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Circuit-breakers for equipment (CBE)

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CIRCUIT-BREAKERS FOR EQUIPMENT (CBE)

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60934 has been prepared by subcommittee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

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

FDIS	Report on voting
23E/1084/FDIS	23E/1104/RVD

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

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

This fourth edition cancels and replaces the third edition published in 2000, Amendment 1:2007 and Amendment 2:2013. This edition constitutes a technical revision.

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

a) clarifications for type testing purposes.

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.

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

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- withdrawn,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

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CIRCUIT-BREAKERS FOR EQUIPMENT (CBE)

1 Scope ~~and object~~

~~This International Standard is applicable to mechanical switching devices designed as "circuit-breakers for equipment" (CBE) intended to provide protection to circuits within electrical equipment.~~

~~NOTE 1 The term "equipment" includes appliances.~~

~~NOTE 2 The protected components are usually motors, transformers, internal wiring, etc.~~

~~CBEs may have a rated short-circuit capacity higher than that required for overload conditions and may, in addition, have a conditional short-circuit current rating in association with a specified short-circuit protective device (SCPD).~~

~~This standard is also applicable to switching devices for protection of electrical equipment in case of undervoltage and/or overvoltage.~~

~~It is applicable for a.c. not exceeding 440 V and/or d.c. not exceeding 250 V and a rated current not exceeding 125 A.~~

~~This standard covers CBEs which are intended for~~

- ~~automatic interruption and non-automatic or automatic resetting;~~
- ~~automatic interruption and non-automatic or automatic resetting and manual switching operation.~~

~~It also covers CBE-switches, in which the means for automatic interruption are inhibited or not present by construction (see 3.1.3).~~

~~NOTE 3 This standard may be used as a guiding document for voltages up to 630 V a.c.~~

~~NOTE 4 Requirements for CBEs suitable for isolation are under consideration.~~

~~This standard contains all the requirements necessary to ensure compliance with the operational characteristics required for these devices by type tests.~~

~~It also contains the details relative to test requirements and methods of testing necessary to ensure reproducibility of test results.~~

This document is applicable to mechanical switching devices designed as "circuit-breakers for equipment" (CBE) for household and similar applications. CBEs according to this document are intended to provide protection to circuits within electrical equipment including its components (e.g. motors, transformers, internal wiring). This document covers also CBEs applicable for protection of electrical equipment in case of undervoltage and/or overvoltage. This document also covers CBEs which are suitable for isolation.

NOTE The term "equipment" includes appliances.

CBEs are not applicable for overcurrent protection of wiring installations of buildings.

CBEs according to this document have:

- a rated voltage not exceeding 440 V AC (between phases) and/or DC not exceeding 250 V;

– a rated current not exceeding 125 A;
– a short-circuit capacity (I_{cn}) of at least 6 × I_n (AC types) and 4 × I_n (DC types) but not exceeding 3 000 A.

CBEs may have a conditional short-circuit current (I_{nc}) rating in association with a specified short-circuit protective device (SCPD). A guide for coordination of a CBE associated in the same circuit with a SCPD is given in Annex F.

For CBEs having a degree of protection higher than IP20 according to IEC 60529, for use in locations where hazardous environmental conditions prevail (e.g. excessive humidity, heat or cold or deposition of dust) and in hazardous locations (e.g. where explosions are liable to occur), special constructions may be required.

This document contains all the requirements necessary to ensure compliance with the operational characteristics required for these devices by type tests. It also contains the details relative to test requirements and methods of testing necessary to ensure reproducibility of test results.

This document states:

a) the characteristics of CBEs;
b) the conditions with which CBEs shall comply, with reference to:
   1) their operation and behaviour in normal service;
   2) their operation and behaviour in case of overload;
   3) their operation and behaviour in case of short-circuits up to their rated short-circuit capacity;
   4) their dielectric properties;
c) the tests intended for confirming that these conditions have been met and the methods to be adopted for the tests;
d) the data to be marked on the devices;
e) the test sequences to be carried out and the number of samples to be submitted for certification purposes (see Annex C);
f) the routine tests to be carried out to reveal unacceptable variations in material or manufacture, likely to affect safety (see Annex I).

