dispositifs de commande** doit être adéquate.

**13.2.1** La conformité est vérifiée par l'essai suivant de 13.2.2 à 13.2.4 inclus, à l'aide des tensions d'essai d'isolation ou de déconnexion du Tableau 12. Cet essai est effectué lorsqu'il est spécifié à l'Article 12 et à l'Article 17.

**Tableau 12 (13.2 de l'édition 3) – Tensions d'essai d'isolation ou de déconnexion <sup>a</sup> (1 sur 2)**

| Isolation ou déconnexion à soumettre à essai <sup>c d e</sup> | Tension d'essai en fonction des tensions de service <sup>b</sup> |                                                          |                                                      |                                                       |                                                       |                                                       |
|---------------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|
|                                                               | Jusqu'à 50 V <sup>f</sup><br>(Classe III)                        | Jusqu'à 50 V <sup>f ou g</sup><br>(Autre que Classe III) | Au-dessus de 50 V, jusqu'à 130 V inclus <sup>g</sup> | Au-dessus de 130 V, jusqu'à 250 V inclus <sup>g</sup> | Au-dessus de 250 V, jusqu'à 440 V inclus <sup>g</sup> | Au-dessus de 440 V, jusqu'à 690 V inclus <sup>g</sup> |
| <b>Isolation fonctionnelle</b> <sup>h</sup>                   | 100                                                              | 100                                                      | 260                                                  | 500                                                   | 880                                                   | 1 380                                                 |
| <b>Isolation principale</b> <sup>i j</sup>                    | 500                                                              | 1 250                                                    | 1 330                                                | 1 450                                                 | 1 640                                                 | 1 890                                                 |
| <b>Isolation supplémentaires</b> <sup>i j k l</sup>           | -                                                                | 1 250                                                    | 1 330                                                | 1 450                                                 | 1 640                                                 | 1 890                                                 |
| <b>Isolation renforcée</b> <sup>i j k l m</sup>               | -                                                                | 2 500                                                    | 2 660                                                | 2 900                                                 | 3 280                                                 | 3 780                                                 |
| <b>Coupure électronique</b> <sup>n o</sup>                    | 100                                                              | 100                                                      | 260                                                  | 500                                                   | 880                                                   | 1 380                                                 |
| <b>Microcoupure</b> <sup>p</sup>                              | 100                                                              | 100                                                      | 260                                                  | 500                                                   | 880                                                   | 1 380                                                 |
| <b>Coupure totale</b> <sup>p</sup>                            | 500                                                              | 1 250                                                    | 1 330                                                | 1 450                                                 | 1 640                                                 | 1 890                                                 |
| <b>Micro-interruption</b> <sup>q</sup>                        | -                                                                | -                                                        | -                                                    | -                                                     | -                                                     | -                                                     |

<sup>a</sup> Au Canada et aux États-Unis, d'autres valeurs sont applicables.

<sup>b</sup> 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 déclencher à moins de 100 mA. On doit prendre soin que la valeur efficace de la tension d'essai soit mesurée à  $\pm 3\%$  près. Voir aussi l'Annexe H.

<sup>c</sup> Les composants spéciaux susceptibles d'empêcher l'exécution de cet 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 à soumettre à essai. Les condensateurs doivent être shuntés, sauf pour les essais pour l'**isolation fonctionnelle** où un pôle est déconnecté. Si cette façon de procéder se révèle inapplicable, on considère que les essais des Articles 15 à 17 sont suffisants.

<sup>d</sup> Pour les **dispositifs de commande des classes I et 0I** et pour les **dispositifs de commande** destinés à des appareils de la classe I, il faut prendre soin de maintenir 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.

<sup>e</sup> Il convient de veiller en effectuant les essais à éviter de surcharger les composants des **dispositifs de commande électroniques**.

<sup>f</sup> Pas d'exigences jusqu'à 24 V efficaces en courant alternatif si le circuit est isolé de l'alimentation par une **isolation double** ou **renforcée** (peut être mis à la terre).

<sup>g</sup> S'applique aux **dispositifs de commande** galvaniquement reliés à l'alimentation.

<sup>h</sup> L'**isolation fonctionnelle** des cartes imprimées soumise en **usage normal** à une tension inférieure ou égale à 50 V n'est pas soumise aux essais de cet article.

<sup>i</sup> Voir 13.3.1.

<sup>j</sup> Toute pièce métallique en contact avec une pièce métallique accessible est considérée comme accessible.

<sup>k</sup> 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 essai efficacement sur une surface isolante accessible.

<sup>l</sup> 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.

<sup>m</sup> Pour les **dispositifs de commande** qui comportent une **isolation renforcée** et une **double isolation**, il convient de prendre des précautions particulières pour 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**.

<sup>n</sup> 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.



Tableau 12 (2 sur 2)

|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ° | Voir Article H.28.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| ° | <p>Pour l'essai des <b>coupsures totales</b> et des <b>microcoupures</b>, 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.</p> <p>Dans le cas des <b>dispositifs de commande thermosensibles</b>, il peut être nécessaire de fournir des échantillons 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.</p> |
| ° | <p>Il n'y a pas d'exigence de rigidité diélectrique pour les <b>micro-interruptions</b>, car on considère qu'il leur suffit de satisfaire aux essais des Articles 15 à 17 inclus. De plus, pour un <b>dispositif de commande</b> qui ne présente aucune <b>microcoupure</b> dans une position de son <b>organe de manœuvre</b> et des <b>micro-interruptions</b> dans les autres positions, les positions correspondant aux <b>micro-interruptions</b> ne font l'objet d'aucune exigence de rigidité diélectrique.</p>                                                                                                   |

**13.2.2** *Lorsqu'on mesure l'isolation renforcée ou l'isolation supplémentaire des parties autres que métalliques, chaque surface appropriée de l'isolation est recouverte d'une feuille métallique de manière à fournir une électrode pour l'essai.*

**13.2.3** *L'isolation est soumise à une tension pratiquement sinusoïdale de fréquence 50 Hz ou 60 Hz. La tension dont la valeur est indiquée dans le Tableau 12 est appliquée pendant 1 min à l'isolation ou à la coupure figurant dans ce même tableau.*

**13.2.4** *Au début de l'essai, la tension appliquée ne dépasse pas la moitié de la valeur spécifiée, puis elle est amenée rapidement à la pleine valeur. Il ne doit se produire ni contournement ni avarie. Des décharges lumineuses sans chute de tension sont négligées.*

### **13.3 Essais complémentaires pour dispositifs de commande intercalés dans un câble souple et dispositifs de commande séparés**

Pour les **dispositifs de commande intercalés dans un câble souple** et pour les **dispositifs de commande séparés**, après les essais de 13.1 ou 13.2, selon ce qui convient, l'échantillon qui a été soumis aux essais de 12.3 doit subir les essais de 13.3.1 à 13.3.4 inclus.

Les **dispositifs de commande de la classe III** ne sont pas soumis aux essais de ces paragraphes.

**13.3.1** *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 matière isolante, 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 pourvu d'une broche ou d'un conducteur de terre, le conducteur de terre est à déconnecter à la source d'alimentation.*

**13.3.2** *La tension est égale à*

- *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 250 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**.

**13.3.3** Le **courant de fuite** est mesuré dans les 5 s qui suivent l'application de la tension d'essai.

**13.3.4** Le **courant de fuite** maximal vers les parties métalliques accessibles et la feuille métallique ne doit pas dépasser les valeurs suivantes:

- pour les **dispositifs de commande des classes 0, 0I** 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.

NOTE Au Canada et aux États-Unis, les valeurs pour les **dispositifs de commande** alimentés en 250 V ou moins sont les suivantes:

- pour les **dispositifs de commande des classes 0, 0I et I** 0,5 mA;
- pour les **dispositifs de commande de classe II** 0,25 mA.

## 14 Échauffements

**14.1** Les **dispositifs de commande** et leurs supports ne doivent pas atteindre des températures excessives en **usage normal**.

**14.1.1** La conformité est vérifiée par l'essai de 14.2 à 14.7 inclus.

**14.1.2** Pendant cet essai, les températures ne doivent pas dépasser les valeurs spécifiées dans le Tableau 13 et les **dispositifs de commande** ne doivent subir aucune modification telle que la conformité à la présente norme et en particulier aux Articles 8, 13 et 20 soit compromise.

**14.2** Les bornes et les **connexions** destinées au raccordement des **conducteurs externes** autres que ceux des **câbles 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 10.1.4.

**14.2.1** 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.

**14.2.2** Si une borne est conçue aussi bien pour des câbles souples que pour des conducteurs fixes, le câble souple approprié est utilisé.

**14.2.3** Les bornes non destinées au raccordement des **conducteurs externes** doivent être équipées de conducteurs de la section minimale spécifiée en 10.2.1 ou de conducteurs spéciaux si ceux-ci sont déclarés en 7.2.

**14.3** Les **dispositifs de commande intercalés dans un câble souple** sont montés ou posés sur une surface de contreplaqué peinte en noir mat.

**14.3.1** Les **dispositifs de commande à montage indépendant** sont montés comme en **usage normal**.

**14.4** Les **dispositifs de commande** doivent être reliés à une alimentation ayant la tension la plus défavorable comprise entre  $0,94 V_R$  et  $1,06 V_R$ . Les circuits non sensibles à la tension



peuvent être reliés à une tension inférieure (mais non inférieure de 10 % à  $V_R$  et chargés de façon telle que le courant le plus défavorable compris entre 0,94 et 1,06 fois le courant assigné circule dans le circuit).

NOTE Aux États-Unis, l'essai est effectué aux tensions spécifiées en 17.2.3.1 et 17.2.3.2.

**14.4.1** Les circuits et les contacts qui ne sont pas destinés aux charges externes doivent être spécifiés par le fabricant.

**14.4.2** Les **organes de manœuvre** sont placés dans la position la plus défavorable.

**14.4.3** Les contacts devant être initialement fermés pour les besoins de l'essai sont fermés avec le courant et la tension assignés du circuit.

**14.4.3.1** Pour les **dispositifs de commande thermosensibles**, l'**élément sensible** est chauffé ou refroidi à une température qui diffère de  $(5 \pm 1)$  K de la température de fonctionnement mesurée dans les conditions du présent article, de manière que les contacts associés soient en position fermée.

**14.4.3.2** Pour tous les autres types de **dispositifs 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.

**14.4.3.3** 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 requis.

**14.4.3.4** Pour les autres **dispositifs de commande automatiques**, la séquence ou partie de la **séquence de fonctionnement** la plus difficile doit être choisie.

**14.4.4** Si le **dispositif de commande** commence à fonctionner pendant l'essai, il est réglé de manière que ses contacts restent constamment fermés.

**14.4.4.1** Si un réglage pour refermer les contacts s'avère difficile, l'essai est arrêté. Une nouvelle **valeur de fonctionnement** est déterminée pour recommencer l'essai.

**14.5** Les **dispositifs de commande** sont soumis à essai dans une enceinte de chauffage et/ou de réfrigération permettant d'obtenir les conditions ambiantes de 14.5.1 et 14.5.2.

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.

**14.5.1** La température de la **tête de commande** est maintenue entre  $T_{\max}$  et soit  $(T_{\max} + 5)$  °C, soit 1,05 fois  $T_{\max}$ , suivant la valeur la plus élevée. La température des surfaces de montage est 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 si  $T_{s \max}$  diffère de  $T_{\max}$ .

**14.5.2** 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** 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.

**14.6** Les températures spécifiées pour la **tête de commande**, les surfaces de montage et l'**élément sensible** doivent être atteintes en 1 h environ.

**14.6.1** Les conditions électriques et thermiques sont maintenues pendant 4 h ou 1 h après l'obtention d'un état de régime suivant la période la plus courte.

**14.6.2** 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 34 doivent être incluses dans la période de 4 h.

**14.7** 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**.

**14.7.1** La température des parties et des surfaces indiquées dans le Tableau 13 doit être déterminée à l'aide de couples thermoélectriques à fil fin ou par des moyens équivalents choisis et disposés de façon à réduire au minimum leur influence sur la température de la partie en essai.

**14.7.2** 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 est 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.

**14.7.3** 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.

**14.7.4** 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 20.

**Tableau 13 (14.1 de l'édition 3) – Températures de chauffage maximum (1 sur 4)**

| Parties                                                                                                                                                           | Température maximale admissible<br>°C |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| Broches des socles de connecteurs et des dispositifs enfichables <sup>a</sup> :                                                                                   |                                       |
| – pour conditions très chaudes                                                                                                                                    | 155                                   |
| – pour conditions chaudes                                                                                                                                         | 120                                   |
| – pour conditions froides                                                                                                                                         | 65                                    |
| Enroulements <sup>b c d e</sup> 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 <b>connexions</b> pour <b>conducteurs externes</b> <sup>a f g</sup>                                                                                     | 85                                    |
| Autres bornes et <b>connexions</b> <sup>a h</sup>                                                                                                                 | 85                                    |
| Enveloppe isolante en caoutchouc ou en polychlorure de vinyle des conducteurs: <sup>a</sup>                                                                       |                                       |
| – 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 <b>isolation supplémentaire</b> <sup>i</sup>                                                                                        | 60                                    |
| Caoutchouc autre que synthétique employé pour les bagues d'étanchéité ou autres parties dont la détérioration pourrait réduire la conformité à la présente norme: |                                       |
| – lorsqu'il est utilisé comme <b>isolation supplémentaire</b> ou comme <b>isolation renforcée</b>                                                                 | 65                                    |
| – dans les autres cas                                                                                                                                             | 75                                    |
| Matières utilisées pour l'isolation autres que celles utilisées pour les fils <sup>i j k</sup> :                                                                  |                                       |
| – 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]                              |
| – Matières moulées <sup>j</sup>                                                                                                                                   |                                       |
| 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 <b>isolation supplémentaire</b> ou comme <b>isolation renforcée</b> | 425                                   |
| autres matières thermodurcissables et toutes les matières thermoplastiques <sup>l</sup>                                                                           | –                                     |
| Toutes <b>surfaces accessibles</b> à l'exception de celles des <b>organes de manœuvre</b> , des poignées, des boutons, des manettes et des organes analogues      | 85                                    |

**Tableau 13 (2 sur 4)**

| Parties                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Température maximale admissible °C |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|
| <b>Surfaces accessibles</b> des poignées, des boutons, des manettes et des organes analogues utilisés pour le transport du <b>dispositif</b> :                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                    |
| – en métal                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 55                                 |
| – en porcelaine ou matière vitrifiée                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 65                                 |
| – en matière moulée caoutchouc ou bois                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 75                                 |
| <b>Surfaces accessibles</b> des <b>organes de manœuvre</b> 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                                 |
| Bois en général                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 90                                 |
| Surfaces en contreplaqué peintes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 85                                 |
| Pièces en cuivre ou en laiton destinées à conduire le courant <sup>a m n</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 230                                |
| Pièces en acier conduisant le courant <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 400                                |
| Autres pièces conduisant le courant <sup>a m</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | –                                  |
| <p><sup>a</sup> Pour ces parties, les essais de 14.7 est répété après les essais de l'Article 17.</p> <p><sup>b</sup> La classification est conforme à la CEI 60085.</p> <p>Comme exemples de matières de la classe A, on peut citer: le coton, la soie naturelle, la soie artificielle et le papier imprégnés, les émaux oléo-résineux, ou à base de résines polyamide.</p> <p>Comme exemples de matières de la classe B, on peut citer: la fibre de verre, les résines mélamine-formaldéhyde et phénol-formaldéhyde.</p> <p>Comme exemples de matières de la classe E, on peut citer:</p> <ul style="list-style-type: none"> <li>– les résines moulées à charge cellulosique, les stratifiés coton et les stratifiés papier agglomérés avec des résines mélamine-formaldéhyde, phénol-formaldéhyde ou phénol-furfural;</li> <li>– les résines polyester à chaînes transversales, les films de triacétate de cellulose, les films de téréphtalate de polyéthylène;</li> <li>– les toiles vernies à base de téréphtalate de polyéthylène agglomérées avec des vernis à base de résines alkydes modifiés à l'huile;</li> <li>– les émaux à base de résines formol-polyvinyle, polyuréthane ou époxyde.</li> </ul> <p>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.</p> <p>Pour les moteurs fermés utilisant des matières 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).</p> <p><sup>c</sup> 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.</p> |                                    |

**Tableau 13 (3 sur 4)**

- <sup>d</sup> 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

$\Delta t$  est l'échauffement;

$R_1$  est la résistance au début de l'essai;

$R_2$  est la résistance à la fin de l'essai;

$t_1$  est la température ambiante de service au début de l'essai, à régler sur  $T_{\max}$ ;

$t_2$  est la température ambiante de service à la fin de l'essai;

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 14 est obtenue en ajoutant l'échauffement à  $T_{\max}$ .

- <sup>e</sup> 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 |

- <sup>f</sup> 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 de tels appareils ne sont généralement pas livrés avec des **conducteurs externes**. Pour les matériels munis de bornes autres que celles pour conducteurs fixes, on relève la température de l'isolation des **conducteurs externes** au lieu de la température des bornes.

Aux États-Unis, la température maximale autorisée est de 75 °C. Des températures supérieures sont autorisées si le **dispositif de commande** porte la marque T obligatoire représentant la caractéristique assignée des **conducteurs externes**.

- <sup>g</sup> 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 matériels 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 21.

Si un **dispositif de commande** est incorporé/intégré dans un appareil, les bornes des **conducteurs externes** seront, 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 cette norme.

- <sup>h</sup> La température mesurée ne doit pas dépasser 85 °C, à moins qu'une valeur plus élevée n'ait été déclarée par le fabricant.

- <sup>i</sup> Les valeurs de température indiquées qui dépendent des matières utilisées peuvent être dépassées s'il est reconnu par l'expérience que les matières utilisées présentent des propriétés particulières de résistance à la chaleur.

**Tableau 13 (4 sur 4)**

|   |                                                                                                                                                                                                                                                                          |
|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| j | Les valeurs entre crochets s'appliquent aux parties d'un matériau utilisées pour des <b>organes de manœuvre</b> , 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 matière isolante, on suppose que la température de la matière isolante au point de contact est 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 de bas de tableau m. |

## 15 Tolérances de fabrication et dérive

**15.1** 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.

NOTE Au Canada et aux États-Unis, les **tolérances de fabrication** et la **dérive** sont exprimées sous forme de tolérances séparées applicables à la **valeur de fonctionnement** déclarée. Pour certains **dispositifs de commande à action de type 2**, les **valeurs de tolérances de fabrication** et de **dérive** admissibles sont précisées. La cohérence est ensuite déterminée, à l'aide de l'appareil spécifié, par mesure de la **valeur de fonctionnement** de l'échantillon et comparaison à la **valeur de fonctionnement** déclarée.

**15.2** La conformité est vérifiée par les essais appropriés de cet article.

**15.3** Pour les **dispositifs de commande** dont le fonctionnement normal se traduit par leur destruction complète ou partielle, les essais des paragraphes appropriés de l'Article 17 sont considérés comme suffisants.

**15.4** Pour les **dispositifs de commande** dont le **fonctionnement** dépend de la méthode de montage sur un appareil ou de l'incorporation dans un appareil, les **tolérances 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 d'une variation (par exemple,  $\pm 10$  K ou  $+5$  K,  $-10$  K).

**15.5** L'étrécissement (ou la cohérence) doit être déterminée de la manière suivante:

**15.5.1** L'appareil d'essai doit être tel que le **dispositif de commande** soit monté de la manière déclarée par le fabricant.

**15.5.2** Pour les **dispositifs de commande sensibles**, l'appareil d'essai doit de préférence être commandé par le **fonctionnement** normal du **dispositif**.

**15.5.3** 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.

**15.5.4** 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 à l'exigence 41 du Tableau 1.

Cependant, le **fonctionnement** du **dispositif de commande** doit être provoqué par un dispositif convenable avec un courant lu ne dépassant pas 0,05 A.

**15.5.5** Pour les **dispositifs de commande sensibles**, la vitesse de variation de la **grandeur de manœuvre** doit être quelconque, à moins qu'une valeur particulière n'ait été déclarée à l'exigence 37 du Tableau 1.

**15.5.6** Les **valeurs de fonctionnement**, le **temps de fonctionnement** ou la **séquence de fonctionnement** approprié doivent être relevés pour chaque échantillon. Entre deux échantillons quelconques, la différence de valeur relevée ne doit en aucun cas dépasser la **tolérance de fabrication** déclarée.

**15.5.7** 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 16 et les essais d'endurance de l'Article 17 pour permettre de déterminer la **dérive**.

**15.6** 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 de la manière suivante:

**15.6.1** Les **tolérances 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 les **tolérances de fabrication** et la **dérive** peut être effectuée.

**15.6.2** 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.

**15.6.3** L'appareil d'essai doit simuler les conditions d'**usage normal** les plus sévères déclarées.

**15.6.4** Si une valeur de la **dérive** a été déclarée séparément au Tableau 1, exigence 42, 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 16 et les essais d'endurance de l'Article 17, pour permettre de déterminer la **dérive**.

**15.7** Voir Annexe J.

**15.8** Voir Annexe J.

## **16 Contraintes climatiques**

### **16.1 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.



**16.1.1** La conformité est vérifiée par les essais appropriés de 16.2 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** est soumis à essai avec son **organe** ou sa **liaison de manœuvre** dans la position la plus défavorable.

## 16.2 Contrainte climatique de température

**16.2.1** L'effet de la température est vérifié de la manière suivante:

- Le **dispositif** complet doit être maintenu à une température de  $(-10 \pm 2) ^\circ\text{C}$  pendant une période de 24 h.
- Le **dispositif** complet doit être ensuite maintenu à une température de  $(60 \pm 5) ^\circ\text{C}$  pendant une période de 4 h.

NOTE En Finlande, en Norvège et en Suède, des valeurs différentes de température et de temps peuvent être exigées.

**16.2.2** Pendant ces deux périodes, le **dispositif** n'est pas mis sous tension.

**16.2.3** Après chaque essai, un **dispositif** 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**. 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.

**16.2.4** De plus, pour les **dispositifs de commande à action de type 2**, l'essai approprié de l'Article 15 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 15 ne doit pas dépasser la **dérive** déclarée à l'exigence 42 du Tableau 1.

## 17 Endurance

### 17.1 Exigences générales

**17.1.1** 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**.

**17.1.2** Les **dispositifs de commande à action de type 2** doivent fonctionner de façon que toute **valeur**, tout **temps** ou **séquence de fonctionnement** ne varient pas d'une quantité supérieure à la **dérive** déclarée.

**17.1.2.1** La conformité à 17.1.1 et 17.1.2 est vérifiée par les essais de 17.1.3, comme indiqué en 17.16.

### 17.1.3 Séquence et conditions d'essais

**17.1.3.1** En général, la séquence d'essais est la suivante:

- un essai de vieillissement selon 17.6 (cet essai ne s'applique qu'aux actions de type 1.M ou 2.M);
- un essai de surtension pour **action automatique** accélérée selon 17.7 (Aux États-Unis, au Canada et dans tous les pays qui utilisent un essai de surcharge, cet essai est remplacé par un essai de surcharge.);



- un essai de fonctionnement pour **action automatique** accélérée selon 17.8;
- un essai de fonctionnement pour **action automatique** à faible vitesse selon 17.9 (cet essai n'est applicable qu'aux **actions automatiques à fermeture, ouverture lentes**);
- un essai de surtension pour **action manuelle** à vitesse accélérée selon 17.10. (Aux États-Unis, au Canada et dans tous les pays qui utilisent un essai de surcharge, cet essai est remplacé par un essai de surcharge.);
- un essai de fonctionnement pour **action manuelle** à faible vitesse selon 17.11;
- un essai de fonctionnement pour **action manuelle** à vitesse élevée selon 17.12 (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 17.13.

**17.1.3.2** Pendant l'essai, les conditions électriques, thermiques et mécaniques doivent être, en général, celles spécifiées en 17.2, 17.3 et 17.4. Les exigences générales d'essai sont données de 17.6 à 17.14 inclus. Les exigences particulières d'essai sont données dans la partie 2 correspondante.

**17.1.3.3** 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, 17.10 à 17.13 inclus sont applicables à de telles **actions manuelles**.

**17.1.3.4** Après tous les essais spécifiés, les échantillons doivent satisfaire aux exigences de 17.14, sauf spécification contraire dans la partie 2 appropriée.

**17.1.4** Voir Annexe H.

## **17.2 Conditions électriques pour les essais**

**17.2.1** 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 nécessiter 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.

**17.2.2** Dans tous les pays qui utilisent un essai de surtension, les charges électriques sont spécifiées au Tableau 14 à la tension assignée  $V_R$ , cette tension étant augmentée à  $1,15 V_R$ , pour l'essai de surtension de 17.7 et 17.10. L'essai de surtension n'est pas utilisé au Canada et aux États-Unis.

**17.2.3** Au Canada, aux États-Unis et dans tous les pays qui utilisent un essai de surcharge, les conditions spécifiées au Tableau 15 et au Tableau 16 s'appliquent. Les essais de surcharge sont effectués sur un seul pôle ou débattement, les autres pôles ou débatttements étant à la charge normale.

**17.2.3.1** Au Canada, aux États-Unis et dans tous les pays qui utilisent un essai de surcharge, les tensions d'essai ( $V_T$ ) sont:

- 120 V pour les **dispositifs de commande** ayant une tension assignée comprise entre 110 V et 120 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.

**17.2.3.2** 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.

**17.2.4** 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.

**17.2.5** 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 14 (17.2.1 de l'édition 3) – Conditions électriques pour l'essai de surtension**

(ce tableau s'applique à tous les pays à l'exception du Canada et des États-Unis)

| Type de circuit<br>selon classification<br>de 6.2       | Opération                           | Circuit alternatif |                                                                      |                                                     | Circuit continu |                                                                      |                                  |
|---------------------------------------------------------|-------------------------------------|--------------------|----------------------------------------------------------------------|-----------------------------------------------------|-----------------|----------------------------------------------------------------------|----------------------------------|
|                                                         |                                     | V                  | A                                                                    | Facteur de puissance<br>( $\pm 0,05$ ) <sup>a</sup> | V               | A                                                                    | Constante de temps ( $\pm 1$ ms) |
| Charge pratiquement<br>résistive (classée en<br>6.2.1)  | Fermeture et<br>ouverture           | $I_R$              | $I_R$                                                                | 0,95                                                | $I_R$           | $I_R$                                                                | Non inductive                    |
| Charge résistive ou<br>inductive (classée en<br>6.2.2)  | Fermeture <sup>b</sup>              | $I_R$              | $6,0 I_X$<br>ou $I_R$<br>selon la plus grande<br>valeur arithmétique | 0,6<br>0,95                                         | $I_R$           | $2,5 I_X$<br>ou $I_R$<br>selon la plus grande valeur<br>arithmétique | 7,5                              |
|                                                         | Ouverture                           | $I_R$              | $I_X$<br>ou $I_R$<br>selon la plus grande<br>valeur arithmétique     | 0,95                                                | $I_R$           | $I_X$<br>ou $I_R$<br>selon la plus grande valeur<br>arithmétique     | Non inductive                    |
| Charge spécifique<br>déclarée (classée en<br>6.2.3)     | Fermeture et<br>ouverture           | $I_R$              | Selon charge                                                         |                                                     | $I_R$           | Selon charge                                                         |                                  |
| Charge 20 mA<br>(classée en 6.2.4)                      | Fermeture et<br>ouverture           | $I_R$              | 20 mA                                                                | 0,95                                                | $I_R$           | 20 mA                                                                | Non inductive                    |
| Charge par moteur<br>déclarée (classée en<br>6.2.5)     | Fermeture et<br>ouverture           | $I_R$              | Selon déclaration                                                    |                                                     | $I_R$           | Selon déclaration                                                    |                                  |
| Charge par <b>mode<br/>pilote</b> (classée en<br>6.2.6) | Fermeture <sup>b</sup><br>Ouverture | $I_R$<br>$I_R$     | $10 VA / I_R$<br>$VA / I_R$                                          | 0,35<br>0,95                                        |                 | <sup>c</sup>                                                         |                                  |

<sup>a</sup> 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.

<sup>b</sup> 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.

<sup>c</sup> Ces valeurs ne sont pas applicables.

**Tableau 15 (17.2.2 de l'édition 3) – Conditions électriques pour les essais de surcharge de 17.7 et 17.10**  
(Ce tableau s'applique au Canada, aux États-Unis et à tous les pays qui utilisent un essai de surcharge)

| Type de circuit                                  | Opération              | Circuit alternatif |                                     | Circuit continu   |                              |
|--------------------------------------------------|------------------------|--------------------|-------------------------------------|-------------------|------------------------------|
|                                                  |                        | V                  | A                                   | V                 | A                            |
| Charge pratiquement résistive (classée en 6.2.1) | Fermeture et ouverture | $I_T$              | $1,5I_R$                            | $I_T$             | $1,5I_R$                     |
| Inductive (autre que par moteur)                 | Fermeture et ouverture | $I_T$              | $1,5I_X$                            | $I_T$             | $1,5I_X$                     |
| Charge par moteur déclarée (classée en 6.2.5)    | Fermeture et ouverture | $I_T$              | $6I_m$ ou selon déclaration         | $I_T$             | $10I_m$ ou selon déclaration |
| Charge par <b>mode pilote</b> (classée en 6.2.6) | Fermeture              | $1,1 I_T$          | $11 VA / I_T$                       | Selon déclaration |                              |
|                                                  | Ouverture              | $1,1 I_T$          | $1,1 VA / I_T$ ou selon déclaration |                   |                              |

Les abréviations suivantes ont été utilisées:

$I_R$  est la tension assignée,  $I_T$  est la tension d'essai (voir 17.2.3.1). Un circuit dans lequel la tension en circuit fermé est 100 % à 110 % de  $I_T$  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, on a fait établir et couper par le **dispositif**, pendant 50 cycles à une cadence de 6 cycles par minute, 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, et
- 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 auxquels on ne demande jamais d'ouvrir le circuit dans de telles conditions, ce qui suit s'applique:

- au Tableau 15:
  - a) 100 %  $I_T$  en alternatif et 0,5  $I_T$  en courant continu pour 1,5 fois le courant assigné
  - b) 100 %  $I_T$  pour le courant de rotor bloqué (fermeture seulement)
- au Tableau 16:
  - 100 %  $I_T$  en alternatif et 0,5  $I_T$  en courant continu.

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 17.7 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.

**Tableau 16 (17.2.3 de l'édition 3) – Conditions électriques pour les essais de surcharge de 17.8, 17.9, 17.11, 17.12 et 17.13**  
(Ce tableau s'applique au Canada, aux États-Unis et à tous les pays qui utilisent un essai de surcharge)

| Type de circuit                                     | Opération              | Circuit alternatif |                                |                                  | Circuit continu   |       |
|-----------------------------------------------------|------------------------|--------------------|--------------------------------|----------------------------------|-------------------|-------|
|                                                     |                        | V                  | A                              | Facteur de puissance             | V                 | A     |
| Charge pratiquement résistive<br>(classée en 6.2.1) | Fermeture et ouverture | $V_T$              | $I_R$                          | 1                                | $V_T$             | $I_R$ |
| Inductive<br>(autre que par moteur)                 | Fermeture et ouverture | $V_T$              | $I_X$                          | 0,75-0,8                         | $V_T$             | $I_X$ |
| Charge par moteur déclarée<br>(classée en 6.2.5)    | Fermeture et ouverture | $V_T$              | $I_m$<br>ou selon charge       | 0,75-0,8<br>ou selon déclaration | $V_T$             | $I_m$ |
| Charge par <b>mode pilote</b><br>(classée en 6.2.6) | Fermeture              | 1,1 $V_T$          | 10 VA/ $V_T$                   | 0,35 maximum                     | Selon déclaration |       |
|                                                     | Ouverture              | 1,1 $V_T$          | VA/ $V_T$ ou selon déclaration | ou selon déclaration             |                   |       |

Les abréviations suivantes ont été utilisées:

$V_R$  est la tension assignée,  $V_T$  est la tension d'essai (voir 17.2.3.1).

$I_m$  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.

NOTE 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, on a fait établir et couper par le **dispositif**, pendant 50 cycles à une cadence de 6 cycles par minute, 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, et
- 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.

### 17.3 Conditions thermiques pour les essais

**17.3.1** Les exigences suivantes sont 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 4.1);
- la surface de montage du dispositif de commande doit être maintenue entre  $T_{s\ max}$ , et soit  $(T_{s\ max} + 5) ^\circ\text{C}$ , 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  $(T_{\max} + 5) ^\circ\text{C}$ , soit 1,05 fois  $T_{\max}$ , suivant la valeur la plus élevée. Si  $T_{\min}$  est inférieure à  $0 ^\circ\text{C}$ , des essais complémentaires doivent être effectués avec la **tête de commande** maintenue entre  $T_{\min}$  et  $(T_{\min} - 5) ^\circ\text{C}$ .

**17.3.2** Pour les essais de 17.8 et 17.13, les températures de 17.3.1 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 seront nécessaires si les essais doivent être effectués aux deux températures ( $T_{\max}$  et  $T_{\min}$ ).

### 17.4 Conditions manuelles et mécaniques des essais

**17.4.1** 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.

**17.4.2** L'**organe de manœuvre** doit être déplacé aux vitesses suivantes:

- pour l'essai à faible vitesse:
  - $(9 \pm 1) ^\circ$  par s pour les mouvements rotatifs;
  - $(5 \pm 0,5)$  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 muni d'un **organe de manœuvre**, l'autorité responsable des essais doit l'équiper d'un **organe de manœuvre** convenable;*
- pour l'essai à vitesse accélérée:
  - $(45 \pm 5) ^\circ$  par s pour les mouvements rotatifs;
  - $(25 \pm 2,5)$  mm/s pour les mouvements linéaires.

**17.4.3** Pendant l'essai à faible vitesse de 17.4.2:

il faut prendre soin que l'appareil d'essai actionne l'**organe de manœuvre**, sans jeu excessif entre l'appareil d'essai et l'**organe de manœuvre**.

**17.4.4** Pendant l'essai à vitesse accélérée de 17.4.2:

- il faut prendre soin que l'appareil d'essai détermine le libre déplacement de l'**organe de manœuvre** de façon à ne pas entraver le fonctionnement normal du mécanisme;
- 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) doit être appliqué(e) 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 appliqué(e) doit être égal(e) au couple ou à la force normal(e) de commande;*
- *pour les **dispositifs de commande** rotatifs 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.*

**17.4.5** *Le dispositif de commande ne doit pas faire l'objet d'une lubrification supplémentaire au cours de ces essais.*

## **17.5 Exigences concernant la rigidité diélectrique**

**17.5.1** *Après tous les essais du présent article, les exigences de 13.2 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 13.2.*

NOTE Au Canada et aux États-Unis, la tension d'essai doit être de la valeur spécifiée en 13.2.

## **17.6 Essai de vieillissement**

**17.6.1** *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 14. Les autres parties du dispositif de commande doivent être maintenues aux températures indiquées en 17.3. Le **dispositif de commande** est chargé électriquement comme décrit en 17.2 pour les conditions de coupure applicables. La durée de l'essai est de  $(100 + 0,02 y)$  h, y étant la valeur déclarée en 7.2. Cet essai s'applique aux **dispositifs de commande** aux actions de type 1.M ou 2.M.*

**17.6.2** *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 l'action 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 7.2 soient dépassées, lors de la répétition de la procédure applicable de l'Article 15. La valeur de «x» est donnée dans la partie 2 correspondante.*

## **17.7 Essai de surtension (ou essai de surcharge au Canada, aux États-Unis et dans tous les pays qui utilisent un essai de surcharge) pour action automatique accélérée**

**17.7.1** *Les conditions électriques doivent être celles spécifiées en 17.2 pour une surtension (ou pour les conditions de surcharge).*

**17.7.2** *Les conditions thermiques doivent être celles spécifiées en 17.3.*

### 17.7.3 Méthode opératoire et vitesse de **fonctionnement**:

- pour les **actions de type 1**, la vitesse de **fonctionnement** et la méthode opératoire doivent faire l'objet d'un accord entre l'autorité responsable des essais et le fabricant;
- 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, ou soit les taux de changement de quantité d'activation ne dépassent pas  $\alpha_2$  et  $\beta_2$  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** de type 2 sont soumis aux essais avec la valeur d'ouverture la plus défavorable déclarée au Tableau 1, exigence 48.

NOTE 2 Pour les **dispositifs de commande** fonctionnant à la température et à la pression, il s'agit normalement de la valeur maximale.

17.7.4 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 7.2.

17.7.5 Pour une action basée sur la détection d'une **grandeur**, on peut augmenter la pente de variation de la **grandeur de manœuvre**, et pour les autres **actions de type 1**, on peut inhiber le **moteur primaire** entre les cycles de **fonctionnement**, pour autant que cela n'affecte pas sensiblement les résultats de l'essai.

17.7.6 Le nombre de cycles automatiques que comporte le présent essai est un dixième du nombre déclaré en 7.2 ou 200 suivant la valeur la plus faible.

17.7.7 Pendant l'essai, les **organes de manœuvre** sont placés dans leur position la plus défavorable.

NOTE Au Canada et aux États-Unis, le nombre de cycles est limité à 50.

### 17.8 Essai d'action automatique accélérée

17.8.1 Les conditions électriques doivent être celles spécifiées en 17.2.

17.8.2 Les conditions thermiques doivent être celles spécifiées en 17.3.

17.8.3 La méthode opératoire et la vitesse de **fonctionnement** doivent être celles utilisées au cours de l'essai de 17.7.3.

17.8.4 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 7.2 diminué du nombre de cycles effectivement exécutés au cours de l'essai de 17.7. 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 en 7.2 puisse être accompli.



**17.8.4.1** Pour les **actions automatiques à fermeture et ouvertures lentes**, le nombre de cycles automatiques spécifiés en 17.8.4 et effectués au cours du présent essai est limité à 75 %. Les 25 % restants correspondent à l'essai de 17.9.

NOTE Au Canada et aux États-Unis, le nombre de cycles pour les **actions de type 2** et certaines **actions de type 1** est spécifié.

## **17.9 Essai d'action automatique lente**

**17.9.1** 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 17.8.

**17.9.2** Les conditions électriques et thermiques doivent être celles spécifiées en 17.2 et 17.3.

**17.9.3** La méthode opératoire 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 pentes de variation de la **grandeur de manœuvre** doivent être les valeurs  $\alpha_1$  et  $\beta_1$  déclarées en 7.2. Pour un **dispositif de commande sensible**, il est admis de changer la pente 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 7.2. 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**.

**17.9.3.1** Cette surveillance est également recommandée pour les autres types de **dispositif de commande** de façon à déterminer la cohérence des essais.

**17.9.4** Si seulement la fermeture, ou l'ouverture, est une **action automatique lente**, il est admis, par suite d'accord intervenu entre l'autorité responsable des essais et le fabricant, d'accélérer le reste de l'action à laquelle les dispositions de 17.8 sont applicables.

## **17.10 Essai de surtension (ou essai de surcharge au Canada, aux États-Unis et dans tous les pays qui utilisent l'essai de surcharge) pour action manuelle accélérée**

**17.10.1** Les conditions électriques doivent être celles spécifiées en 17.2 pour une surtension (ou pour les conditions de surcharge).

**17.10.2** Les conditions thermiques doivent être celles spécifiées en 17.3.

**17.10.3** La méthode opératoire doit être celle spécifiée en 17.4 pour l'essai à vitesse accélérée. Le nombre de cycles de **manœuvre** doit être un dixième du nombre déclaré en 7.2 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.

**17.10.4** Au Canada et aux États-Unis où l'essai de surcharge est applicable, le nombre de cycles est limité à 50.

## **17.11 Essai d'action manuelle à faible vitesse**

**17.11.1** Les conditions électriques doivent être celles spécifiées en 17.2.

**17.11.2** Les conditions thermiques doivent être celles spécifiées en 17.3.

**17.11.3** La méthode opératoire doit être celle spécifiée en 17.4 pour l'essai à faible vitesse.

**17.11.4** Le nombre de cycles de **manœuvre** doit être un dixième du nombre déclaré en 7.2 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.

## **17.12 Essai d'action manuelle à grande vitesse**

NOTE Cet essai est applicable uniquement pour les actions multipolaires, et lorsqu'une inversion de polarité se produit pendant cette action.

**17.12.1** Les conditions électriques sont spécifiées en 17.2.

**17.12.2** Les conditions thermiques sont celles spécifiées en 17.3.

**17.12.3** La méthode opératoire est celle spécifiée en 17.4 pour l'essai à grande vitesse.

**17.12.4** 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.

**17.12.5** Au Canada et aux États-Unis où l'essai de surcharge est applicable, le nombre de cycles est limité à 50.

## **17.13 Essai d'action manuelle à vitesse accélérée**

**17.13.1** Les conditions électriques sont celles spécifiées en 17.2.

**17.13.2** Les conditions thermiques sont celles spécifiées en 17.3.

**17.13.3** La méthode opératoire est celle spécifiée en 17.4 pour l'essai à vitesse accélérée.

**17.13.4** Le nombre de cycles de **manœuvre** est égal au nombre déclaré en 7.2 diminué du nombre de cycles effectués au cours des essais de 17.10, 17.11 et 17.12. 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.

**17.13.5** Pendant l'essai, la **défaillance** d'un composant quelconque d'une **action de type 1** autre qu'un **dispositif de commande de protection** qui n'est pas déterminante au regard des exigences de l'essai ne constitue pas 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** spécifié puisse être accompli.

## **17.14 Évaluation de la conformité**

Après l'exécution de tous les essais applicables de 17.6 à 17.13 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 de la présente norme;
- si les exigences de l'Article 14 concernant les points désignés à la Note de bas de tableau a du Tableau 13, c'est-à-dire les bornes, les parties transportant le courant et les surfaces de support, sont encore satisfaites;
- si les exigences des Articles et Paragraphe 8, 17.5 et 20 sont toujours satisfaites. Pour les essais de 17.5 et de l'Article 20, les **dispositifs de commande** pour lesquels des échantillons spéciaux ont été soumis à l'Article 13 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 15, 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 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 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**.

Voir aussi l'Annexe H.

## 17.15 Vacant

## 17.16 Essai pour les dispositifs à usages particuliers

Les essais applicables pour les **dispositifs de commande** à usages particuliers sont spécifiés dans la partie 2 correspondante.

17.17 à 17.18 Voir Annexe J.

## 18 Résistance mécanique

### 18.1 Exigences générales

**18.1.1** Les **dispositifs de commande** doivent être construits de manière à pouvoir supporter les contraintes mécaniques susceptibles de se produire en **usage normal**.

**18.1.2** Les **organes de manœuvre** des **dispositifs de commande des classes I et II** ou des **dispositifs** destinés à des appareils 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**.

**18.1.3** Les **dispositifs de commande intégrés et incorporés** n'ont pas à subir les essais de 18.2 car leur résistance aux chocs sera soumise à essai selon la norme particulière de l'appareil.

**18.1.4** La conformité est vérifiée par les essais applicables de 18.2 à 18.8 inclus effectués séquentiellement sur un échantillon.

**18.1.5** Après les essais appropriés, le **dispositif de commande** ne doit présenter aucun dommage qui compromettrait la conformité à la présente norme et en particulier aux exigences des Articles 8, 13 et 20. On ne doit pas constater de décollement des revêtements, barrières ou autres éléments d'isolation.

Il doit encore être possible d'enlever et de replacer les parties amovibles et autres parties externes, telles que les **capots**, 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 13.

Une détérioration de la peinture, de faibles renforcements qui ne réduisent pas les **lignes de fuite** ou les **distances dans l'air** au-dessous des valeurs spécifiées à l'Article 20 et de

*petites ébréchures qui n'affectent pas la protection contre les chocs électriques ou l'humidité ne sont pas retenus. Des fissures non visibles à l'œil nu et des fissures superficielles dans des matières moulées en fibre renforcée et matières analogues sont négligées. Si une **enveloppe** décorative est doublée par une **enveloppe** intérieure, il n'est pas tenu compte du bris de l'**enveloppe** décorative, si l'**enveloppe** intérieure satisfait à l'essai après l'enlèvement de l'**enveloppe** décorative.*

**18.1.6** Au Canada et aux États-Unis, si les filets pour le branchement d'un conduit métallique sont taraudés sur la totalité d'un trou dans une paroi d'une enveloppe ou si une construction équivalente est utilisée, il ne doit pas y avoir d'arête vive, pas moins de trois ni plus de cinq filets complets dans le métal et la construction du dispositif doit être telle qu'une douille de conduit appropriée puisse être fixée correctement.

**18.1.6.1** Au Canada et aux États-Unis, si les filets pour le branchement d'un conduit métallique ne sont pas taraudés sur la totalité d'un trou dans une paroi d'une enveloppe, le manchon d'un conduit ou élément analogue, il doit y avoir au moins 3,5 filets complets dans le métal; ce taraudage sera doté d'une butée de conduit et aura un trou d'entrée lisse bien arrondi d'un diamètre interne approximativement égal à celui du conduit métallique rigide de taille correspondante qui doit procurer une protection aux conducteurs équivalente à celle procurée par une douille de conduit standard.

**18.1.6.2** Aux États-Unis, une enveloppe filetée pour supporter un conduit métallique rigide doit présenter au moins cinq filets complets pour l'insertion du conduit.