2 Normative references

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

~~IEC 60050(151):1978, *International Electrotechnical Vocabulary (IEV) – Chapter 151: Electrical and magnetic devices*~~

~~IEC 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*~~

~~IEC 60050(604):1987, *International Electrotechnical Vocabulary (IEV) – Chapter 604: Generation, transmission and distribution of electricity – Operation*~~

~~IEC 60050(826):1982, *International Electrotechnical Vocabulary (IEV) – Chapter 826: Electrical installations of buildings*~~
~~Amendment 1 (1990)~~

~~Amendment 2 (1995)~~
~~Amendment 3 (1999)~~

IEC 60060-1:~~1989~~ 2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-20:~~1979~~, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

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

IEC 60227 (all parts), *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*

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

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

~~IEC 60417-1:1998, *Graphical symbols for use on equipment – Part 1: Overview and application*~~

IEC 60529:~~1989~~, *Degrees of protection provided by enclosures (IP Code)*

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

IEC 60664-1:~~1992~~ 2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 60664-3:~~1992~~, *Insulation coordination for equipment within low-voltage systems – Part 3: ~~Use of coatings to achieve insulation coordination of printed board assemblies~~ Use of coating, potting or moulding for protection against pollution*

~~IEC 60695-2-1 (all sheets), *Fire hazard testing – Part 2: Test methods – Section 1: Glow-wire test methods*~~

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

~~IEC 60898:1995, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations*~~

IEC 60898-1:2015, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 1: Circuit-breakers for a.c. operation*

~~IEC 60947-1:1999, *Low-voltage switchgear and controlgear – Part 1: General rules*~~

~~IEC 60950:1999, *Safety of information technology equipment*~~

IEC 61000-4-2:~~1995~~, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – ~~Section 2:~~ Electrostatic discharge immunity test ~~– Basic EMC Publication~~* ~~2)~~

~~1) There is a consolidated edition 3.1 (1999) that includes IEC 60099-1 (1991) and its amendment 1 (1999).~~

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Section 3: Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test – Basic EMC Publication*

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Section 5: Surge immunity test*

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

CISPR 22:1997, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

CISPR 32, *Electromagnetic compatibility of multimedia equipment – Emission requirements*

3 Terms and definitions

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

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

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

3.1 Definitions related to protection and switching devices

3.1.1
circuit-breaker
mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time duration and breaking currents under specified abnormal conditions such as those of short circuit

[SOURCE: IEC 60050-441:1984, 441-14-20]

3.1.2
circuit-breaker for equipment
CBE
circuit-breaker specifically designed for the protection of equipment

Note 1 to entry: These CBEs are intended for:

– automatic interruption and non-automatic or automatic resetting;

– automatic interruption and non-automatic or automatic resetting and manual switching operation.

3.1.3
CBE-switch
CBE without overcurrent releases, equipped or not with releases tripping by voltage or by mechanical means

NOTE The relevant specific requirements are given in annex K.

[2] There is a consolidated edition 1.1 (1999) that includes IEC 61000-4-2 (1995) and its amendment 1 (1998).

3.1.3
E-type CBE
void

3.1.4
fuse
device that, by the fusing of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all of the parts that form the complete device

[SOURCE: IEC 60050-441:1984, 441-18-01]

3.1.5
switching device
device designed to make or break the current in one or more electric circuits

[SOURCE: IEC 60050-441:1984, 441-14-01]

3.1.6
mechanical switching device
switching device designed to close and open one or more electric circuits by means of separable contacts

[SOURCE: IEC 60050-441:1984, 441-14-02, modified – The note has been deleted.]

3.1.7
switch
~~(~~mechanical~~)~~ switch
mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions which may include specified operating overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions such as those of short circuit

[SOURCE: IEC 60050-441:1984, 441-14-10, modified – The note has been deleted.]

3.1.8
disconnector
mechanical switching device which in the open position complies with the requirements specified for the isolating function

[SOURCE: IEC 60050-441:1984, 441-14-05, modified – The wording of the definition has been changed and the note deleted.]

3.1.9
disconnection
interruption of an electrical circuit in a pole so as to provide insulation between the supply and those parts intended to be disconnected from the supply

3.1.10
full-disconnection
disconnection that provides the equivalent of basic insulation by contact separation

3.1.11
micro-disconnection
disconnection that provides compliance of performance by contact separation

3.1.12
isolation
isolating function
function intended to cut off the supply from all or a discrete section of the installation by separating the installation from every source of electrical energy for reasons of safety

3.2 General terms

3.2.1
ambient air temperature
temperature, determined under prescribed conditions, of the air surrounding the complete CBE

Note 1 to entry: For example, for an enclosed CBE, it is the air outside the enclosure.

[SOURCE: IEC 60050-441:1984, 441-11-13, modified –"complete switching device or fuse" has been replaced by "CBE".]

3.2.2
applied voltage
voltage which exists across the terminals of a pole of a CBE just before the making of the current

Note 1 to entry: In the case of AC, it is the RMS value.

[SOURCE: IEC 60050-441:1984, 441-17-24, modified – "switching device" has been replaced by "CBE". Note 1 to entry has been added.]

3.2.3
main circuit
<of a CBE> all the conductive parts of a CBE included in the circuit which it is designed to close and to open

[SOURCE: IEC 60050-441:1984, 441-15-02, modified – "switching device" has been replaced by "CBE".]

3.2.4
control circuit
<of a CBE> circuit (other than a path of the main circuit) intended for the closing operation or opening operation, or both, of a CBE

[SOURCE: IEC 60050-441:1984, 441-15-03, modified – "switching device" and "device" have been replaced by "CBE".]

3.2.5
auxiliary circuit
<of a CBE> all the conductive parts of a CBE intended to be included in a circuit other than the main circuit and the control circuit of the CBE

[SOURCE: IEC 60050-441:1984, 441-15-04, modified – "switching device" and "device" have been replaced by "CBE" and the note has been deleted.]

3.2.6
pole
<of a CBE> part of a CBE associated exclusively with one, electrically separated, conducting path of its main circuit provided with contacts intended to connect and disconnect the main circuit itself and excluding those portions which provide a means for mounting and operating the poles together

[SOURCE: IEC 60050-441:1984, 441-15-01, modified – "provided with contacts intended to connect and disconnect the main circuit itself" has been added, "switching device" has been replaced by "CBE" and the note has been deleted.]

3.2.7
protected pole
pole provided with an overcurrent release

Note 1 to entry: For the definition of overcurrent release, see 3.6.2.

3.2.8
unprotected pole
pole without overcurrent release but otherwise generally capable of the same performance as a protected pole of the same CBE

Note 1 to entry: For the definition of overcurrent release, see 3.6.2.

3.2.9
neutral conductor
N
conductor electronically connected to the neutral point ~~of a system~~ and capable of contributing to the transmission of electrical energy

~~[IEV 826-01-03]~~

[SOURCE: IEC 60050-826:2004, 826-14-07]

3.2.10
closed position
position in which the predetermined continuity of the main circuit of a CBE is secured

[SOURCE: IEC 60050-441:1984, 441-16-22, modified – "device" has been replaced by "CBE"]

3.2.11
open position
position in which the predetermined clearance between open contacts in the main circuit of a CBE is provided

[SOURCE: IEC 60050-441:1984, 441-16-23, modified – "device" has been replaced by "CBE"]

3.2.12
incorporated mounting
method of mounting where the user provides in his or her equipment a cavity to fix the CBE in its position

3.3 Definitions related to current

3.3.1
current
flow of electric charge through a conductor

3.3.2
rated current
current assigned by the manufacturer for a specified operating condition of the CBE

3.3.3
overcurrent
current exceeding the rated current

[SOURCE: IEC 60050-441:1984, 441-11-06]

3.3.4
overload current
overcurrent that occurs in an electrically undamaged circuit

3.3.5
short-circuit current
overcurrent resulting from a fault of negligible impedance between points intended to be at different potentials in normal service ~~[IEV 441-11-07, modified]~~

Note 1 to entry: A short-circuit current may result from a fault or from an incorrect connection.