*La conformité à 18.1.6, 18.1.6.1 et 18.1.6.2 est vérifiée par examen.*

**18.1.6.3** Au Canada et aux États-Unis, un manchon de conduit ou manchon fileté fixé à l'enveloppe par sertissage ou par un moyen similaire doit pouvoir résister sans arrachement aux essais suivants:

- traction directe de 890 N pendant 5 min. Pour cet essai, le dispositif est tenu d'être supporté par un conduit rigide de la manière prévue et de supporter un poids suspendu de 90,8 kg;
- le dispositif est tenu d'être supporté de façon rigide par un moyen autre que les raccords de conduit. Une force de flexion de 67,8 Nm est à appliquer pendant 5 min au conduit perpendiculairement à son axe et le bras de levier à mesurer de la paroi de l'enveloppe sur laquelle le manchon est situé au point d'application de la force de flexion;
- un couple de 67,8 Nm est à appliquer au conduit pendant 5 min dans le sens du serrage de la connexion et le bras de levier à mesurer à partir du conduit.

Il peut s'en suivre une déformation de l'enveloppe en essai. Cette déformation ne constitue pas une **défaillance**.

## **18.2 Résistance aux chocs**

**18.2.1** *A l'exception des dispositions de 18.4, les **dispositifs de commande intercalés dans un câble souple, séparés et à montage indépendant** sont vérifiés en appliquant des coups à l'échantillon au moyen de l'appareil prévu dans la CEI 60068-2-75.*

**18.2.2** *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.*

**18.2.3** *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.*

**18.2.4** *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  $(0,5 \pm 0,04)$  Nm.*

**18.2.4.1** *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  $(1,0 \pm 0,05)$  Nm.*

**18.2.5** *Pour toutes les surfaces, trois coups sont appliqués en chaque point qui est susceptible de présenter une faiblesse.*

**18.2.5.1** Il faut veiller à ce que les conséquences de chaque série de trois coups n'aient pas d'influence sur la série suivante.

**18.2.5.2** Si l'on se doute qu'un défaut a été favorisé par l'application des coups précédents, ce défaut est négligé 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.

**18.2.6** Les lampes de signalisation et leurs **capots** 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 cm<sup>2</sup> 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**.

### 18.3 Vacant

### 18.4 Variante de conformité – Résistance aux chocs

NOTE Au Canada et aux États-Unis, les épaisseurs minimales de la feuille de métal ou de l'enveloppe métallique indiquées dans les Tableaux 17 et 18 sont considérées comme satisfaisant aux exigences de 18.2 et les essais spécifiés ne sont pas requis.

**Tableau 17 (18.4.1 de l'édition 3) – Épaisseur minimale de la feuille métallique pour les enveloppes en acier au carbone ou en acier inoxydable**

| Sans cadre de support <sup>a</sup>              |                                                  | Avec cadre de support ou renforcement équivalent <sup>a</sup> |                                                  | Épaisseur minimale en pouces (mm) |                           |
|-------------------------------------------------|--------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------|-----------------------------------|---------------------------|
| Largeur maximale <sup>b</sup><br>en pouces (cm) | Longueur maximale <sup>c</sup><br>en pouces (cm) | Largeur maximale <sup>b</sup><br>en pouces (cm)               | Longueur maximale <sup>c</sup><br>en pouces (cm) | Non recouvert                     | Recouvert de métal        |
| 4,0 (10,2)                                      | Non limitée                                      | 6,25 (15,9)                                                   | Non limitée                                      | 0,020 <sup>d</sup> (0,51)         | 0,023 <sup>d</sup> (0,58) |
| 4,75 (12,1)                                     | 5,75 (14,6)                                      | 6,75 (17,1)                                                   | 8,25 (21,0)                                      |                                   |                           |
| 6,0 (15,2)                                      | Non limitée                                      | 9,5 (24,1)                                                    | Non limitée                                      | 0,026 <sup>d</sup> (0,66)         | 0,029 <sup>d</sup> (0,74) |
| 7,0 (17,8)                                      | 8,75 (22,2)                                      | 10,0 (25,4)                                                   | 12,5 (31,8)                                      |                                   |                           |
| 8,0 (20,3)                                      | Non limitée                                      | 12,0 (30,5)                                                   | Non limitée                                      | 0,032 (0,81)                      | 0,034 (0,86)              |
| 9,0 (22,9)                                      | 11,5 (29,2)                                      | 13,0 (33,0)                                                   | 16,0 (40,6)                                      |                                   |                           |
| 12,5 (31,8)                                     | Non limitée                                      | 19,5 (49,5)                                                   | Non limitée                                      | 0,042 (1,07)                      | 0,045 (1,14)              |
| 14,0 (35,6)                                     | 18,0 (45,7)                                      | 21,0 (53,3)                                                   | 25,0 (63,5)                                      |                                   |                           |
| 18,0 (45,7)                                     | Non limitée                                      | 27,0 (68,6)                                                   | Non limitée                                      | 0,053 (1,35)                      | 0,056 (1,42)              |
| 20,0 (50,8)                                     | 25,0 (63,5)                                      | 29,0 (73,7)                                                   | 36,0 (91,4)                                      |                                   |                           |
| 22,0 (55,9)                                     | Non limitée                                      | 33,0 (83,8)                                                   | Non limitée                                      | 0,060 (1,52)                      | 0,063 (1,60)              |
| 25,0 (63,5)                                     | 31,0 (78,7)                                      | 35,0 (88,9)                                                   | 43,0 (109,2)                                     |                                   |                           |
| 25,0 (63,5)                                     | Non limitée                                      | 39,0 (99,1)                                                   | Non limitée                                      | 0,067 (1,70)                      | 0,070 (1,78)              |
| 29,0 (73,7)                                     | 36,0 (91,4)                                      | 41,0 (104,1)                                                  | 51,0 (129,5)                                     |                                   |                           |
| 33,0 (83,8)                                     | Non limitée                                      | 51,0 (129,5)                                                  | Non limitée                                      | 0,080 (2,03)                      | 0,084 (2,13)              |
| 38,0 (96,5)                                     | 47,0 (119,4)                                     | 54,0 (137,2)                                                  | 66,0 (167,6)                                     |                                   |                           |
| 42,0 (106,7)                                    | Non limitée                                      | 64,0 (162,6)                                                  | Non limitée                                      | 0,093 (2,36)                      | 0,097 (2,46)              |
| 47,0 (119,4)                                    | 59,0 (149,9)                                     | 68,0 (172,7)                                                  | 84,0 (213,4)                                     |                                   |                           |
| 52,0 (132,1)                                    | Non limitée                                      | 80,0 (203,2)                                                  | Non limitée                                      | 0,108 (2,74)                      | 0,111 (2,82)              |
| 60,0 (152,4)                                    | 74,0 (188,0)                                     | 84,0 (213,4)                                                  | 103,0 (261,6)                                    |                                   |                           |
| 63,0 (160,0)                                    | Non limitée                                      | 97,0 (246,4)                                                  | Non limitée                                      | 0,123 (3,12)                      | 0,126 (3,20)              |
| 73,0 (185,4)                                    | 90,0 (228,6)                                     | 103,0 (261,6)                                                 | 127,0 (322,6)                                    |                                   |                           |

<sup>a</sup> En référence aux Tableaux 17 et 18, un cadre support est une structure d'angle ou une goulotte ou une section rigide pliée de feuille métallique, fixée de façon rigide à la surface enveloppe et ayant approximativement les mêmes dimensions extérieures; il a une rigidité en torsion suffisante pour résister aux moments de torsion qui peuvent être appliqués par l'intermédiaire de la surface enveloppe lorsqu'elle est tordue. Une construction considérée comme ayant un renforcement équivalent peut être réalisée par des conceptions offrant une structure aussi rigide qu'une structure construite avec un cadre angulaire ou des goulottes. Les constructions considérées comme ne comportant pas de cadre support sont: a) une feuille simple avec flasques simples préformés ou bords préformés, b) une feuille simple ondulée ou striée, c) une surface enveloppe attachée de façon lâche à un support, par exemple par des clips à ressort.

<sup>b</sup> La largeur est la plus petite dimension d'une feuille de métal rectangulaire qui fait partie de l'enveloppe. Les surfaces adjacentes d'une enveloppe peuvent avoir des supports communs et être faites dans une feuille simple.

<sup>c</sup> «Non limitée» ne s'applique que si le bord de la surface est un flasque d'au moins 0,5 in (12,7 mm) ou est fixé à des surfaces adjacentes qui ne sont pas enlevées en usage normal.

<sup>d</sup> La feuille d'acier pour une enveloppe destinée à un usage à l'extérieur ne doit pas avoir une épaisseur inférieure à 0,034 in (0,86 mm) si elle est recouverte de zinc et inférieure à 0,032 in (0,81 mm) si elle n'est pas recouverte.

**Tableau 18 (18.4.2 de l'édition 3) – Épaisseur minimale de la feuille métallique pour les enveloppes en aluminium, cuivre ou laiton**

| Sans cadre de support <sup>a</sup>              |                                                  | Avec cadre de support ou renforcement équivalent <sup>a</sup> |                                                  |                                      |
|-------------------------------------------------|--------------------------------------------------|---------------------------------------------------------------|--------------------------------------------------|--------------------------------------|
| Largeur maximale <sup>b</sup><br>en pouces (cm) | Longueur maximale <sup>c</sup><br>en pouces (cm) | Largeur maximale <sup>b</sup><br>en pouces (cm)               | Longueur maximale <sup>c</sup><br>en pouces (cm) | Épaisseur maximale<br>en pouces (mm) |
| 3,0 (7,6)                                       | Non limitée                                      | 7,0 (17,8)                                                    | Non limitée                                      | 0,023 <sup>d</sup> (0,58)            |
| 3,5 (8,9)                                       | 4,0 (10,2)                                       | 8,5 (21,6)                                                    | 9,5 (24,1)                                       |                                      |
| 4,0 (10,2)                                      | Non limitée                                      | 10,0 (25,4)                                                   | Non limitée                                      | 0,029 (0,74)                         |
| 5,0 (12,7)                                      | 6,0 (15,2)                                       | 10,5 (26,7)                                                   | 13,5 (34,3)                                      |                                      |
| 6,0 (15,2)                                      | Non limitée                                      | 14,0 (35,6)                                                   | Non limitée                                      | 0,036 (0,91)                         |
| 6,5 (16,5)                                      | 8,0 (20,3)                                       | 15,0 (38,1)                                                   | 18,0 (45,7)                                      |                                      |
| 8,0 (20,3)                                      | Non limitée                                      | 19,0 (48,3)                                                   | Non limitée                                      | 0,045 (1,14)                         |
| 9,5 (24,1)                                      | 11,5 (29,2)                                      | 21,0 (53,3)                                                   | 25,0 (63,5)                                      |                                      |
| 12,0 (30,5)                                     | Non limitée                                      | 28,0 (71,1)                                                   | Non limitée                                      | 0,058 (1,47)                         |
| 14,0 (35,6)                                     | 16,0 (40,6)                                      | 30,0 (76,2)                                                   | 37,0 (94,0)                                      |                                      |
| 18,0 (45,7)                                     | Non limitée                                      | 42,0 (106,7)                                                  | Non limitée                                      | 0,075 (1,91)                         |
| 20,0 (50,8)                                     | 25,0 (63,4)                                      | 45,0 (114,3)                                                  | 55,0 (139,7)                                     |                                      |
| 25,0 (63,5)                                     | Non limitée                                      | 60,0 (152,4)                                                  | Non limitée                                      | 0,095 (2,41)                         |
| 29,0 (73,7)                                     | 36,0 (91,4)                                      | 64,0 (162,6)                                                  | 70,0 (178,1)                                     |                                      |
| 37,0 (94,0)                                     | Non limitée                                      | 87,0 (221,0)                                                  | Non limitée                                      | 0,122 (3,10)                         |
| 42,0 (106,7)                                    | 53,0 (134,6)                                     | 93,0 (236,2)                                                  | 114,0 (289,6)                                    |                                      |
| 52,0 (132,1)                                    | Non limitée                                      | 123,0 (312,4)                                                 | Non limitée                                      | 0,153 (3,89)                         |
| 60,0 (152,4)                                    | 74,0 (188,0)                                     | 130,0 (330,2)                                                 | 160,0 (406,4)                                    |                                      |

<sup>a</sup> En référence aux Tableaux 17 et 18, un cadre support est une structure d'angle ou une goulotte ou une section rigide pliée de feuille métallique, fixée de façon rigide à la surface d'enveloppe et ayant approximativement les mêmes dimensions extérieures; il a une rigidité en torsion suffisante pour résister aux moments de torsion qui peuvent être appliqués par l'intermédiaire de la surface enveloppe lorsqu'elle est tordue. Une construction considérée comme ayant un renforcement équivalent peut être réalisée par des conceptions offrant une structure aussi rigide qu'une structure construite avec un cadre angulaire ou des goulottes. Les constructions considérées comme ne comportant pas de cadre support sont: a) une feuille simple avec flasques simples préformés ou bords préformés, b) une feuille simple ondulée ou striée, c) une surface enveloppe attachée de façon lâche à un support, par exemple par des clips à ressort.

<sup>b</sup> La largeur est la plus petite dimension d'une feuille de métal rectangulaire qui fait partie de l'enveloppe. Les surfaces adjacentes d'une enveloppe peuvent avoir des supports communs et être faites dans une feuille simple.

<sup>c</sup> «Non limitée» ne s'applique que si le bord de la surface est un flasque d'au moins 0,5 in (12,7 mm) ou est fixé à des surfaces adjacentes qui ne sont pas enlevées en usage normal.

<sup>d</sup> Les feuilles d'aluminium, de cuivre ou de laiton pour une enveloppe destinée à un usage à l'extérieur (étanche ou imperméable) ne doivent pas avoir une épaisseur inférieure à 0,029 in (0,74 mm).

**18.4.1** Le métal forgé doit avoir une épaisseur d'au moins 3 mm et d'au plus 6 mm aux endroits destinés aux trous filetés pour les conduits. Toutefois, le métal «moulé» peut avoir une épaisseur d'au moins 1,6 mm sur une surface au plus égale à 150 cm<sup>2</sup> et n'ayant pas de dimension supérieure à 150 mm aux autres endroits que ceux prévus pour les trous filetés pour les conduits, et peut avoir une épaisseur de 2,4 mm au moins pour les surfaces plus larges.

## 18.5 Dispositifs de commande séparés

**18.5.1** Les *dispositifs de commande séparés* doivent en plus être vérifiés par l'essai de 18.5.2 et 18.5.3 à l'aide de l'appareil représenté à la Figure 4.



**18.5.2** Deux mètres de câble souple du type le plus léger spécifié en 10.1.4 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 illustrée à la Figure 4.

L'échantillon doit être posé ou placé sur une surface de verre, comme illustré, et le câble souple doit être soumis à une traction progressive ne dépassant pas la valeur indiquée au Tableau 9. 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.

**18.5.3** Après les essais, l'échantillon doit être évalué comme indiqué en 18.1.5.

## **18.6 Dispositifs de commande intercalés dans un câble souple**

**18.6.1** 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 5. La largeur du tambour ne doit pas être inférieure à 200 mm et doit être suffisante pour permettre la chute libre du **dispositif** équipé des câbles comme spécifié en 18.6.2.

**18.6.2** Les **dispositifs de commande à câbles fixés à demeure** ayant des **fixations de type X** doivent être équipés du ou des câbles souples de la plus petite section spécifiée en 10.1.4, avec une longueur libre d'environ 50 mm. Les bornes sont serrées avec un couple égal aux deux tiers du couple spécifié en 19.1. Les **dispositifs à câbles fixés à demeure** ayant des **fixations du type M**, du **type Y** et du **type Z** doivent être soumis à essai avec le(s) câble(s) souple(s) déclaré(s) ou fourni(s) avec les échantillons, ce(s) câble(s) étant coupé(s) de manière à dépasser d'environ 50 mm du **dispositif**.

**18.6.3** 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.

**18.6.4** 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 18.5.

**18.6.5** La vitesse de rotation du tambour est cinq tours par min, ce qui correspond à 10 chutes par minute.

**18.6.6** Après cet essai, le **dispositif de commande** doit être évalué comme indiqué en 18.1.5. Une attention spéciale est portée aux connexions du (des) câble(s) souple(s)

## **18.7 Dispositifs de commande à cordon de traction**

**18.7.1** Les **dispositifs de commande à cordon de traction** doivent être en plus soumis à essai de la manière décrite en 18.7.2 et 18.7.3.

**18.7.2** Le **dispositif de commande** doit être monté conformément aux déclarations du fabricant et le **cordon** 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.

**18.7.3** Les forces de traction applicables sont données dans le Tableau 19.

**Tableau 19 (18.7 de l'édition 3) – Valeurs d'essai des forces de cordon de traction**

| Courant assigné<br>A | Force<br>N        |                               |
|----------------------|-------------------|-------------------------------|
|                      | Direction normale | Direction la plus défavorable |
| Jusqu'à 4 inclus     | 50                | 25                            |
| Plus de 4            | 100               | 50                            |

**18.7.4** Après cet essai, le **dispositif de commande** doit être évalué comme indiqué en 18.1.5.

## **18.8 Dispositifs de commande au pied**

**18.8.1** Les **dispositifs de commande** au pied doivent en plus être soumis à essai de la manière suivante:

**18.8.2** Le **dispositif** 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.

**18.8.3** 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.

**18.8.4** Après l'essai, le **dispositif de commande** doit être évalué comme indiqué en 18.1.5.

## **18.9 Organe de manœuvre et liaisons de manœuvre**

**18.9.1** 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.
- 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**.



**18.9.2** Pour un **dispositif de commande** destiné à fonctionner avec un **organe de manœuvre**, mais soumis aux essais sans cet organe, ou pour un dispositif 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 matières de remplissage et les matières analogues, autres que les résines durcissant à l'air, ne sont pas considérées comme satisfaisantes pour éviter le desserrage.

**18.9.3** 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 à la présente norme.

## 19 Pièces filetées et connexions

### 19.1 Pièces filetées déplacées lors du montage et des opérations d'entretien

**19.1.1** Les pièces 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 pièces 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.

**19.1.2** Ces pièces doivent être faciles à remonter après qu'elles ont été dévissées complètement.

NOTE Les constructions qui empêchent l'enlèvement complet d'une pièce filetée sont considérées comme remplissant cette exigence.

**19.1.3** Ces pièces filetées doivent avoir un filetage métrique ISO ou un filetage d'efficacité équivalente.

NOTE Provisoirement, les filetages SI, BA et Unifiés sont considérés comme ayant une efficacité équivalente aux filetages métriques ISO. Un essai d'équivalence d'efficacité est à l'étude. En attendant qu'il soit agréé, toutes les valeurs de couple applicables à des filetages autres que ISO (métriques), SI, BA, et Unifiés sont augmentées de 20 %.

**19.1.4** 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.

**19.1.5** Ces vis peuvent être du type à filet gros à condition qu'elles soient pourvues 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.

**19.1.6** Ces pièces 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 13 ou 20.

**19.1.7** Ces vis ne doivent pas être en métal tendre, ou sujet au fluage, tel que le zinc ou l'aluminium.

Cette exigence ne s'applique pas aux pièces utilisées soit comme **capot** 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.

**19.1.8** 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.

**19.1.9** Ces pièces filetées, quand elles sont utilisées dans les **dispositifs de commande intercalés dans un câble souple**, si elles sont destinées à transmettre la pression de contact, et si elles ont 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.

**19.1.10** *La conformité à 19.1.1 à 19.1.9 inclus est vérifiée par examen et par l'essai de 19.1.11 à 19.1.15 inclus.*

**19.1.11** *Les pièces filetées sont serrées et desserrées:*

- *10 fois si l'une des pièces filetées est en matériau non métallique, ou*
- *cinq fois si les deux pièces sont en matériau métallique.*

**19.1.12** *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 10.1.4 ou de la section nominale spécifiée en 10.2.1 est placé dans la borne.*

**19.1.13** *Il convient d'adapter la forme du tournevis à la tête de la vis à soumettre à essai.*

**19.1.14** *Le conducteur est déplacé après chaque desserrage de la pièce filetée. Pendant l'essai, on ne doit constater aucune détérioration qui nuirait à l'emploi ultérieur des pièces filetées, telle que rupture des vis ou dommages aux têtes à fente ou aux rondelles.*

**19.1.15** *L'essai est effectué à l'aide d'un tournevis ou une clef appropriée en appliquant le couple de torsion, sans secousses, indiqué dans le Tableau 20.*

**Tableau 20 (19.1 de l'édition 3) – Valeurs d'essai  
du couple de torsion des pièces filetées**

| Diamètre nominal de filetage<br>mm                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |   | Couple de torsion<br>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 <sup>a</sup> inclus                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |   | 0,8                                                                                                                                                                                                                                                                                                                                                                          | 2,0 | 1,0  |
| Plus de 5,3 <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |   | –                                                                                                                                                                                                                                                                                                                                                                            | 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: <ul style="list-style-type: none"><li>• à tête cylindrique avec un évidement pour <b>outil spécial</b> dont le diamètre du cercle circonscrit dépasse le diamètre extérieur du filetage;</li><li>• à tête à fente simple ou en croix, ayant une longueur dépassant 1,5 fois le diamètre extérieur du filetage.</li></ul> |     |      |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | – | 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 les autres vis en matière non métallique.                                                                                                                                                                                                                                                                                                                               |     |      |
| <sup>a</sup> 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 <b>dispositifs de commande</b> à manchons simples utilisant des matériaux thermoplastiques et sur lesquels on n'exerce pas de couple au montage pour le réglage ou le nouveau <b>régla</b> ge (c'est-à-dire pour <b>coupe-circuit thermiques</b> ), 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. |   |                                                                                                                                                                                                                                                                                                                                                                              |     |      |

## 19.2 Connexions transportant le courant

**19.2.1** Les connexions transportant le courant 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 pièce 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**.

**19.2.2** 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 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 13 ou 20.

NOTE 1 L'exigence concernant le blocage des éléments d'une connexion transportant le courant n'implique pas l'interdiction de toute rotation ou déplacement, mais la limitation convenable de ces mouvements de manière qu'ils ne puissent affecter la conformité du dispositif de commande aux exigences de la présente norme.

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 pièces est convenablement limité par une interaction mécanique des pièces entre elles ou par des rondelles élastiques ou des moyens analogues.

NOTE 3 On considère que cette exigence est 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 matières de remplissage peuvent être utilisées si les parties avec lesquelles elles sont en contact ne sont soumises à aucune contrainte en **usage normal**.

**19.2.3** 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 des matières non métalliques autres que céramique ou des matières 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 possibilité d'utiliser une matière non métallique est conditionnée par sa stabilité dimensionnelle dans la plage de températures applicable au **dispositif de commande**.

**19.2.4** 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 pourvues d'un dispositif de blocage approprié.

**19.2.4.1** Les vis à filet gros peuvent être utilisées pour assurer la continuité de la mise à la terre à condition que deux vis au moins soient utilisées pour chaque connexion.

NOTE Au Canada et aux États-Unis, pour réaliser la continuité de terre, l'utilisation d'une seule vis est permise si deux filets complets au moins sont engagés. Si deux vis sont utilisées, chacune d'elles doit s'engager sur un filet complet au moins.