3.3.6
conventional tripping current
I_t
specified value of current which causes a CBE to operate within a specified time (conventional time)

3.3.7
conventional non-tripping current
I_{nt}
specified value of current which a CBE is capable of carrying for a specified time (conventional time) without tripping

3.3.8
instantaneous tripping current
I_i
value of current for which a CBE will operate automatically without intentional time-delay within a time less than 0,1 s

3.3.9
instantaneous non-tripping current
I_{ni}
value of current for which a CBE will not operate automatically without intentional time-delay within a time equal to or less than 0,1 s

3.4 Definitions related to voltage

3.4.1
rated voltage
value of voltage assigned by the manufacturer to a CBE or to its components and to which operation and performance characteristics are referred

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

3.4.2
working voltage
highest value of the AC or DC voltage across any particular insulation which can occur when a CBE is supplied at rated voltage

Note 1 to entry: Transients are disregarded.

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

3.4.3
overvoltage
~~any~~ voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions

3.4.4
temporary overvoltage
overvoltage at power frequency of relatively long duration

3.4.5
transient overvoltage
~~short-duration~~ overvoltage with a duration of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

~~[IEV 604-03-13]~~

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

3.4.6
temporary withstand voltage
highest value of a temporary overvoltage which does not cause breakdown of insulation under specified conditions

3.5 Definitions related to constructional elements of a CBE

3.5.1
accessible part
part which can be touched in normal use

3.5.2
conductive part
part which is capable of conducting current although it may not necessarily be used for carrying service current

[SOURCE: IEC 60050-441:1984, 441-11-09]

3.5.3
exposed conductive part
conductive part which can readily be touched and which is not normally alive, but which may become alive under fault conditions

Note 1 to entry: Typical exposed conductive parts are walls of metal enclosures, metal operating handles, etc.

[SOURCE: IEC 60050-441:1984, 441-11-10, modified – Note 1 to entry has been reworded.]

3.5.4
live part
conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor or a PEM conductor or a PEL conductor

Note 1 to entry: This term does not necessarily imply a risk of electric shock.

~~[IEV 826-03-01]~~

[SOURCE: IEC 60050-826:2004, 826-12-08]

3.5.5
detachable part
part which can be removed without the aid of a general purpose tool

3.5.6
main contact
contact included in the main circuit of a CBE, intended to carry, in the closed position, the current of the main circuit

[SOURCE: IEC 60050-441:1984, 441-15-07, modified – "mechanical switching device" has been replaced by "CBE".]

3.5.7
auxiliary contact
contact included in an auxiliary circuit of a CBE and mechanically operated by the CBE

[SOURCE: IEC 60050-441:1984, 441-15-10, modified – "of a CBE" has been added and "the switching device" has been replaced by "the CBE".]

3.5.8
control contact
contact included in a control circuit of a CBE and mechanically operated by the CBE

[SOURCE: IEC 60050-441:1984, 441-15-09, modified – "mechanical switching device" and "device" have been replaced by "CBE".]

3.5.9
form A contact
make contact
control or auxiliary contact which is closed when the main contacts of a CBE are closed and open when they are open

[SOURCE: IEC 60050-441:1984, 441-15-12, modified – The term "“a” contact" has been replaced by "form A contact". "mechanical switching device" has been replaced by "CBE".]

3.5.10
form B contact
break contact
control or auxiliary contact which is open when the main contacts of a CBE are closed and closed when they are open

[SOURCE: IEC 60050-441:1984, 441-15-13, modified – The term "“b” contact" has been replaced by "form B contact". "mechanical switching device" has been replaced by "CBE".]