**19.2.5** Les connexions transportant le courant peuvent faire usage de vis autotaraudeuses par enlèvement de matière si ces vis donnent naissance à un filetage normal.

**19.2.5.1** Les vis autotaraudeuses par enlèvement de matière peuvent être utilisées pour assurer la continuité de la mise à la terre à condition que deux vis au moins soient utilisées pour chaque connexion.

NOTE Au Canada et aux États-Unis, pour réaliser la continuité de terre, l'utilisation d'une seule vis est permise si deux filets complets au moins sont engagés. Si deux vis sont utilisées, chacune d'elles doit s'engager sur un filet complet au moins.

**19.2.6** 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 risqueraient d'être altérées par la présence d'un revêtement nuisible à leur fonctionnement, tels que les bilames qui, lorsqu'elles ne sont pas protégées par un revêtement, doivent être serrées 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.

**19.2.7** La conformité à 19.2.1 à 19.2.6 inclus est vérifiée par examen. De plus, la conformité à 19.2.3 et 19.2.6 est vérifiée par examen des parties métalliques élastiques après que les essais de l'Article 17 ont été effectués.

## 20 Lignes de fuite, distances dans l'air et distances à travers l'isolation solide

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 des revêtements de type 2 comme spécifié dans la CEI 60664-3 doivent répondre aux exigences minimales de 20.3 pour l'isolation solide. L'espacement entre les conducteurs placés avant la protection ne doit pas être inférieur aux valeurs indiquées au Tableau 1 de la CEI 60664-3:2003. Voir également l'Annexe Q.

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 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 la CEI 60664-4.

Les valeurs tabulées de l'Article 20 sont des valeurs minimales absolues qui doivent être maintenues pendant toutes les conditions de fabrication et pendant toute la durée de vie du matériel.

*La conformité est vérifiée par examen, par des mesures et par les essais de cet article.*

NOTE 1 Les exigences et les essais sont basés sur la CEI 60664-1 où des informations complémentaires peuvent être obtenues.

NOTE 2 Une **ligne de fuite** ne peut 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.

NOTE 3 Voir l'Annexe S à titre d'indication.

## 20.1 Distances dans l'air

Les **distances dans l'air** ne doivent pas être inférieures aux valeurs données par le Tableau 22 dans le cas A, en tenant compte du **degré de pollution** et de la **tension assignée de choc** nécessaire pour satisfaire aux catégories de surtension du Tableau 21, 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 20.1.12 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 du cas B.

*La conformité est vérifiée par examen, par des mesures et, si nécessaire, par l'essai de 20.1.12.*

NOTE 1 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 indications sont fournies à l'Annexe L.

NOTE 2 Les **dispositifs de commande** construits selon les dimensions minimales du Tableau 22, cas A, n'ont pas besoin d'être soumis à l'essai de choc électrique de 20.1.12. Pour plus d'information sur les cas A et B, voir 5.1.3.2 et 5.1.3.3 de la CEI 60664-1:2007.

*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 2. Les ouvertures sont supposées être couvertes par une pièce métallique plate.

NOTE Les distances dans l'air sont mesurées comme spécifié à l'Annexe B.

**Tableau 21 (20.1 de l'édition 3) – Tension assignée de choc pour les matériels alimentés directement par le réseau (provenant de la CEI 60664-1:2007, Tableau F.1)**

| Tension nominale du réseau d'alimentation basée sur la CEI 60038 <sup>a b</sup><br>V |                                  | Tension phase-neutre déduite selon les tensions nominales c.a. ou c.c. jusques et y compris<br>V | Tension assignée de choc requise selon la catégorie de surtension <sup>c</sup><br>V |       |       |       |
|--------------------------------------------------------------------------------------|----------------------------------|--------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------|-------|-------|
| Système triphasé à quatre fils <sup>a</sup>                                          | Systèmes monophasés <sup>d</sup> |                                                                                                  | 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<br>277/480                                                                   |                                  | 300                                                                                              | 1 500                                                                               | 2 500 | 4 000 | 6 000 |
| 400/690                                                                              |                                  | 600                                                                                              | 2 500                                                                               | 4 000 | 6 000 | 8 000 |

<sup>a</sup> La première valeur énumérée est la tension phase-neutre ou tension phase-terre, la deuxième valeur est la tension entre phases.

<sup>b</sup> Pour les **dispositifs de commande** capables de générer une surtension aux bornes du **dispositif**, 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.

<sup>c</sup> Voir l'Annexe L pour une explication relative aux **catégories de surtension** et l'Annexe M à titre d'indication. La **catégorie de surtension** peut être spécifiée dans une partie 2 ou dans la norme finale de l'équipement.

<sup>d</sup> Voir l'Annexe K pour d'autres systèmes d'alimentation (par exemple, noter que certains systèmes de câblage triphasés à trois fils demandent une **tension assignée de choc** supérieure à celle des systèmes triphasés à quatre fils de tension similaire).

**Tableau 22 (20.2 de l'édition 3) – Distances dans l'air pour la coordination de l'isolement (provenant de la CEI 60664-1:2007, Tableau F.2)**

| Tension assignée de choc du Tableau 21 <sup>a</sup><br>kV | Distances dans l'air jusqu'à 2 000 m au-dessus du niveau de la mer <sup>b</sup><br>mm |      |     |     |                                                          |     |     |     |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------|------|-----|-----|----------------------------------------------------------|-----|-----|-----|
|                                                           | Cas A                                                                                 |      |     |     | Cas B<br>(essai de choc électrique exigé – voir 20.1.12) |     |     |     |
|                                                           | Degré de pollution <sup>c</sup>                                                       |      |     |     | Degré de pollution <sup>c</sup>                          |     |     |     |
|                                                           | 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  | 1,5 | 3   | 0,3                                                      | 0,3 | 1,2 | 2   |
| 2,5                                                       | 1,5                                                                                   | 1,5  |     |     | 0,6                                                      | 0,6 |     |     |
| 4,0                                                       | 3                                                                                     | 3    |     |     | 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.

<sup>a</sup> Pour l'**isolation fonctionnelle**, la **tension assignée de choc** est donnée par la valeur de la colonne 3 du Tableau 21 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**.

<sup>b</sup> 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 la CEI 60664-1:2007, Tableau A.2.

<sup>c</sup> Voir l'Annexe N pour une explication des **degrés de pollution**.

**20.1.1** 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 22, cas A s'appliquent à l'exception de ce qui est permis par 20.1.7.

*La conformité est vérifiée par des mesures.*

**20.1.1.1** 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.

**20.1.2** Pour l'**isolation fonctionnelle**, le Tableau 22, cas A s'applique

– à l'exception de ce qui est permis par 20.1.7;

ou

– excepté que les **distances dans l'air** pour les **dispositifs de commande électroniques** ne sont pas spécifiées si les exigences de H.27.1.1.3 sont respectées avec les **distances dans l'air** court-circuitées.



**20.1.3** La conformité avec 20.1 est vérifiée par des mesures en utilisant les méthodes de mesure données à l'Annexe B et la Figure 17.

**20.1.3.1** Pour les **dispositifs de commande** équipés avec une entrée de matériel ou un socle de prise, les mesures sont faites deux fois, une fois avec un connecteur ou une fiche approprié inséré, et une fois sans fiche ou connecteur inséré.

**20.1.3.2** 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 10.1.4, et une fois sans être équipées de conducteurs.

**20.1.3.3** 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 10.2.1, et une fois sans être équipées de conducteurs.

**20.1.4** 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 normalisé représenté à la Figure 2, mais n'est pas pressée dans les ouvertures.

**20.1.5** Le doigt d'épreuve normalisé est appliqué aux ouvertures comme spécifié en 8.1, la distance à travers l'isolation entre **parties actives** et la feuille métallique ne doit pas alors être réduite en dessous des valeurs spécifiées.

**20.1.6** 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.

**20.1.6.1** La force est appliquée au moyen du doigt d'épreuve normalisé 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.

**20.1.7** 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 au choc électrique de 20.1.12 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 20.1.12.

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 constituant du **dispositif de commande**.

**20.1.7.1** Pour les **microcoupures** et les interruptions, il n'est pas spécifié de distance minimale pour les **distances dans l'air** entre les contacts. Pour les autres parties séparées par l'action des contacts, les **distances dans l'air** peuvent être plus faibles que celles indiquées par le Tableau 22 mais ne doivent pas être inférieures à la distance entre les contacts.



**20.1.7.2** Pour les **coupures totales** de circuit, les valeurs spécifiées au Tableau 22, 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.

**20.1.8** Les **distances dans l'air** pour l'**isolation supplémentaire** ne doivent pas être inférieures à celles spécifiées pour l'**isolation principale** au Tableau 22, cas A.

*La conformité est vérifiée par des mesures.*

**20.1.9** Les **distances dans l'air** pour l'**isolation renforcée** ne doivent pas être inférieures à celles du Tableau 22, 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.*

**20.1.10** 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 21.

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 21 basée sur la tension primaire de transformateurs abaisseurs et basée sur la valeur efficace maximale mesurée de la tension secondaire des transformateurs abaisseurs.

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 la CEI 60664-1:2007 donne la valeur des **distances dans l'air** pour des tensions de tenue supérieures.

NOTE 2 Voir également les références à l'Article 24.

*La conformité est vérifiée par des mesures ou par un essai si nécessaire.*

**20.1.11** 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 21 basées sur la valeur maximale mesurée de la **tension de service** du circuit **TBT**.

**20.1.12** L'essai de tension de choc, si nécessaire, est appliqué selon 6.1.2.2.1 de la CEI 60664-1:2007.

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 constituant du **dispositif de commande**.

**20.1.13** 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 d'isolement de l'isolation principale** du côté secondaire ne doivent pas être inférieures à celles spécifiées au Tableau 22 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**.

Pour les circuits alimentés avec une tension inférieure à la tension assignée, par exemple sur le secondaire d'un transformateur, les **distances d'isolement de l'isolation fonctionnelle** sont basées sur la **tension de service**, laquelle est utilisée comme tension assignée pour le Tableau 21.

**20.1.14** Voir Annexe J.

**20.1.15** Voir Annexe H.

## **20.2 Lignes de fuite**

**20.2.1** Les **dispositifs de commande** doivent être construits de façon telle que les **lignes de fuite de l'isolation principale** ne soient pas inférieures à celles spécifiées au Tableau 23 pour la tension assignée en tenant compte du groupe de matériau et du **degré de pollution**.

Les **lignes de fuite** ne sont pas spécifiées pour les **dispositifs de commande électroniques** si les exigences de H.27.1.1.3 sont remplies avec les **lignes de fuite** court-circuitées.

*La conformité est vérifiée par examen et par des mesures.*

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 2. Les ouvertures sont supposées être couvertes par une pièce métallique plate.

NOTE Les **lignes de fuite** sont mesurées comme spécifié à l'Annexe B.

**20.2.2** Les **dispositifs de commande** doivent être construits de façon telle que les **lignes de fuite** pour l'**isolation fonctionnelle** ne soient pas inférieures à celles spécifiées au Tableau 24 pour la **tension de service** en tenant compte du **degré de pollution** et du groupe de matériaux.

D'autres critères peuvent être spécifiés par des parties 2 pour certaines situations, par exemple les sources d'allumage haute tension.

*La conformité est vérifiée par examen et par des mesures.*

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 2. Les ouvertures sont supposées être couvertes par une pièce métallique plate.

NOTE 1 Les **lignes de fuite** sont mesurées comme spécifié à l'Annexe B.

NOTE 2 La relation entre les groupes de matériaux et la valeur des indices de résistance au cheminement (IRC) est donnée en 6.13.

Les valeurs d'IRC ci-dessus se réfèrent aux valeurs obtenues selon la CEI 60112 et soumises à essai avec la solution A.

Les matériaux dont la valeur d'IRC a précédemment satisfait à ces groupes de matériaux sont acceptables sans autre essai.

NOTE 3 Pour le verre, les céramiques et les autres matériaux isolants non organiques qui n'ont pas de cheminement, les **lignes de fuite** n'ont pas besoin d'être supérieures aux **distances dans l'air** correspondantes pour la coordination de l'isolement.

**Tableau 23 (20.3 de l'édition 3) – Lignes de fuite minimales pour l'isolation principale**

| Tension assignée jusqu'et y compris<br><br>V | Lignes de fuite <sup>a</sup><br>mm                             |      |                     |     |                  |                     |      |                  |                     |      |                  |      |
|----------------------------------------------|----------------------------------------------------------------|------|---------------------|-----|------------------|---------------------|------|------------------|---------------------|------|------------------|------|
|                                              | Degré de pollution                                             |      |                     |     |                  |                     |      |                  |                     |      |                  |      |
|                                              | Matériau de câblage imprimé <sup>b</sup><br>Degré de pollution | 1    | 2                   |     |                  | 3                   |      |                  | 4                   |      |                  |      |
|                                              |                                                                |      | Groupe de matériaux |     |                  | Groupe de matériaux |      |                  | Groupe de matériaux |      |                  |      |
| 1 <sup>c</sup>                               | 2 <sup>d</sup>                                                 |      | I                   | II  | III <sup>e</sup> | I                   | II   | III <sup>e</sup> | I                   | II   | III <sup>e</sup> |      |
| 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 |

<sup>a</sup> 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 au Tableau 22.

<sup>b</sup> Lorsque les cartes de circuits imprimés sont revêtues selon l'Annexe P ou selon l'Article Q.1 et que le revêtement a un IRC d'au moins 175, les valeurs spécifiées pour le **degré de pollution** 1 sont autorisées. L'IRC doit être mesuré selon la CEI 60112.

<sup>c</sup> Groupes de matériaux I, II, IIIa et IIIb.

<sup>d</sup> Groupes de matériaux I, II et IIIa.

<sup>e</sup> 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.

**Tableau 24 (20.4 de l'édition 3) – Lignes de fuite minimales pour l'isolation fonctionnelle**

| Valeur efficace de la tension de service <sup>a</sup><br><br>V | Lignes de fuite <sup>b c</sup><br>mm                           |       |       |                     |      |      |                     |                  |      |                     |                  |      |
|----------------------------------------------------------------|----------------------------------------------------------------|-------|-------|---------------------|------|------|---------------------|------------------|------|---------------------|------------------|------|
|                                                                | Degré de pollution                                             |       |       |                     |      |      |                     |                  |      |                     |                  |      |
|                                                                | Matériau de câblage imprimé <sup>d</sup><br>Degré de pollution |       | 1     | 2                   |      |      | 3                   |                  |      | 4                   |                  |      |
|                                                                |                                                                |       |       | Groupe de matériaux |      |      | Groupe de matériaux |                  |      | Groupe de matériaux |                  |      |
| 1 <sup>e</sup> 2 <sup>f</sup>                                  |                                                                |       | I     | II                  | III  | I    | II                  | III <sup>g</sup> | I    | II                  | III <sup>g</sup> |      |
| 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   |

<sup>a</sup> Pour des **tensions de service** supérieures, les valeurs du Tableau F.4 de la CEI 60664-1:2007 s'appliquent.

<sup>b</sup> Pour le verre, les céramiques et les autres matériaux non organiques qui n'ont pas de cheminement, les **lignes de fuite** n'ont pas besoin d'être supérieures aux **distances dans l'air** associées.

<sup>c</sup> 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.

<sup>d</sup> Lorsque les cartes de circuits imprimés sont revêtues selon l'Annexe P ou selon l'Article Q.1 et que le revêtement a un IRC d'au moins 175, les valeurs spécifiées pour le **degré de pollution** 1 sont autorisées. L'IRC doit être mesuré selon la CEI 60112.

<sup>e</sup> Groupes de matériaux I, II, IIIa et IIIb.

<sup>f</sup> Groupes de matériaux I, II et IIIa.

<sup>g</sup> 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.*

**20.2.3 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**.

*La conformité est vérifiée par examen et par des mesures.*

**20.2.4** 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.*

**20.2.5** Voir Annexe J.

### **20.3 Isolation solide**

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 susceptibles de se produire pendant la durée de vie espérée du matériel.

**20.3.1** Il n'y a pas d'exigence concernant l'épaisseur de l'**isolation principale** ou l'**isolation fonctionnelle**.

**20.3.2** 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 est à 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 de métal entre les deux couches d'isolation.

**20.3.2.1** L'exigence de 20.3.2 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 13.2 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 13.2 pour l'**isolation renforcée**.

*La conformité est vérifiée par examen et par essai.*

**20.3.2.2** L'exigence de 20.3.2 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 des Articles 27 et H.27 ne dépasse pas la valeur permise spécifiée au Tableau 13.
- 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 14, résiste à l'essai de rigidité diélectrique de 13.2, 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 des Articles 14, 27 et H.27, l'optocoupleur étant manœuvré dans les conditions les plus défavorables se produisant pendant ces essais.

*La conformité est vérifiée par examen et par essai.*

## 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** qui sont vérifiés par les essais de 21.3.*

*Il n'existe pas d'exigence pour les petites parties telles que définies en 3.1 de la CEI 60695-2-11:2000.*

NOTE Aux États-Unis, la conformité est vérifiée par la procédure décrite à l'Annexe D.

### 21.2 Dispositifs de commande intercalés dans un câble souple, intégrés et incorporés

Les séquences d'essais suivantes 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.

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.

**21.2.1** *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:*

- l'essai à la bille 1 de G.5.1;
- l'essai au fil incandescent de l'Article G.2 réalisé à 550 °C.

**21.2.2** *Pour les parties qui maintiennent en position les parties transportant le courant, autres que les connexions électriques:*

- l'essai à la bille 2 de G.5.2;
- l'essai au fil incandescent de l'Article G.2 réalisé à 550 °C.

NOTE 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 H.27.1.1.1.

**21.2.3** *Pour les parties qui maintiennent ou retiennent en position les connexions électriques,*

- l'essai à la bille 2 de G.5.2 ,

*suivi de l'essai au fil incandescent à la température appropriée à l'application et telle que déclarée pour le **dispositif de commande**:*

NOTE 1 Pour plus d'informations, voir l'Annexe F.

**Essai au fil incandescent à 650 °C**

- l'essai au fil incandescent de l'Article G.2 réalisé à 650 °C.

**Essai au fil incandescent à 750 °C**

- l'essai au fil incandescent de l'Article G.2 réalisé à 750 °C.

**Essai au fil incandescent à 850 °C**

- l'essai au fil incandescent de l'Article G.2 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 H.27.1.1.1.

NOTE 2 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.

NOTE 3 Pour les **dispositifs de commande** destinés à être incorporés dans des appareils relevant du domaine d'application de la CEI 60335-1, les parties situées à 3 mm au maximum des connexions électriques peuvent devoir être évaluées selon 30.2 de la norme en question.

#### **21.2.4** *Pour toutes les autres parties (à l'exception des garnitures décoratives, boutons, etc.)*

– *l'essai au fil incandescent de l'Article G.2 réalisé à 550 °C.*

*doit être effectué.*

NOTE Sauf indication contraire dans la partie 2, les diaphragmes, joints et pâtes d'étanchéité des presse-étoupe ne sont pas soumis aux essais de 21.2.4.

#### **21.2.5 Vacant**

#### **21.2.6 Vacant**

#### **21.2.7 Résistance aux courants de cheminement**

Toutes les parties non métalliques pour lesquelles une **ligne de fuite** est spécifiée en 20.2 doivent avoir une résistance aux courants de cheminement comme déclaré.

NOTE 1 Les valeurs spécifiées pour la résistance aux courants de cheminement sont données soit dans les parties 2 de la CEI 60730 ou dans la norme correspondante du matériel concerné.

Les **dispositifs de commande** prévus pour un **fonctionnement en TBT** ne sont pas soumis à un essai de résistance aux courants de cheminement.

NOTE 2 A l'intérieur d'un **dispositif de commande**, différentes parties peuvent avoir des valeurs différentes de IRC (degré de protection contre le cheminement) selon le **microenvironnement** de la partie.

*La conformité est vérifiée par les essais de l'Article G.4 réalisés à l'une des valeurs d'IRC suivantes telles que déclarées à l'exigence 30 du Tableau 1:*

- 100 V;
- 175 V;
- 250 V;
- 400 V;
- 600 V.

NOTE 3 Pour les besoins de 21.2.7, on ne considère pas que la proximité des contacts d'arc augmente le dépôt de matière conductrice externe, étant donné que les essais d'endurance de l'Article 17, suivis par les essais de rigidité diélectrique de l'Article 13, 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**

La séquence d'essais de 21.2.1 à 21.2.7 s'applique, précédée du préconditionnement de 21.3.1.



### 21.3.1 Préconditionnement

*Le preconditionnement doit être effectué dans une étuve comme suit:*

- sans indication de  $T$ :  $1 \times 24$  h à  $(80 \pm 2) ^\circ\text{C}$ , le circuit de la partie commutateur et le mécanisme d'entraînement n'étant pas reliés, les **couvercles** amovibles étant retirés;
- avec indication de  $T$  pour des températures ne dépassant pas  $85 ^\circ\text{C}$ :  $1 \times 24$  h à  $(80 \pm 2) ^\circ\text{C}$ , la partie commutateur du **dispositif de commande** et le mécanisme d'entraînement n'étant pas reliés et sans **couvercles** et ensuite  $6 \times 24$  h à  $(T_{\text{max}} \pm 2) \text{ K}$  avec **couvercles**, les circuits de la partie commutation et le mécanisme d'entraînement étant reliés;
- avec indication de  $T$  pour des températures dépassant  $85 ^\circ\text{C}$ :  $6 \times 24$  h à  $(T_{\text{max}} \pm 2) \text{ K}$  avec **couvercles**, le circuit de commutation et le mécanisme d'entraînement étant reliés.

### 21.4 Dispositifs avec interrupteur au mercure

Les **dispositifs** utilisant un interrupteur au mercure destinés à être branchés à un circuit sous tension de service, tel que défini en 2.1.3, doivent fonctionner de façon acceptable lorsqu'ils sont soumis à essai en série avec un fusible à cartouche non réarmable standard sur un circuit en courant continu présentant la tension spécifiée pour l'essai de 17.1.1, mais on peut employer du courant alternatif sous une charge non inductive si le dispositif est destiné à être utilisé uniquement en courant alternatif. Le calibre nominal du fusible et la capacité du circuit d'essai doivent être conformes aux indications du Tableau 25.

*L'enveloppe et toute autre partie métallique exposée sont à mettre à la masse et du coton est à placer autour de toutes les ouvertures de l'enveloppe.*

*Il ne doit pas y avoir allumage du coton ou de l'isolant des conducteurs du circuit ni émission de flamme ou de métal en fusion à l'exception de mercure provenant de l'enveloppe contenant l'interrupteur. Le câblage fixé au dispositif, à l'exception des câbles du tube, ne doit pas être endommagé. Des **manœuvres** successives sont à effectuer en fermant tour à tour l'interrupteur à mercure sur le court-circuit, puis le court-circuit sur le tube à mercure au moyen d'un dispositif de commutation approprié.*

NOTE Dans les pays membres du CENELEC, 21.4 n'est pas applicable.

**Tableau 25 (21.4 de l'édition 3) – Conditions applicables au court-circuit de l'interrupteur à mercure**

| V       | Calibre maximal <sup>a</sup> | Courant de court-circuit<br>A | Calibre minimal du fusible <sup>b c</sup> |         |         |
|---------|------------------------------|-------------------------------|-------------------------------------------|---------|---------|
|         |                              |                               | 0–125                                     | 126–250 | 251–660 |
| 0–250   | 2 000 VA                     | 1 000                         | 20                                        | 15      | –       |
| 0–250   | 30 A                         | 3 500                         | 30                                        | 30      | –       |
| 0–250   | 63 A                         | 3 500                         | 70                                        | 70      | –       |
| 251–660 | 63 A                         | 5 000                         | –                                         | –       | 30      |

<sup>a</sup> Des exigences pour les applications supérieures à 63 A sont à l'étude.

<sup>b</sup> Le calibre minimal du fusible doit être au moins égal à l'ampérage assigné de l'interrupteur ou du fusible standard le plus proche, sans dépasser quatre fois l'ampérage assigné à pleine charge du moteur, et il ne doit en aucun cas être inférieur à la valeur indiquée.

<sup>c</sup> Pour le présent essai, les ampérages assignés des fusibles sont 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250. Des fusibles de taille intermédiaire peuvent être utilisés.

Le coton utilisé doit être tel que spécifié à l'Annexe C.



*Il n'est pas nécessaire que l'interrupteur soit en état de marche après les essais.*

## 22 Résistance à la corrosion

### 22.1 Résistance à la rouille

**22.1.1** Les parties en métaux ferreux, y compris les **capots** et les enveloppes, doivent être protégées contre la corrosion si celle-ci peut affecter la conformité à la présente norme.

**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 l'essai suivant.*

**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  $(40 \pm 2)$  °C.*

**22.1.5** *Après un séchage de 10 min dans une étuve à une température de  $(100 \pm 5)$  °C, les surfaces des parties ne doivent présenter aucune trace de corrosion susceptible d'affecter la conformité aux exigences des Articles 8, 13 et 20.*

**22.1.6** *On ne prend pas en considération des traces de rouille sur les arêtes ni un voile jaunâtre disparaissant par simple frottement.*

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, une couche de graisse peut constituer une protection suffisante contre la rouille. De telles parties ne sont soumises à l'essai que s'il y a doute au sujet de l'efficacité de la couche de graisse et l'essai est alors effectué sans dégraissage préalable.

## 23 Exigences de compatibilité électromagnétique (CEM) – Émission

*Voir aussi l'Article H.23.*

**23.1** Les **dispositifs de commande séparés** et à montage indépendant, qui accomplissent des cycles en **fonctionnement** normal, doivent être construits de façon à ne pas générer des interférences radio excessives. Les **dispositifs de commande intégrés** et les **dispositifs de commande incorporés** ne sont pas soumis aux essais de 23.1 car le résultat de ces essais peut être affecté par l'incorporation du **dispositif de commande** dans le matériel. Ils peuvent, cependant, être effectués sur demande du fabricant.

Il convient que les matériels utilisant des **dispositifs de commande incorporés** ou intégrés soient conformes à leur norme produit CEM correspondante. Les **dispositifs de commande incorporés** et **intégrés** sont soumis à essai dans le matériel en configuration d'utilisation finale.

*La conformité est vérifiée par l'une des méthodes suivantes:*

- Essais selon la CISPR 14-1, avec la modification suivante et/ou la CISPR 22, classe B. En 4.2.3.3 de la CISPR 14-1:2005, la valeur de 200 ms est remplacée par 20 ms.*
- Essais tels que détaillés en 23.1.1 et 23.1.2, ayant pour conséquence une durée d'émission de fréquences radio de 20 ms. Quand de tels **dispositifs de commande** ont une cadence des claquements supérieure à 5, la méthode a) doit être suivie.*

- c) *Examen et/ou essais pour montrer que la durée minimale entre le **fonctionnement** des contacts en **fonctionnement** normal ne peut être inférieure à 10 min.*

*La conformité avec les méthodes b) ou c) montre qu'il y a conformité avec la méthode a).*

### 23.1.1 Conditions d'essai

*Trois échantillons non encore utilisés sont soumis à cet essai.*

*Les conditions électriques et thermiques sont comme spécifié en 17.2 et 17.3 excepté ce qui suit:*

- pour les **dispositifs de commande sensibles**, le taux de changement des grandeurs de manœuvre est  $\alpha_1$  et  $\beta_1$ ;*
- 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 7 du Tableau 1. Pour les **dispositifs de commande** déclarés pour utilisation avec des charges purement résistives, le facteur de puissance est 1,0.*

### 23.1.2 Procédure d'essai

*Le **dispositif de commande** est mis en fonction pendant cinq **cycles de fonctionnement par contact**.*

*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.*

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.

**23.2** Les **dispositifs de commande** destinés aux 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 doivent satisfaire aux exigences de la CISPR 11.

NOTE Voir aussi le Tableau 1, exigence 89.

## 24 Éléments constitutants

**24.1** Les transformateurs 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 la CEI 61558-2-6.

Les condensateurs utilisés pour obtenir la réduction des perturbations de radiodiffusion doivent répondre aux exigences de la CEI 60384-14.

Les fusibles doivent répondre aux exigences de la CEI 60127-1 ou de la CEI 60269-1, selon celle qui correspond.

**24.1.1** 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 17.2.2, 17.2.3.1 et 17.2.3.2.

Les alimentations en mode de commutation ou les transformateurs utilisés dans des convertisseurs doivent satisfaire aux exigences de la CEI 61558-2-16.

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 2.1.5.

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 T.3 s'appliquent.

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.

**24.2** Les composants autres que ceux cités en 24.1 sont vérifiés en effectuant les essais de la présente norme.

**24.2.1** Cependant, pour les composants qui ont préalablement satisfait à une norme de sécurité CEI 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 CEI;
- b) les essais, selon la présente norme, de toutes les conditions qui ne sont pas prévues par les essais préalables de la norme de sécurité CEI.

Voir aussi l'Annexe J.

**24.3** L'Annexe U ne s'applique pas aux relais utilisés en tant que composants dans un **dispositif de commande**.

**24.4** Les alimentations en mode de commutation non couvertes par 24.2.1, y compris leurs circuits périphériques, utilisées dans les **dispositifs de commande électroniques** doivent satisfaire aux essais de 24.4.1 et à toutes les exigences applicables de la présente norme.

NOTE Les critères de conformité pour les essais sont donnés en 24.4.1.11.

#### **24.4.1 Essais de surcharge pour les alimentations en mode de commutation**

**24.4.1.1** *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.*

**24.4.1.2** *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.*

**24.4.1.3** *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.*

**24.4.1.4** *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.*

**24.4.1.5** En l'absence de protection contre les surintensités, la surcharge maximale correspond à la puissance utile maximale que peut fournir l'alimentation.

**24.4.1.6** 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.

**24.4.1.7** La durée de l'essai est de 1 h ou jusqu'à l'obtention des résultats finaux.

**24.4.1.8** La tension maximale en circuit ouvert de chaque enroulement (directement au niveau de l'enroulement du transformateur) et le courant maximal de charge sont mesurés et enregistrés afin de pouvoir déterminer la puissance de sortie maximale.

**24.4.1.9** 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 H.24.

**24.4.1.10** Pour les applications **TBTS**, pour lesquelles la tension maximale en circuit ouvert mesurée directement à l'enroulement secondaire du transformateur dépasse les limites spécifiées en 2.1.5, 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 H.8.1.10.1.

**24.4.1.11** A la suite de chaque essai (toujours en condition chaude), le transformateur est à soumettre à l'essai de rigidité diélectrique de 13.2.

**24.4.1.12** La conformité doit s'appliquer selon les points a), b), c), d), e) et f) de H.27.1.1.3.

**24.5** L'Annexe J ne s'applique pas aux **thermistances** utilisées dans un circuit qui satisfait à toutes les exigences suivantes:

- **dispositif de commande** de type 1 tel que spécifié dans le Tableau 1, exigence 39;
- raccordement à un circuit **TBTS**/TBTP tel que spécifié à l'Article T.1;
- circuit de faible puissance tel que spécifié en H.27.1.1.1;
- le **dispositif de commande** ou l'équipement terminal est conforme à l'Article H.27 lorsque la **thermistance** est ouverte ou en court-circuit;
- **dispositif de commande** avec **fonctions de commande de classe A** tel que spécifié dans le Tableau 1, exigence 92.

## 25 Fonctionnement normal

Voir Annexe H.

## 26 Exigences de compatibilité électromagnétique (CEM) – Immunité

Voir l'Article H.26.

NOTE En général, les essais de l'Article H.26 ne sont pas applicables aux **dispositifs de commande** non électroniques à cause de leur tolérance à de telles perturbations. Les essais appropriés pour les types spécifiques de **dispositifs de commande** non électroniques peuvent être inclus dans d'autres articles de la partie 2 appropriée.

## 27 Fonctionnement anormal

**27.1** Voir Annexe H et Annexe J.

## 27.2 Essai de brûlure

Les **dispositifs de commande** avec des électroaimants incorporés doivent résister aux effets de blocage du mécanisme du **dispositif de commande**.

*La conformité est vérifiée par les essais de 27.2.1 et 27.2.2.*

NOTE Pour les relais et les contacteurs, la conformité à cette exigence est considérée comme satisfaite par l'accomplissement des essais de l'Article 17.

**27.2.1** *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 17.2.2, 17.2.3.1 et 17.2.3.2.*

*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.*

**27.2.2** *Après 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 à la présente norme;*
- *les exigences de 13.2 sont encore satisfaites.*

NOTE Le **dispositif de commande** n'a pas besoin d'être fonctionnel à la suite de l'essai.

## 27.2.3 Essai de sortie mécanique bloquée (essai de température anormale)

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 26. Les températures sont mesurées par la méthode spécifiée en 14.7.1. 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 13.

**27.2.3.1** *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.*

NOTE Au Canada et aux États-Unis, l'essai est effectué sous les tensions indiquées en 17.2.3.1 et 17.2.3.2.

Pour les **dispositifs de commande** comprenant des moteurs déclarés fonctionnant en triphasé, il faut réaliser l'essai avec une quelconque des phases déconnectée.

**Tableau 26 (27.2.3 de l'édition 3) – 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<br>– valeur maximale | 200                                 | 215 | 225 | 240 | 260 | 280 | 300 | 330 |
| Après la première heure<br>– valeur maximale   | 175                                 | 190 | 200 | 215 | 235 | 255 | 275 | 305 |
| – moyenne arithmétique                         | 150                                 | 165 | 175 | 190 | 210 | 230 | 250 | 280 |

**27.2.3.2** 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.

**27.2.3.3** Pendant l'essai, le moteur doit être constamment sous tension.

**27.2.3.4** Immédiatement après l'achèvement de l'essai, le moteur doit être capable de satisfaire à l'essai de rigidité diélectrique spécifié à l'Article 13, sans réalisation préalable de l'épreuve hygroscopique de 12.2.

### 27.3 Essai de surtension et de manque de tension

Un **dispositif de commande** à électroaimant incorporé doit fonctionner comme prévu à n'importe quelle tension dans le domaine compris 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 que seulement un **dispositif de commande** ayant un  $T_{\min}$  inférieur 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  $0,85 V_{R \min}$ .

**27.4** Voir Annexe H.

## 27.5 Essais de surcharge pour les dispositifs de commande intercalés dans un câble souple

Les essais de surcharge suivants sont effectués sur des **dispositifs de commande intercalés dans un câble souple** tels qu'indiqués en 11.10.2 et équipés d'une prise et socles de prise de courant.

- Les **dispositifs de commande** tels que spécifiés sans dispositif de protection et sans fusible incorporé sont chargés pendant 1 h avec le courant de déclenchement conventionnel pour le fusible qui dans l'installation protégera 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 état 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 CEI 60127-1 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 électronique** a été chargé pendant 30 min.
- 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 température ne doit pas dépasser les valeurs indiquées au Tableau 13.

## 27.6 Essai de court circuit de pile

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.

**27.6.1** A l'issue de cet essai, le **dispositif de commande** doit être considéré comme satisfaisant 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 à la présente norme;
- les exigences de 13.2 sont encore satisfaites.

NOTE Le **dispositif de commande** n'a pas besoin d'être fonctionnel à la suite de l'essai.



## 28 Guide sur l'utilisation des coupures électroniques

Voir Annexe H.

*Dimensions en millimètres*

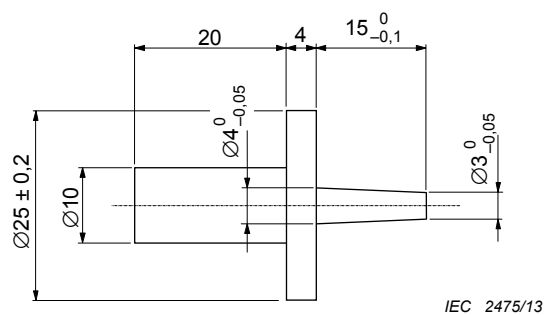
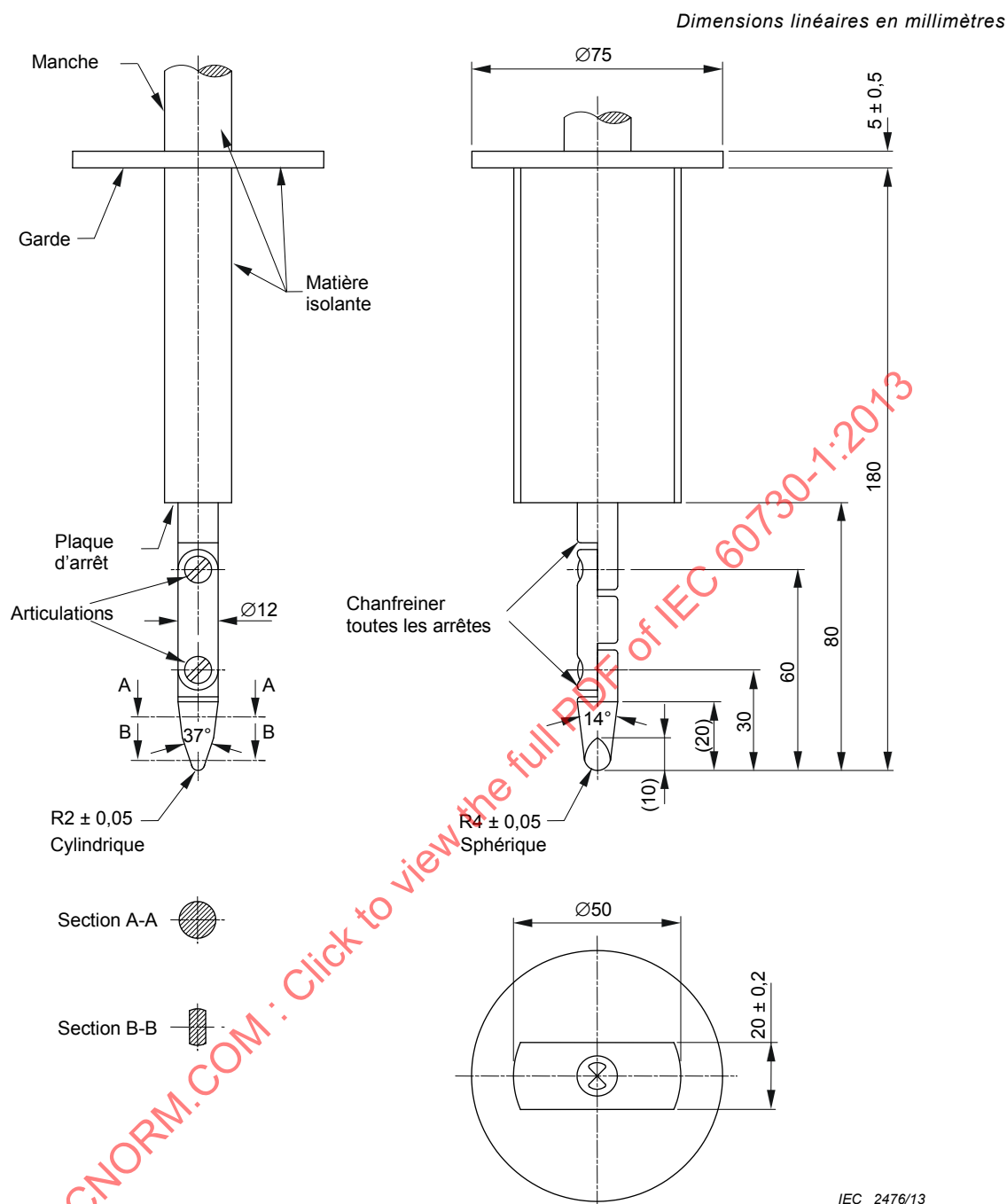


Figure 1 – Broche d'essai

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Tolérances des dimensions sans indication de tolérance:

sur les angles  $\begin{matrix} 0 \\ -10^\circ \end{matrix}$

sur les dimensions linéaires:

jusqu'à 25 mm:  $\begin{matrix} 0 \\ -0,05 \end{matrix}$

au-dessus de 25 mm:  $\pm 0,2$

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-rainure 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 2 – Doigt d'épreuve normalisé**

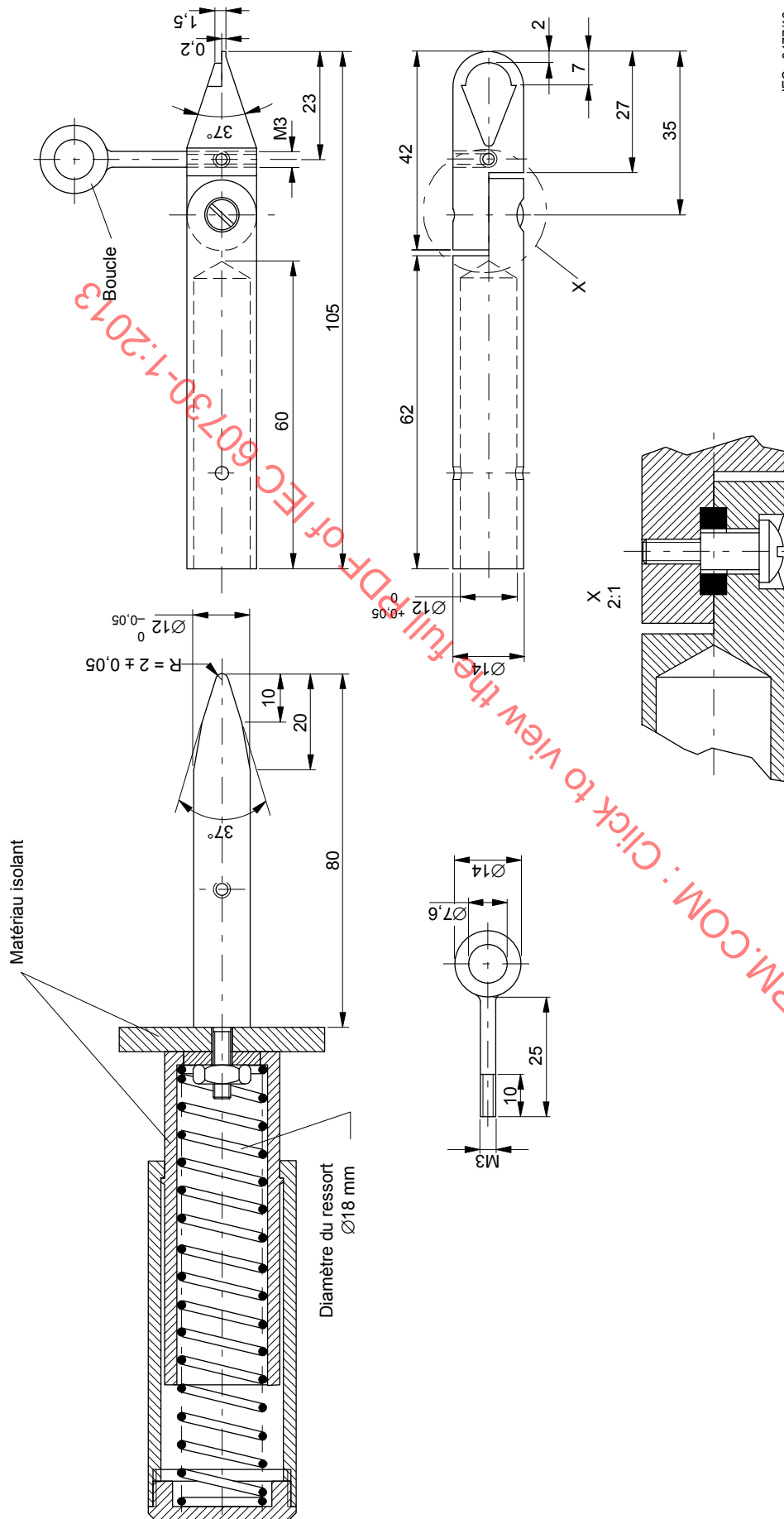
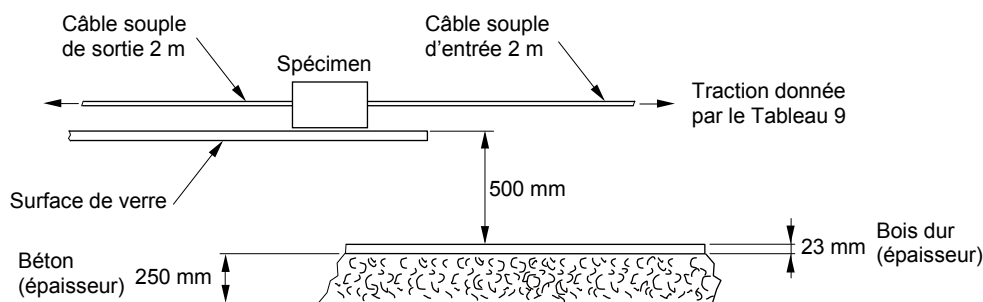


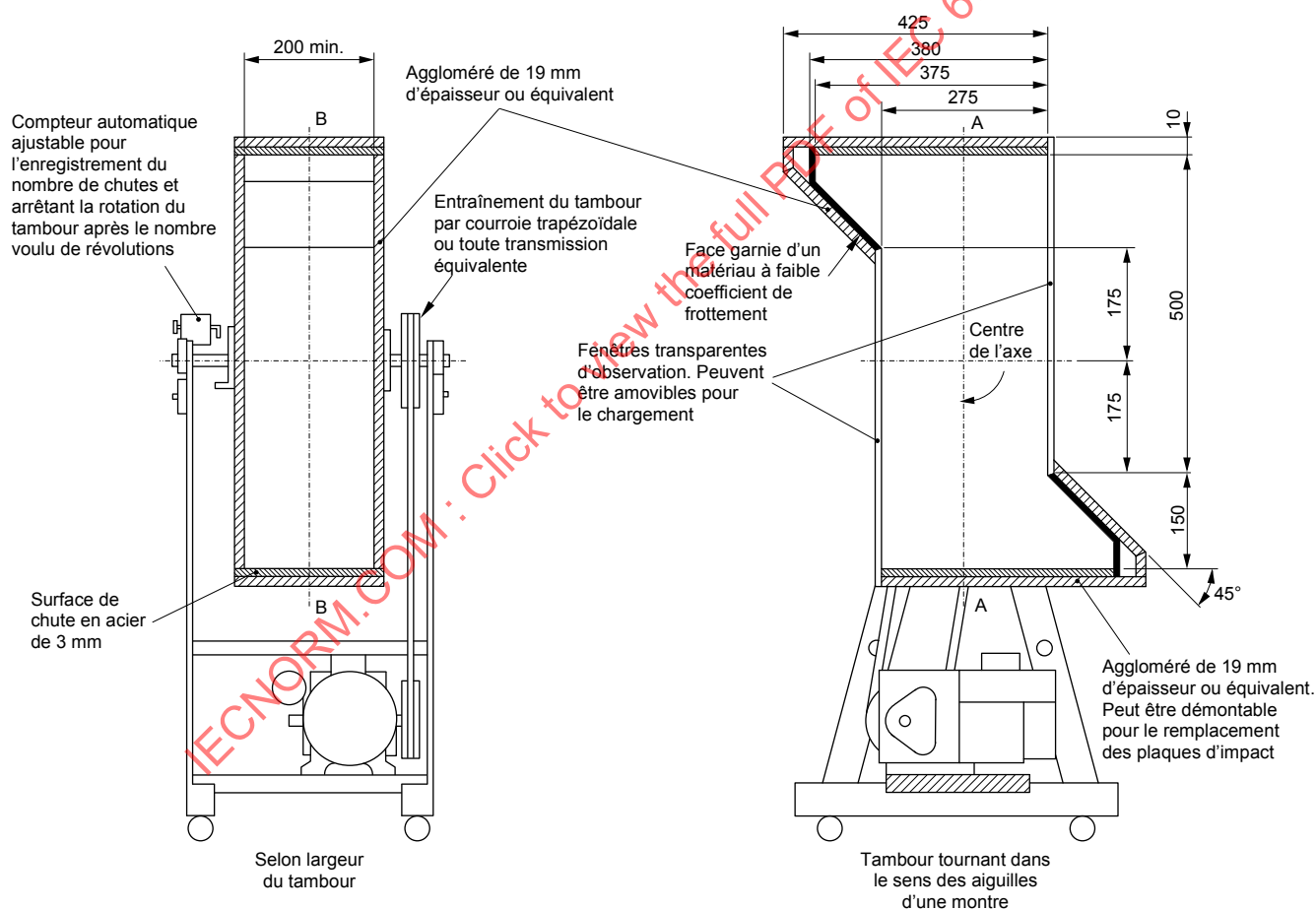
Figure 3 – Ongle d'essai



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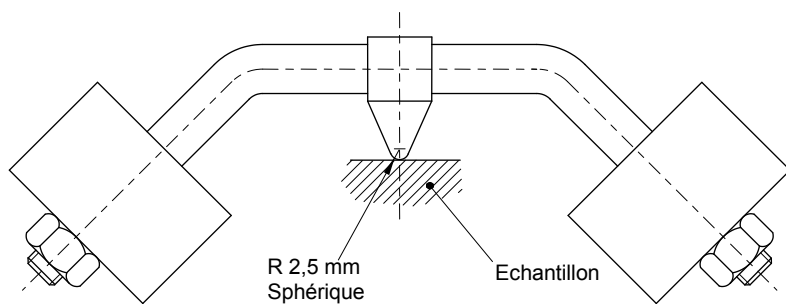
Figure 4 – Essai de chute pour dispositifs de commande séparés

Dimensions en millimètres



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Figure 5 – Appareil pour essai de chutes répétées

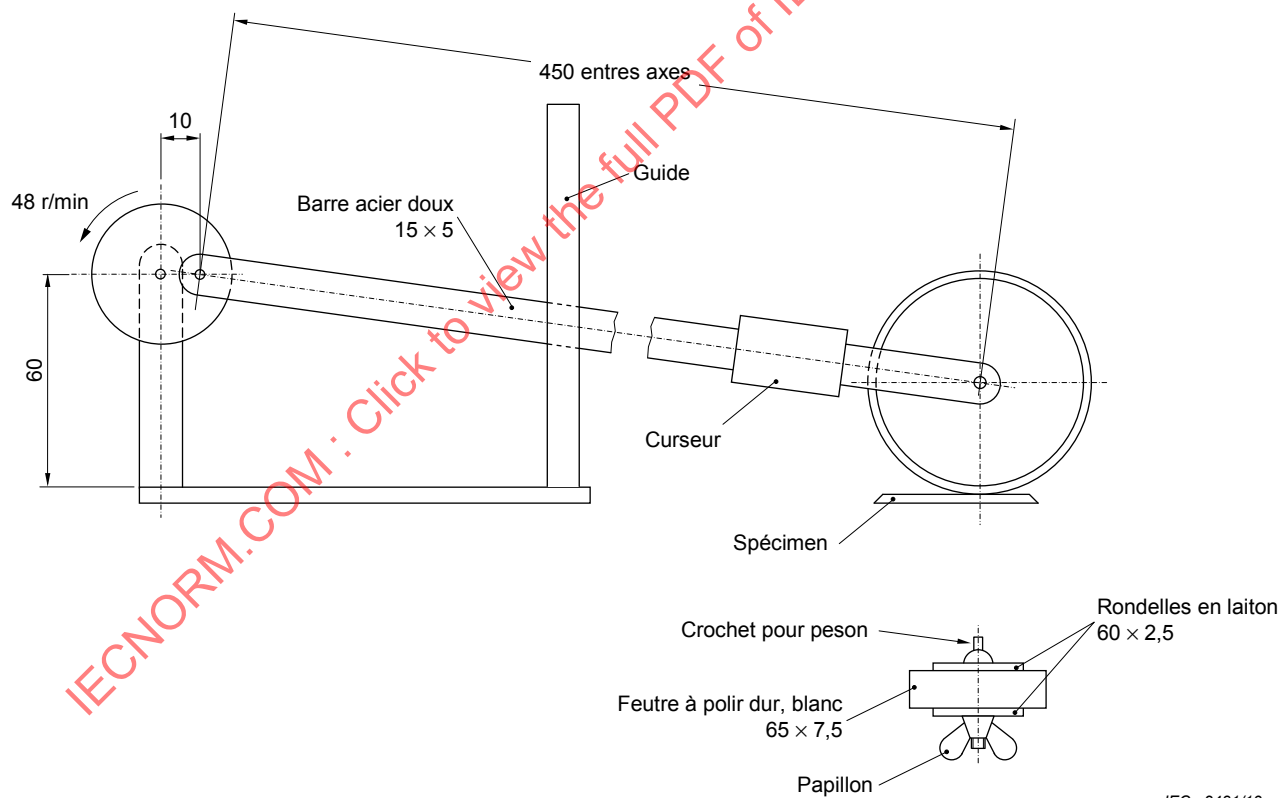


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Figure 6 – Appareil pour l'essai à la bille

Figure 7 – Vacant

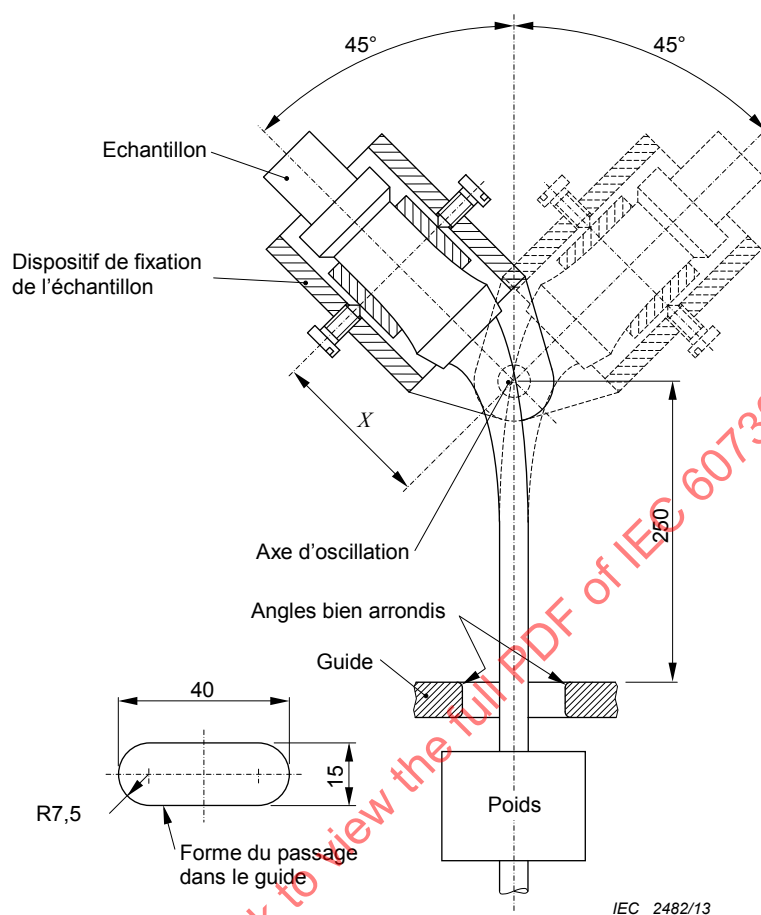
Dimensions en millimètres



IEC 2481/13

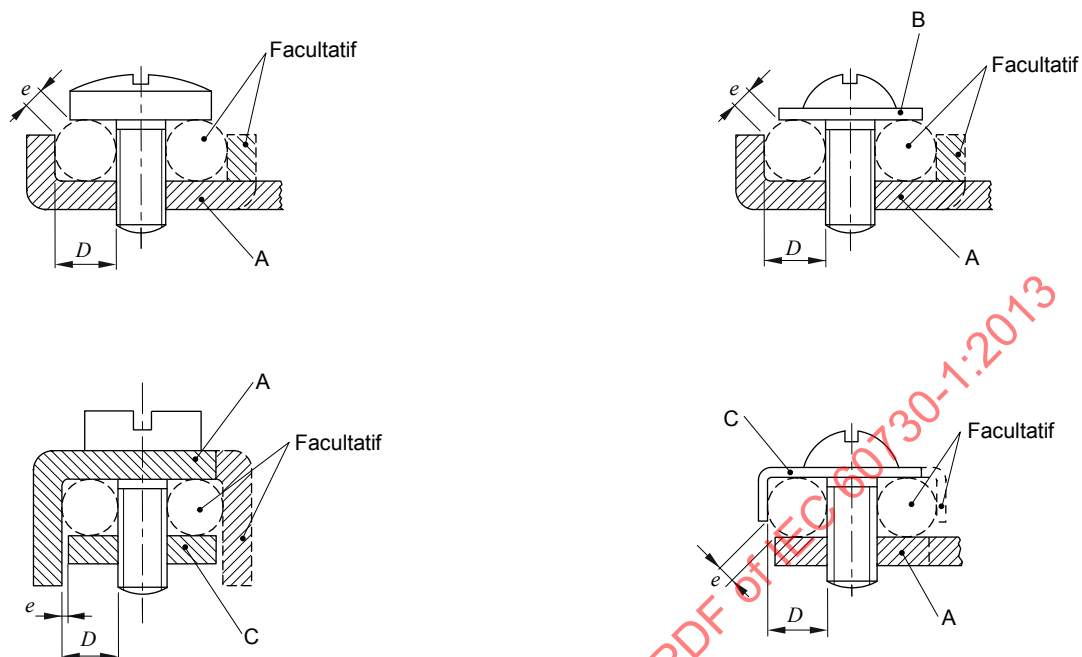
Figure 8 – Appareil pour vérifier l'indélébilité des marquages

Dimensions en millimètres

**Figure 9 – Appareil d'essai de flexion**

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

IEC 2483/13

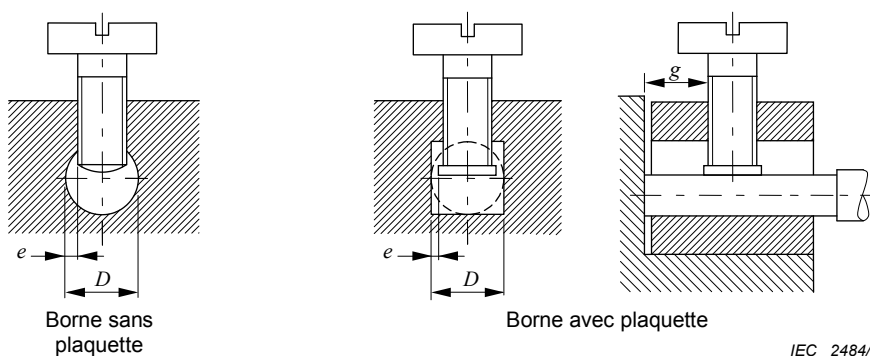
- A partie fixe
- B rondelle ou plaquette
- C dispositif empêchant le conducteur ou ses brins de s'échapper
- D logement du conducteur
- E goujon

Figure 10 – Bornes à serrage sous tête de vis et bornes à goujon fileté (1 sur 2)

Dimensions en millimètres

| Courant circulant dans la borne <sup>a</sup>                                                                                                         |                             | Diamètre minimal du logement du conducteur<br><i>D</i> | Écartement maximal entre pièces de maintien du conducteur<br><i>e</i> | Couple minimal<br>Nm |                      |            |          |
|------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|--------------------------------------------------------|-----------------------------------------------------------------------|----------------------|----------------------|------------|----------|
| Pour conducteur souple<br>A                                                                                                                          | Pour conducteur rigide<br>A |                                                        |                                                                       | Vis à fente          |                      | Autres vis |          |
|                                                                                                                                                      |                             |                                                        |                                                                       | Une vis<br><i>g</i>  | Deux vis<br><i>g</i> | Une vis    | Deux vis |
| 0-6                                                                                                                                                  | 0-6                         | 1,4                                                    | 1,0                                                                   | 0,4                  | —                    | 0,4        | —        |
| 6-10                                                                                                                                                 | 0-6                         | 1,7                                                    | 1,0                                                                   | 0,5                  | —                    | 0,5        | —        |
| 10-16                                                                                                                                                | 6-10                        | 2,0                                                    | 1,5                                                                   | 0,8                  | —                    | 0,8        | —        |
| 16-25                                                                                                                                                | 10-16                       | 2,7                                                    | 1,5                                                                   | 1,2                  | 0,5                  | 1,2        | 0,5      |
| 25-32                                                                                                                                                | 16-25                       | 3,6                                                    | 1,5                                                                   | 2,0                  | 1,2                  | 2,0        | 1,2      |
| —                                                                                                                                                    | 25-32                       | 4,3                                                    | 2,0                                                                   | 2,0                  | 1,2                  | 2,0        | 1,2      |
| 32-40                                                                                                                                                | 32-40                       | 5,5                                                    | 2,0                                                                   | 2,0                  | 1,2                  | 2,0        | 1,2      |
| 40-63                                                                                                                                                | 40-63                       | 7,0                                                    | 2,0                                                                   | 2,0                  | 2,0                  | 3,0        | 2,0      |
| La pièce qui retient le conducteur en place peut être en matière isolante à condition de ne pas participer à la transmission de l'effort de serrage. |                             |                                                        |                                                                       |                      |                      |            |          |
| Les dessins ne préjugent pas des détails non cotés.                                                                                                  |                             |                                                        |                                                                       |                      |                      |            |          |
| <sup>a</sup> Des exigences pour les applications supérieures à 63 A sont à l'étude.                                                                  |                             |                                                        |                                                                       |                      |                      |            |          |

Figure 10 – Bornes à serrage sous tête de vis et bornes à goujon fileté (2 sur 2)



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Dimensions en millimètres

| Courant circulant dans la borne <sup>a</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                    | Diamètre minimal du logement du conducteur<br><i>D</i> | Écartement maximal entre pièces de maintien du conducteur<br><i>e</i> | Distance minimale entre la vis de serrage et l'extrémité du conducteur engagé à fond |     | Couple minimal<br>Nm |                      |             |          |            |          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|--------------------------------------------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------|-----|----------------------|----------------------|-------------|----------|------------|----------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                    |                                                        |                                                                       |                                                                                      |     | Vis sans tête        |                      | Vis à fente |          | Autres vis |          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                    |                                                        |                                                                       |                                                                                      |     | Une vis<br><i>g</i>  | Deux vis<br><i>g</i> | Une vis     | Deux vis | Une vis    | Deux vis |
| Pour conducteur souple<br><i>A</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Pour conducteur rigide<br><i>A</i> |                                                        |                                                                       |                                                                                      |     |                      |                      |             |          |            |          |
| 0-10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | 0-6                                | 2,5                                                    | 0,5                                                                   | 1,5                                                                                  | 1,5 | 0,2                  | 0,2                  | 0,4         | 0,4      | 0,4        | 0,4      |
| 10-16                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 6-10                               | 3,0                                                    | 0,5                                                                   | 1,5                                                                                  | 1,5 | 0,25                 | 0,2                  | 0,5         | 0,4      | 0,5        | 0,4      |
| 16-25                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 10-16                              | 3,6                                                    | 0,5                                                                   | 1,8                                                                                  | 1,5 | 0,4                  | 0,2                  | 0,8         | 0,4      | 0,8        | 0,4      |
| 25-32                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 16-25                              | 4,0                                                    | 0,6                                                                   | 1,8                                                                                  | 1,5 | 0,4                  | 0,25                 | 0,8         | 0,5      | 0,8        | 0,5      |
| -                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 25-32                              | 4,5                                                    | 1,0                                                                   | 2,0                                                                                  | 1,5 | 0,7                  | 0,25                 | 1,2         | 0,5      | 1,2        | 0,5      |
| 32-40                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 32-40                              | 5,5                                                    | 1,3                                                                   | 2,5                                                                                  | 2,0 | 0,8                  | 0,7                  | 2,0         | 1,2      | 2,0        | 1,2      |
| 40-63                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | 40-63                              | 7,0                                                    | 1,5                                                                   | 3,0                                                                                  | 2,0 | 1,2                  | 0,7                  | 2,5         | 1,2      | 3,0        | 1,2      |
| <p>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 pièces distinctes, comme dans le cas d'une borne à étrier.</p> <p>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 <i>D</i>.</p> <p>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.</p> <p>Les dessins ne préjugent pas des détails non cotés.</p> |                                    |                                                        |                                                                       |                                                                                      |     |                      |                      |             |          |            |          |
| <sup>a</sup> Des exigences pour les applications supérieures à 63 A sont à l'étude.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                    |                                                        |                                                                       |                                                                                      |     |                      |                      |             |          |            |          |

Figure 11 – Bornes à trou



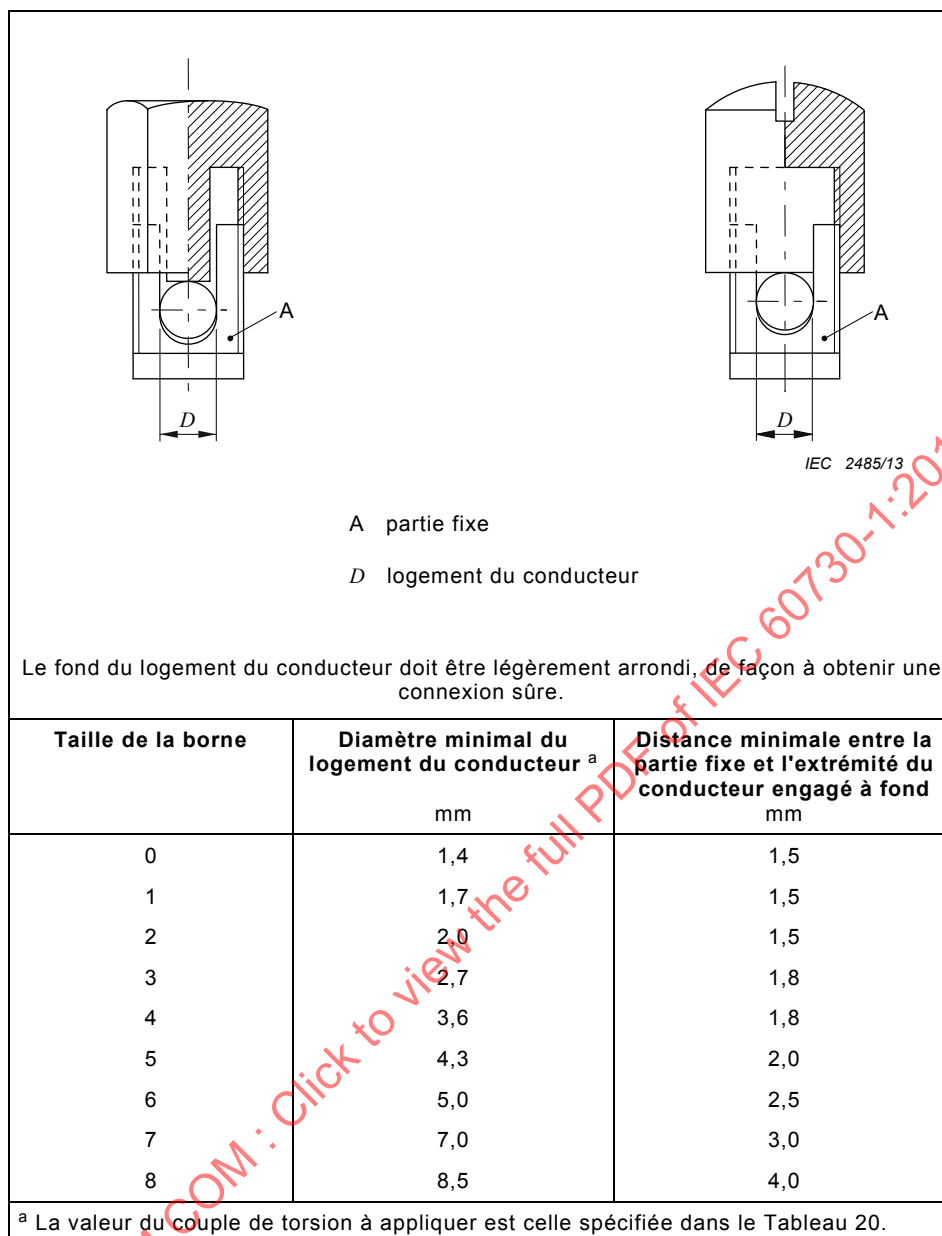
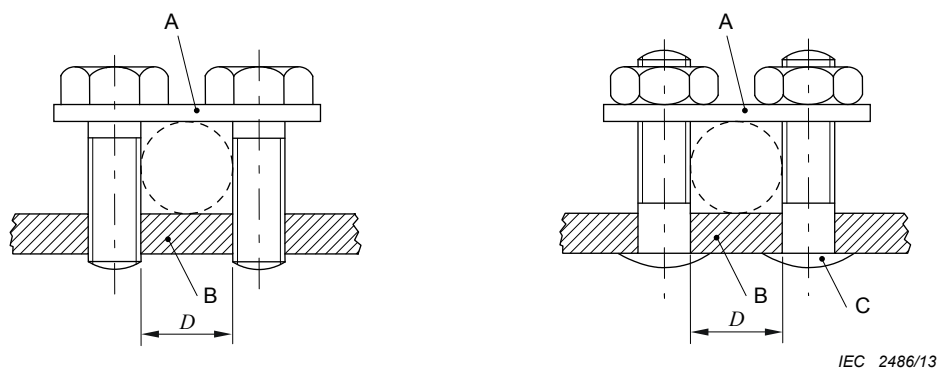
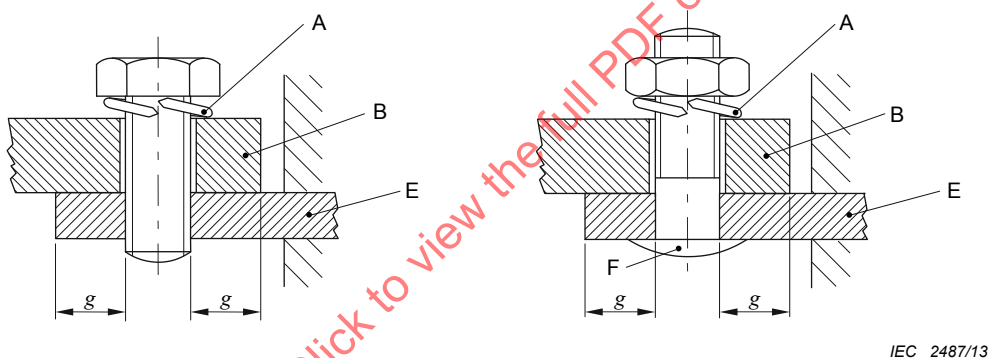


Figure 12 – Bornes à capot taraudé



- A plaque
- B partie fixe
- C goujon
- D logement du conducteur

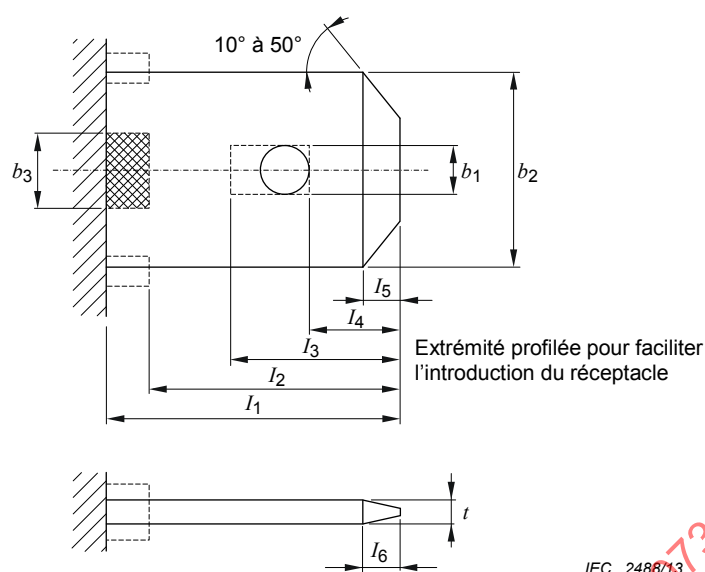
#### a) Bornes à plaque



- A dispositif de blocage
- B cosse ou barrette
- E partie fixe
- F goujon

#### b) Bornes à cosse

Figure 13 – Bornes pour plaque et cosse



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Dimensions en millimètres

| Dimension pour les<br>Figures 14 et 15 <sup>a</sup> | Taille de raccord |                   |                             |                             |
|-----------------------------------------------------|-------------------|-------------------|-----------------------------|-----------------------------|
|                                                     | 2,8               | 4,8               | 6,3                         | 9,5                         |
| $l_1$ (min.) <sup>b</sup>                           | 7,7               | 6,9               | 8,6                         | 14,0                        |
| $l_2$ (min.) <sup>b</sup>                           | 7,0               | 6,2               | 7,9                         | 12,0                        |
| $l_3$ (max.) <sup>c</sup>                           | 3,0               | 5,2               | 6,7                         | 8,2                         |
| $l_4$                                               | $1,0 \pm 0,2$     | $2,5 \pm 0,25$    | $3,2 \pm 0,3$               | $4,2 \pm 0,3$               |
| $l_5$ (max.)                                        | 0,7               | 1,2               | 1,3                         | 1,7                         |
| $l_6$ (max.)                                        | 0,7               | 1,2               | 1,3                         | 1,7                         |
| $b_1$ (fente) <sup>a</sup>                          | $1,2^{+0,1}_0$    | $1,4^{+0,2}_0$    | $1,6^{+2,0}_0$ <sup>d</sup> | $2,1^{+2,0}_0$ <sup>d</sup> |
| $b_1$ (fente) <sup>a</sup>                          | $1,2^{+0,1}_0$    | $1,4^{+0,2}_0$    | $1,6^{+0,1}_0$              | $2,1^{+0,2}_0$              |
| $b_2$                                               | $2,8 \pm 0,1$     | $4,75 \pm 0,2$    | $6,3^{+0,15}_{-0,1}$        | $9,5^{+0,15}_{-0,1}$        |
| $b_3$ (min.) <sup>e</sup>                           | 2,0               | 2,0               | 2,5                         | 2,5                         |
| $t$ <sup>f</sup>                                    | $0,5 \pm 0,025$   | $0,8 \pm 0,03$    | $0,8 \pm 0,03$              | $1,2 \pm 0,03$              |
| $p$ (max.) <sup>g</sup>                             | 0,8               | 1,2               | 1,2                         | 1,7                         |
| $k$                                                 | –                 | $0,7^{+0}_{-0,1}$ | $1,0^{+0}_{-0,1}$           | $1,5^{+0}_{-0,1}$           |
| $x$                                                 | –                 | $1,0 \pm 0,2$     | $1,0 \pm 0,2$               | $1,4 \pm 0,2$               |

NOTE Les dessins ne préjugent pas des détails non cotés.

<sup>a</sup> 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, pourvu que la **languette** en résultant soit conforme à la présente norme.

Les détails pour des **languettes** pourvues de bossages ou de cavités sont à l'étude.

<sup>b</sup> Pour ménager une **distance dans l'air** suffisante pour les **réceptacles** destinés à être pourvus 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.

<sup>c</sup> Il faut que la longueur de la fente ( $l_3-l_4$ ) soit au moins égale à sa largeur ( $b_1$ ).

<sup>d</sup> Ces tolérances sont choisies pour permettre aux **languettes** d'être utilisées comme une partie d'une borne à vis.

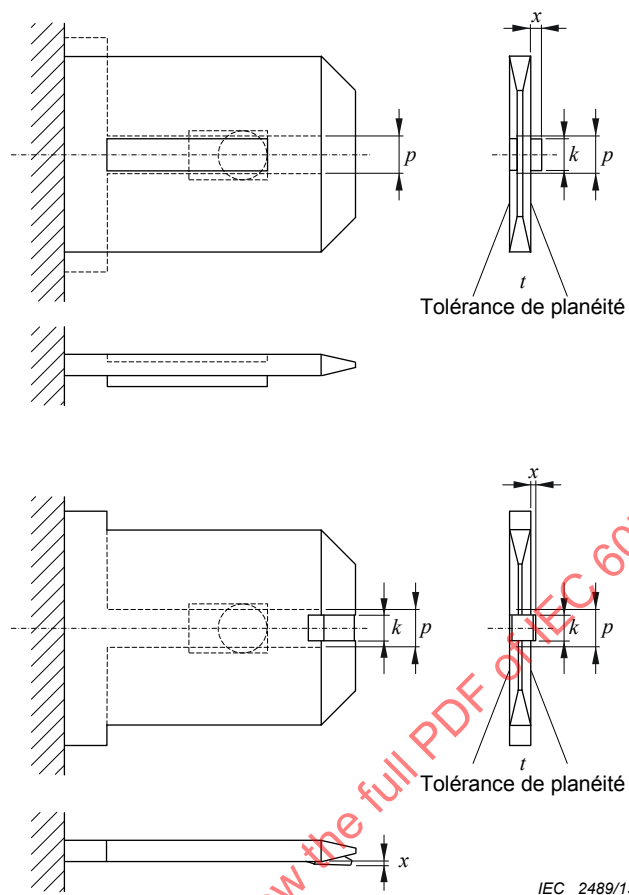
<sup>e</sup> Sur la surface quadrillée, l'épaisseur ne doit pas être supérieure à la limite supérieure de l'épaisseur spécifiée pour le matériau.

<sup>f</sup> 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  $(3,2 \pm 0,2)$  mm<sup>2</sup> dans une surface circulaire. De plus, la planéité totale doit avoir une tolérance de 0,03 mm.

<sup>g</sup> 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**.

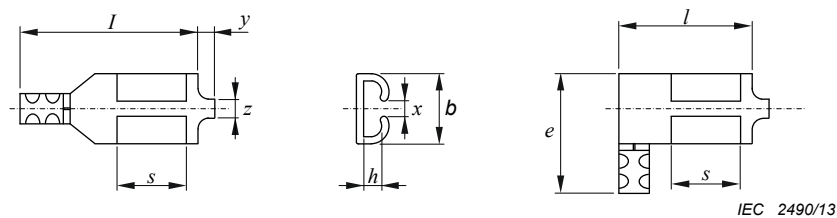
Figure 14 – Languettes

Pour les dimensions, voir Figure 14



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Figure 15 – Languettes pour des raccords non réversibles



Dimensions en millimètres

| Dimension                                                                                                                                                                                                                                                                          | Taille de raccord |     |     |      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|-----|-----|------|
|                                                                                                                                                                                                                                                                                    | 2,8               | 4,8 | 6,3 | 9,5  |
| <i>b</i> (max.)                                                                                                                                                                                                                                                                    | 4                 | 6   | 8   | 12,5 |
| <i>e</i> (max.)                                                                                                                                                                                                                                                                    | 12                | 12  | 15  | 20   |
| <i>h</i> (max.) <sup>a</sup>                                                                                                                                                                                                                                                       | 1                 | 2   | 2,5 | 3,2  |
| <i>l</i> (max.)                                                                                                                                                                                                                                                                    | 18                | 18  | 22  | 27   |
| <i>s</i> (min.)                                                                                                                                                                                                                                                                    | 4,5               | 5   | 6   | 10   |
| <i>x</i> (min.) <sup>b</sup>                                                                                                                                                                                                                                                       | -                 | 0,9 | 1,2 | 1,7  |
| <i>y</i> (max.)                                                                                                                                                                                                                                                                    | 0,5               | 0,5 | 0,5 | 1,0  |
| <i>z</i> (max.)                                                                                                                                                                                                                                                                    | 1,5               | 1,5 | 2,0 | 2,0  |
| <p>Les dimensions cotées s'entendent pour les connexions serties.</p> <p>Les dimensions pour les <b>réceptacles</b> équipés d'un manchon et pour les <b>réceptacles</b> ayant un fourreau pré-isolé sont à l'étude.</p> <p>Les dessins ne préjugent pas des détails non cotés.</p> |                   |     |     |      |
| <sup>a</sup> Écartement maximal par rapport à la ligne médiane de la lame de la <b>languette</b> .                                                                                                                                                                                 |                   |     |     |      |
| <sup>b</sup> Ne s'applique qu'aux <b>réceptacles</b> pour raccords non réversibles.                                                                                                                                                                                                |                   |     |     |      |

Figure 16 – Réceptacles

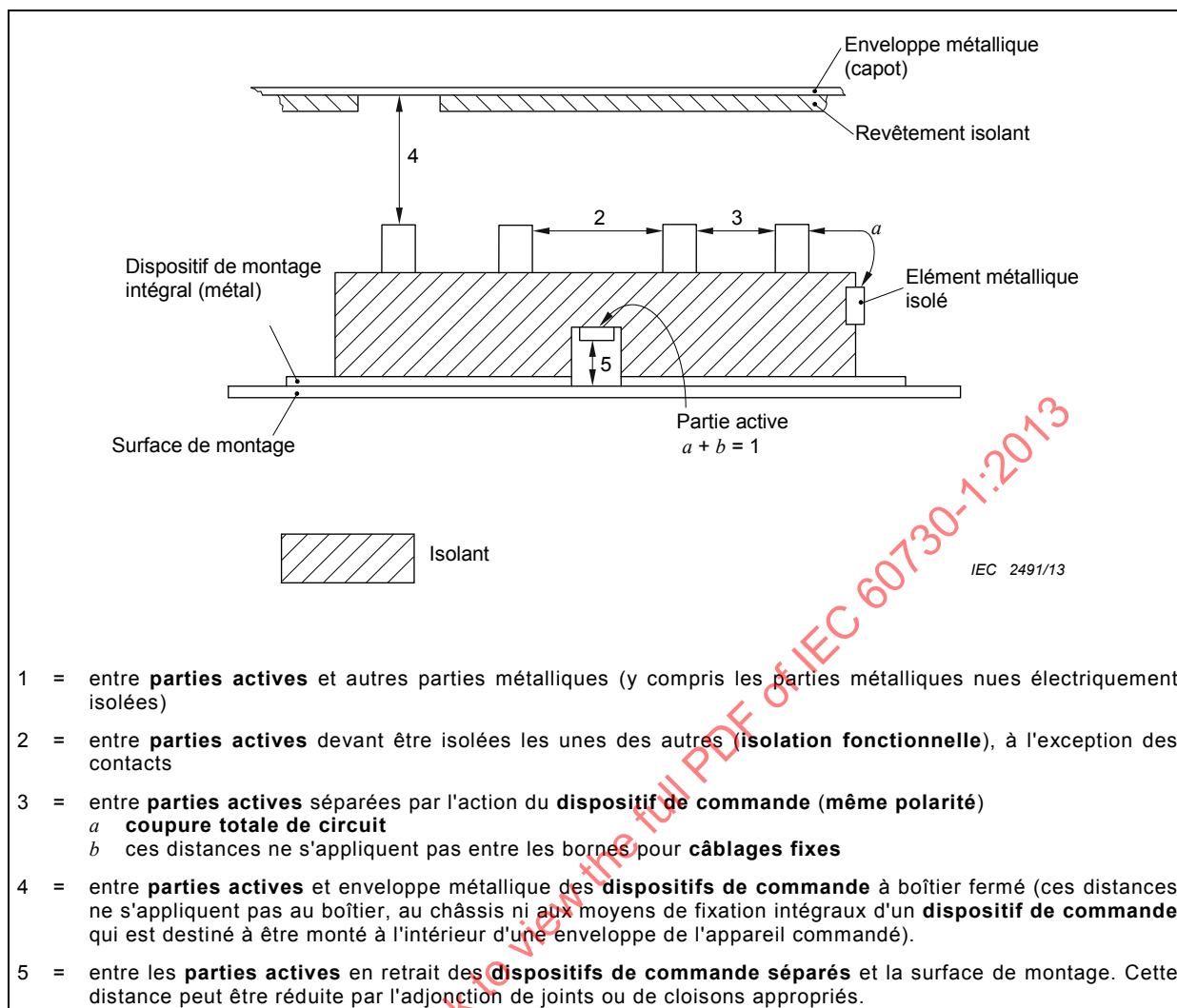
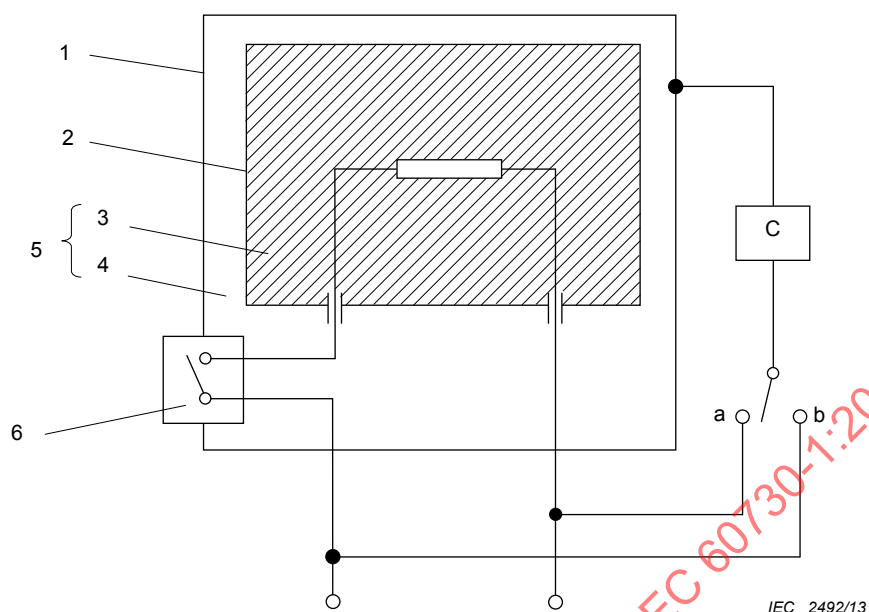


Figure 17 – Mesure des lignes de fuite et des distances dans l'air

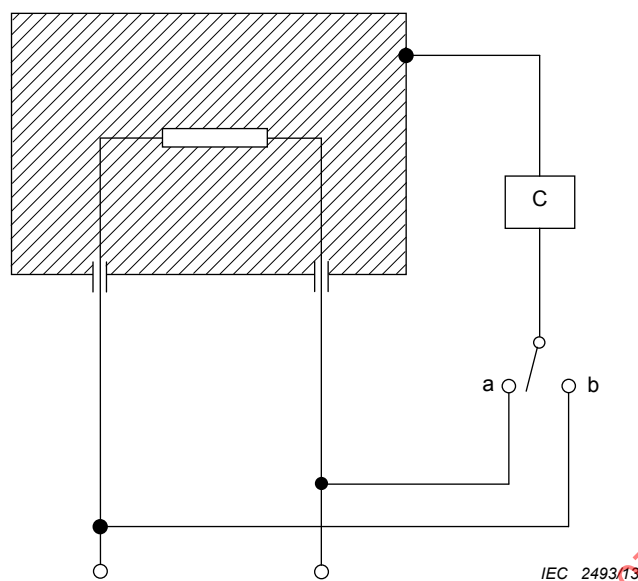
## Figures 18 à 24 Vacant



## Légende

- C circuit de la Figure E.1  
 1 **partie accessible**  
 2 **partie métallique inaccessible**  
 3 **isolation principale**  
 4 **isolation supplémentaire**  
 5 **double isolation**  
 6 **isolation renforcée**

**Figure 25 – Schéma pour la mesure du courant de fuite à la température de régime pour connexion monophasée des dispositifs de commande de la classe II**



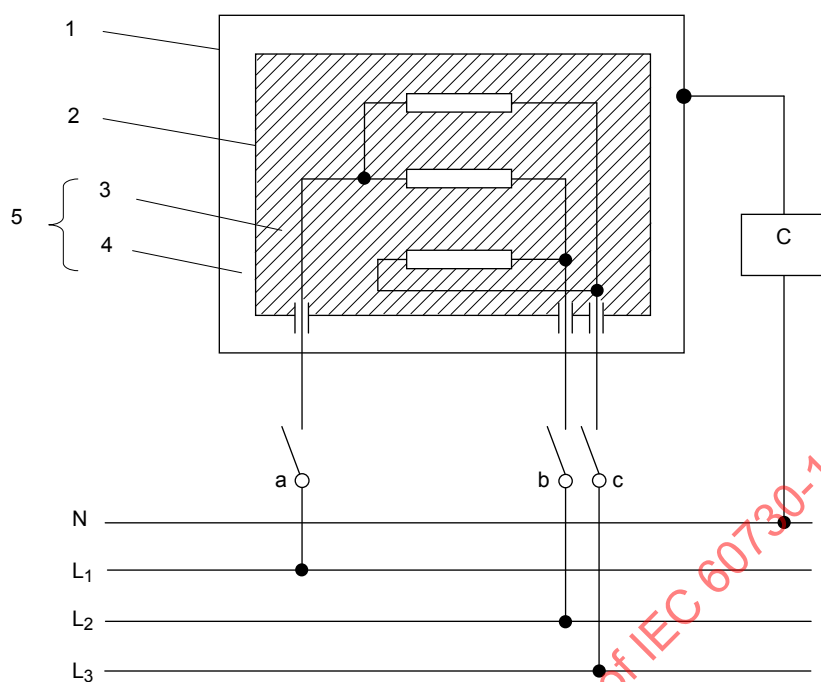
# Légende

C circuit de la Figure E.1

**Figure 26 – Schéma pour la mesure du courant de fuite à la température de régime pour connexion monophasée des dispositifs de commande autres que ceux de la classe II**

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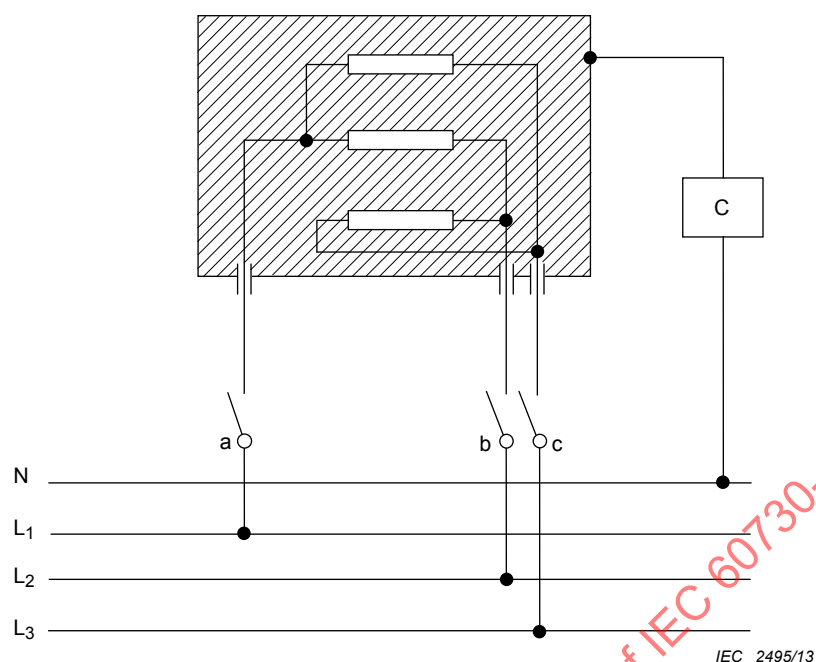
**Légende**

- C circuit de la Figure E.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 27 – Schéma pour la mesure du courant de fuite à la température de régime pour connexions triphasées des dispositifs de commande de la classe II**



**Légende**

C circuit de la Figure E.1

**Connexions et alimentations**

$L_1, L_2, L_3, N$  tension d'alimentation avec neutre

**Figure 28 – Schéma pour la mesure du courant de fuite à la température de régime pour connexions triphasées des dispositifs de commande autres que ceux de la classe II**

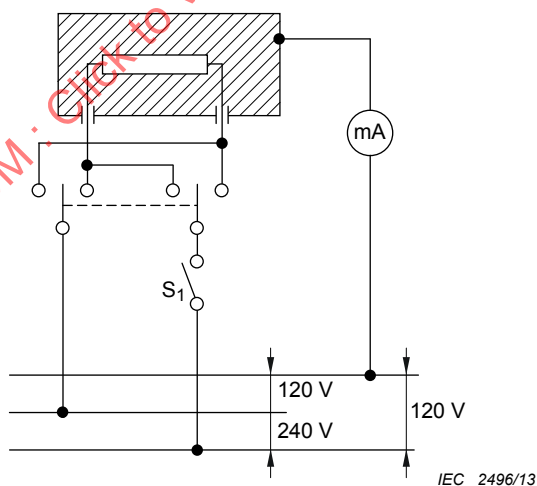
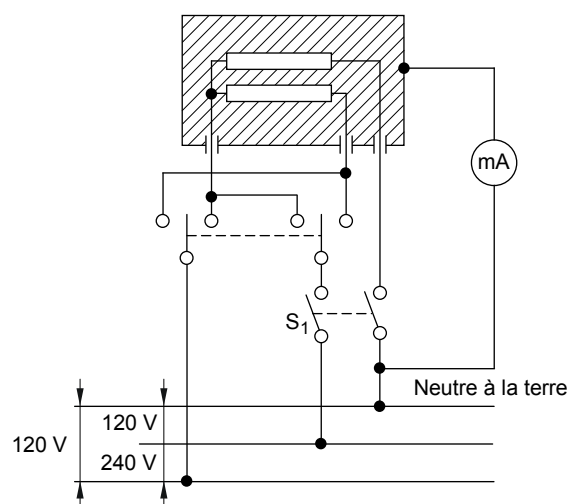


**Figure 29 – Schéma pour la mesure du courant de fuite à la température de régime pour connexion monophasée des dispositifs de commande autres que ceux de la classe II**



IEC 2497/13

**Figure 30 – Schéma pour la mesure du courant de fuite à la température de régime 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 et indications

**A.1** Les marques apposées sur les **dispositifs de commande** doivent être suffisamment indélébiles pour la sécurité et font donc l'objet d'un classement selon les exigences relatives à leur indélébilité:

**A.1.1** Marques facultatives dans le cadre des exigences de la présente norme.

**A.1.2** Marques obligatoires dans le cadre des exigences de la présente norme, mais inaccessibles à l'**utilisateur** final, après le montage ou l'intégration du **dispositif de commande** dans le matériel.

Il faut que ces marques soient suffisamment indélébiles pour résister aux manipulations dans les ateliers du **fabricant du dispositif 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 marques doivent en outre rester lisibles au cas où elles seraient exposées à des vapeurs de solvants ou autres produits agressifs.

**A.1.3** Marques obligatoires dans le cadre des exigences de la présente norme 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.1.2, ces marques 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 et autres commandes doivent être particulièrement résistantes aux **manœuvres** manuelles continues de l'utilisateur. Il convient que les autres marques résistent aux nettoyages, polissages, etc.

**A.1.4** La conformité aux exigences d'indélébilité de A.1.2 et A.1.3 est vérifiée par l'application des essais de l'Article A.2 ou A.3 à l'aide de l'appareil de la Figure 8.

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 normalisé doit consister en 12 allers et retours (soit 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 suivants sont employés pour l'essai:

- un détergent liquide neutre obtenu par mélange d'un alkyl sulfonate de benzène et de détergents non ioniques;
- de l'essence minérale (solvant d'hexane aliphatique ayant une teneur maximale en aromates de 0,1 % en volume, une valeur de Kauributanol de 29, un point d'ébullition initiale d'environ 65 °C, un point d'évaporation d'environ 69 °C et une masse volumique d'environ 0,68 g/cm<sup>3</sup>); et
- de l'eau.

**A.2** La conformité aux exigences de l'indélébilité des marques entrant dans la classe de A.1.2 est vérifiée par les essais suivants:

**A.2.1** Les marques 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  $(40 \pm 5) ^\circ\text{C}$  finement pulvérisée ou en frottant avec un chiffon humide.

**A.2.2** On doit laisser complètement sécher l'échantillon à la température ambiante de  $(25 \pm 5) ^\circ\text{C}$ .

**A.2.3** L'échantillon ainsi traité doit ensuite être soumis à un essai de frottement exécuté avec l'appareil de la Figure 8, 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 de la marque ne permet pas d'employer l'appareil pour blanchir ou frotter (par exemple, si elle 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, la marque doit rester lisible.

**A.3** La conformité aux exigences de l'indélébilité des marques entrant dans la classe de A.1.3 est vérifiée par les essais suivants:

**A.3.1** La marque doit être soumise à un essai de frottement à sec exécuté avec l'appareil de la Figure 8, en utilisant un tissu sec et un poids de 750 g.

**A.3.2** La marque doit ensuite être soumise à un essai de frottement avec un tissu imbibé d'eau et un poids de 750 g.

**A.3.3** Le marque doit 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  $(40 \pm 5) ^\circ\text{C}$  finement pulvérisée ou en frottant avec un chiffon humide.

**A.3.4** Après un séchage complet de la surface ainsi traitée, les marques doivent être soumises 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 à partir de 7,5 mm pour permettre de mieux atteindre la marque 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, la marque doit rester lisible.

## 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**, on part des hypothèses suivantes,  $D$  étant la **distance dans l'air** pour les dimensions considérées (voir les Figures B.1 à 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  $80^\circ$  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, on considère que la **ligne de fuite** suit le profil de l'encoche, sauf spécification contraire ci-dessus (voir Figure B.2);
- pour des pièces 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 considération 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 aux Figures B.1 à B.10, on utilise l'identification suivante:

.....

est une **ligne de fuite**;

—————

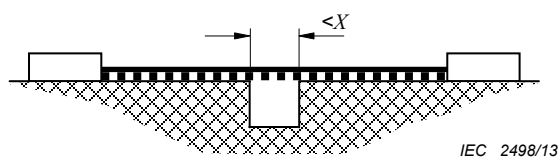
est une **distance dans l'air**.

Pour les valeurs de  $X$ , voir le Tableau B.1.

Tableau B.1 – Valeurs de  $X$

| Degré de pollution | Largeur $X$ des sillons:<br>valeur minimales<br>mm |
|--------------------|----------------------------------------------------|
| 1                  | 0,25                                               |
| 2                  | 1,0                                                |
| 3                  | 1,5                                                |
| 4                  | 2,5                                                |

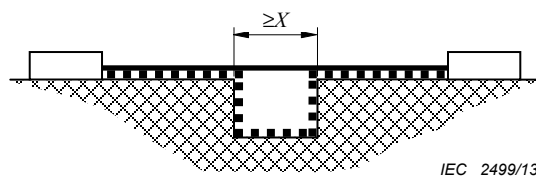
Si la **distance dans l'air** associée est inférieure à 3 mm, la largeur minimale du sillon peut être réduite au tiers de cette **distance dans l'air**.



Ce chemin de ligne de fuite 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**

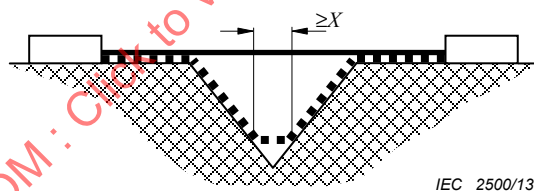


Ce chemin de ligne de fuite comporte une encoche de profondeur quelconque et de largeur égale ou supérieure à  $X$ .

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**



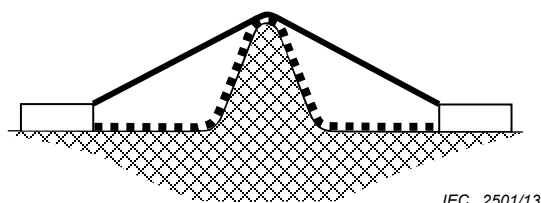
Ce chemin de ligne de fuite comporte une encoche en V dont la largeur est supérieure ou égale à  $X$ .

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**

————— Distance dans l'air      ..... Ligne de fuite

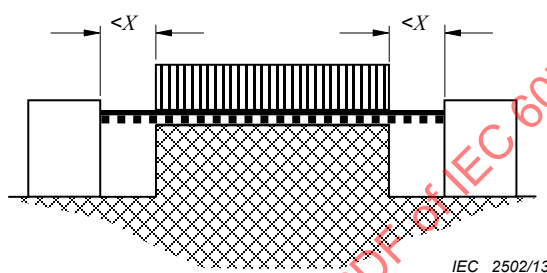


Ce chemin de ligne de fuite comporte une nervure.

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.

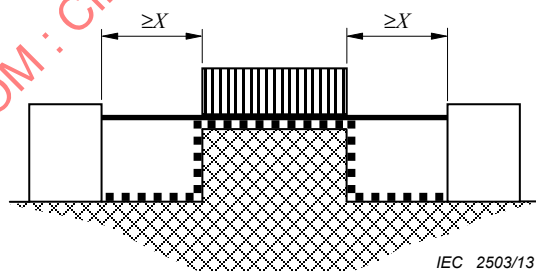
**Figure B.4 – Nervure**



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 illustré.

**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 égale ou supérieure à  $X$ .

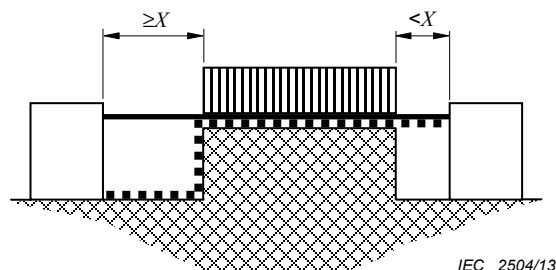
Règle: Le chemin de la **distance dans l'air** est la distance en ligne droite comme illustré.

Le chemin de la **ligne de fuite** longe le profil des encoches.

**Figure B.6 – Partie non collée avec encoche large**

— Distance dans l'air      ■■■■■■■■ Ligne de fuite

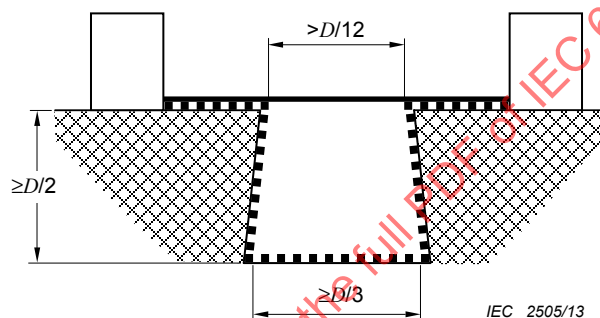




Ce chemin de ligne de fuite comporte une partie non collée avec une encoche de largeur inférieure à  $X$  d'un côté et une encoche de largeur égale ou supérieure à  $X$  de l'autre côté.

Règle: Le chemin de la **distance dans l'air** et de la **ligne de fuite** est comme illustré.

**Figure B.7 – Partie non collée avec encoche étroite et encoche large**



Ce chemin de ligne de fuite comporte une encoche à flancs divergents, dont la profondeur est égale ou supérieure à  $D/2$  et dont la largeur est égale ou supérieure à  $D/12$  pour la partie la plus étroite, et égale ou supérieure à  $D/3$  à la base.

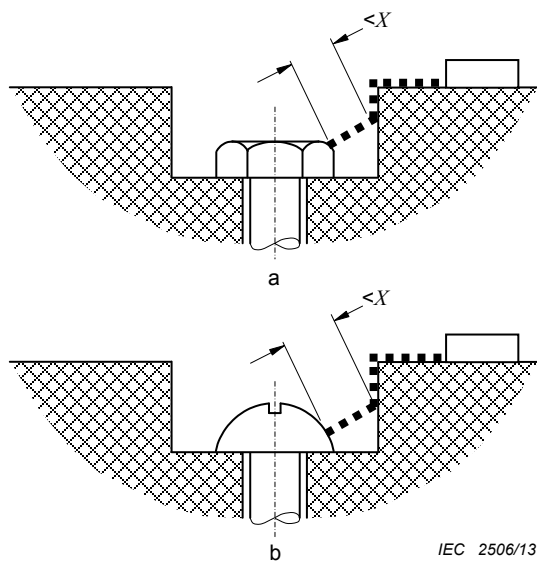
Règle: Le chemin de la **distance dans l'air** est la distance en ligne droite.

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  $80^\circ$ .

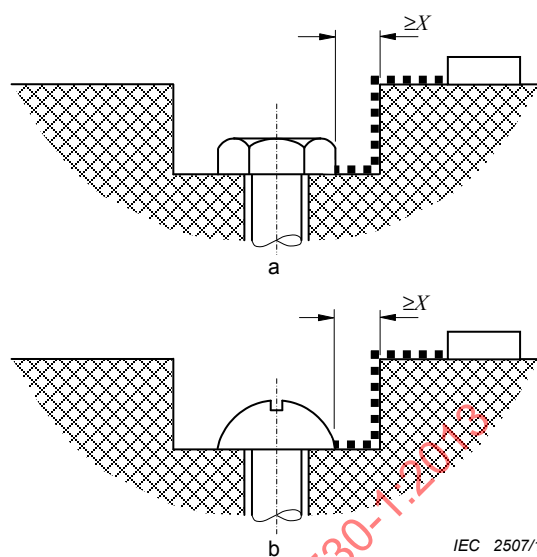
**Figure B.8 – Flancs divergents**

— Distance dans l'air      ..... Ligne de fuite



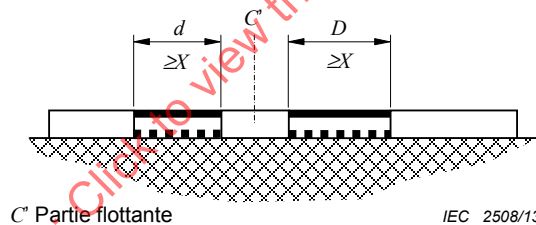
Distance entre tête de vis et paroi de logement trop faible pour être comptée pour le chemin de la ligne de fuite.

**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  $d + D$

La ligne de fuite est aussi  $d + D$

**Figure B.11 – Partie flottante conductrice**

— Distance dans l'air      ..... Ligne de fuite

## **Annexe C** (normative)

### **Coton utilisé pour l'essai des interrupteurs au mercure (ne s'applique pas dans les pays membres du CENELEC)**

#### **C.1 Classification**

Non stérile.

#### **C.2 Exigences générales**

Le coton absorbant doit être fait de fibres croisées, blanchies, exemptes d'impuretés ou de matériaux gras.

#### **C.3 Longueur des fibres**

Au moins 60 % des fibres, en poids, doivent mesurer au moins 12 mm de longueur; pas plus de 10 % des fibres, en poids, peuvent mesurer 6 mm de longueur ou moins.

#### **C.4 Hydrophilie**

Un échantillon du coton doit être complètement submergé par l'eau en moins de 10 s. L'échantillon doit retenir pas moins de 24 fois sa masse d'eau.

#### **C.5 Acidité et alcalinité**

L'eau extraite du coton doit être neutre.

#### **C.6 Résidus sur allumage**

Il ne doit pas y avoir plus de 0,2 % de résidus.

#### **C.7 Matériau soluble dans l'eau**

Il ne doit pas y avoir plus de 0,25 % de résidus.

#### **C.8 Matières grasses**

Il ne doit y avoir aucune trace de couleur bleue, verte ou brunâtre dans la solution d'éther et la quantité de résidus ne doit pas dépasser 0,7 %.

#### **C.9 Teintures**

Il ne doit y avoir aucune trace de teinture bleue ou verte. Une légère trace de jaune est admissible.

#### **C.10 Autres matières étrangères**

Les pincées de coton prélevées pour détermination de la longueur des fibres doivent être exemptes de taches d'huile ou de particules métalliques.

**Annexe D**  
(informative)

**Chaleur, feu et courant de cheminement**

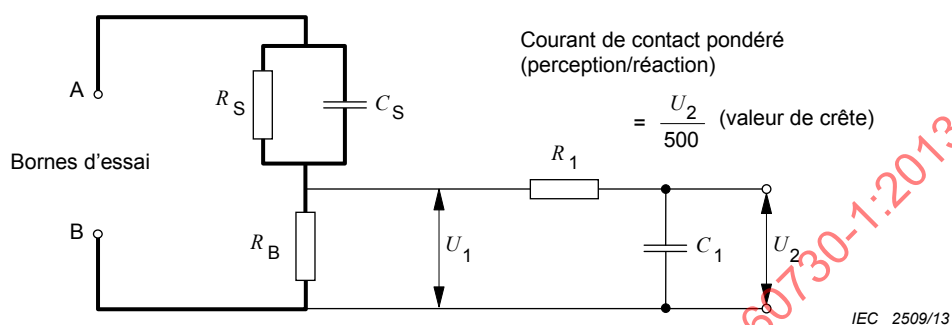
L'UL 746C est applicable au Canada et aux États-Unis. Une révision est à l'étude.

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## Annexe E (normative)

### Circuit de mesure des courants de fuite

Un circuit approprié à la mesure des **courants de fuite** conformément à H.8.1.10 est représenté à la Figure E.1.



|       |                    |       |                     |
|-------|--------------------|-------|---------------------|
| $R_S$ | 1 500 $\Omega$     | $R_1$ | 10 000 $\Omega$     |
| $R_B$ | 500 $\Omega$       | $C_1$ | 0,022 $\mu\text{F}$ |
| $C_S$ | 0,22 $\mu\text{F}$ |       |                     |

NOTE Cette figure est issue de la CEI 60990:1999, Figure 4.

**Figure E.1 – Circuit de mesure des courants de fuite**

## **Annexe F** (informative)

### **Essais relatifs aux dangers du feu**

Les informations pour les **dispositifs de commande** à intégrer ou incorporer dans des appareils conformes à la série CEI 60335 sont données par référence à la CEI 60335-1.

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## Annexe G (normative)

### Essais de résistance à la chaleur et au feu

#### G.1 Vacant

#### G.2 Essai au fil incandescent

*L'essai au fil incandescent est effectué conformément à la CEI 60695-2-10 et à la CEI 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.3 Vacant

#### G.4 Essai de résistance et de tenue au cheminement

*L'essai de résistance et de tenue au cheminement est effectué conformément à la CEI 60112.*

*Pour les besoins de cette norme, ce qui suit s'applique:*

- *A l'Article 5 de la CEI 60112:2003, Eprouvette, la Note 3 s'applique aussi aux essais de résistance et de tenue au cheminement de l'Article 10 de la CEI 60112:2003.*
- *A l'Article 7 de la CEI 60112:2003, Appareillage d'essai, la Note 1 en 7.1 ne s'applique pas. On utilise la solution d'essai A décrite en 7.3 de la CEI 60112:2003, Amendement 1:2009.*
- *En 7.3 de la CEI 60112:2003, Amendement 1:2009, Solutions d'essai, la solution A doit généralement être utilisée.*
- *En 8.2 de la CEI 60112:2003 "Préparation", la tension indiquée dans la dernière phrase est établie en 21.2.7 de la présente norme. L'essai de résistance et de tenue au cheminement de l'Article 10 de la CEI 60112:2003 est réalisé, cinq fois.*

#### G.5 Essai à la bille

*L'essai à la bille est effectué conformément à la CEI 60695-10-2 (voir Figure 6 pour l'appareillage d'essai).*

##### G.5.1 Essai à la bille 1

*Pour les besoins de la présente norme, 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 14,*
- *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 la CEI 60335-1, 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.

### **G.5.2 Essai à la bille 2**

*L'essai à la bille est effectué comme décrit en G.5.1, excepté que la température dans le four chauffant doit être de  $T_b \pm 2\text{ °C}$ ,  $T_b$  étant égal à la plus grande des valeurs suivantes:*

- 100 °C lorsque  $T_{\text{max}}$  est de 30 °C jusqu'à 55 °C non compris;
- 125 °C lorsque  $T_{\text{max}}$  est de 55 °C jusqu'à 85 °C non compris;
- $T_{\text{max}} + 40\text{ °C}$  si  $T_{\text{max}}$  est de 85 °C ou plus;
- 20 K au-dessus de la température maximale enregistrée pendant l'essai d'échauffement de l'Article 14;
- la température obtenue pendant l'essai de H.27.1.1.3 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 la CEI 60335-1, la température peut différer selon 30.1 de la norme citée.

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## Annexe H (normative)

### Exigences pour les dispositifs de commande électroniques

L'Annexe H complète ou modifie les articles correspondants de la présente norme.

#### H.2 Termes et définitions

##### H.2.4 Définitions relatives aux coupures et interruptions de circuit

###### H.2.4.2 Addition:

NOTE Un **dispositif électronique** n'assure pas cette coupure.

###### H.2.4.3 Addition:

NOTE Un **dispositif électronique** n'assure pas cette coupure.

###### H.2.4.4 Addition:

NOTE Un **dispositif électronique** n'assure pas cette coupure.

*Ajouter la définition suivante:*

###### H.2.4.6

###### **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 36 du Tableau 1.

La coupure peut être obtenue par une **manœuvre automatique** ou par une **manœuvre manuelle**.

Quelques **dispositifs de commande** peuvent comporter des circuits de coupure ayant plus d'une configuration.

Une **coupure électronique** peut ne pas convenir pour certaines applications. Voir l'Article H.28.

##### H.2.5 Définitions concernant la classification des dispositifs de commande d'après leur construction

*Ajouter les définitions suivantes:*

###### H.2.5.7

###### **dispositif de commande électronique**

**dispositif de commande** qui comporte au moins un **dispositif électronique**

###### H.2.5.8

###### **dispositif électronique**

dispositif qui produit un déséquilibre dynamique d'électrons

Note 1 à l'article: La fonction essentielle et la construction sont basées sur la technologie des dispositifs à semi-conducteurs, des tubes à vide ou des tubes à décharge dans un gaz.

### H.2.5.9

#### **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 imprimée.

### H.2.5.10

#### **circuit intégré**

**dispositif électronique** contenu dans la masse d'un matériau semi-conducteur et interconnecté à la surface, ou près de la surface, de ce matériau

Note 1 à l'article: Le matériau semi-conducteur est normalement enfermé dans un milieu enrobé.

### H.2.5.11

#### **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

## H.2.7 Définitions concernant la protection contre les chocs électriques

*Ajouter la définition suivante:*

### H.2.7.14

#### **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

*Ajouter les définitions suivantes:*

## H.2.16 Définitions relatives à la structure des dispositifs de commande utilisant des logiciels

### H.2.16.1

#### **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 **panne/ erreur 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.2.16.2

#### **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.2.16.3

#### **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**