3.5.11
form C contact
make-break contact
control or auxiliary contact which has a make-break three-terminal changeover element

3.5.12
actuator
part of the actuating system to which an external actuating force is applied

[SOURCE: IEC 60050-441:1984, 441-15-22, modified – The note has been deleted.]

3.5.13
actuating system
<of a CBE> all the operating means of a CBE which transmit the actuating force to the contacts

3.5.14
actuating force (moment)
force (moment) applied to an actuator necessary to complete the intended operation

[SOURCE: IEC 60050-441:1984, 441-16-17, modified – "(moment)" has been added.]

3.6 Definitions related to releases in CBEs

3.6.1
release
device, mechanically connected to or integrated into a CBE, which releases the holding means and permits the automatic opening of the CBE

[SOURCE: IEC 60050-441:1984, 441-15-17, modified – "or integrated into" has been added and "mechanical switching device" has been replaced by "CBE".]

3.6.2
overcurrent release
release which causes a CBE to open, with or without time-delay, when the current in the release exceeds a predetermined value

Note 1 to entry: In some cases, this value can depend upon the rate of rise of current.

[SOURCE: IEC 60050-441:1984, 441-16-33, modified – "permits" has been replaced by "causes" and "mechanical switching device" has been replaced by "CBE".]

3.6.3
inverse time-delay overcurrent release
overcurrent release which causes a CBE to open after a time-delay inversely dependent upon the value of the overcurrent

Note 1 to entry: Such a release may be designed so that the time-delay approaches a definite minimum for high values of overcurrent.

3.6.4
direct overcurrent release
overcurrent release directly energized by the current in the main circuit of a CBE

3.6.5
instantaneous overcurrent release
overcurrent release which operates without any intentional time-delay

3.6.6
overload release
overcurrent release intended for protection against overloads

[SOURCE: IEC 60050-441:1984, 441-16-38]

3.6.7
short-circuit release
overcurrent release intended for protection against short circuits

3.6.8
shunt release
release energized by a source of voltage

Note 1 to entry: The source of voltage may be independent of the voltage of the main circuit.

Note 2 to entry: For CBEs, shunt releases independent of the main circuit may be called "relay releases".

[SOURCE: IEC 60050-441:1984, 441-16-41, modified – Note 2 to entry has been added.]

3.6.9
undervoltage release
shunt release which causes a CBE to open, with or without time-delay, when the voltage across the terminals of the release falls below a predetermined value

[SOURCE: IEC 60050-441:1984, 441-16-42, modified – "mechanical switching device" has been replaced by "CBE".]

3.6.10
zero-voltage release
shunt release ~~energized by a source of voltage,~~ which causes a CBE to open if the supply voltage falls below 0,1 times the rated voltage

3.6.11
over-voltage release
shunt release which causes a CBE to open, with or without time-delay, when the voltage across the terminals of the release rises above a predetermined value

3.6.12
thermal overload release
inverse time-delay overload release depending for its operation, including its time-delay, on the thermal action of the current flowing in the release

[SOURCE: IEC 60050-441:1984, 441-16-39]

3.6.13
magnetic overload release
overload release depending for its operation on the force exerted by the current in the main circuit exciting the coil of an electromagnet

Note 1 to entry: Such a release usually has an inverse time-delay/current characteristic.

[SOURCE: IEC 60050-441:1984, 441-16-40]

3.7 Definitions related to insulation coordination ~~and clearances in a CBE~~

3.7.1
functional insulation
insulation between live parts which is necessary only for the proper functioning of the equipment

3.7.2
basic insulation
insulation applied to live parts to provide basic protection against electric shock

Note 1 to entry: Basic insulation does not necessarily include insulation used for functional purposes.

3.7.3
supplementary insulation
independent insulation applied in addition to basic insulation to provide protection against electric shock in the event of failure of basic insulation

3.7.4
reinforced insulation
single insulation system, applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation

Note 1 to entry: A single insulation system does not imply that the insulation must be one homogeneous piece. It may comprise several layers which can not be tested singly as basic or supplementary or reinforced insulation.

3.7.5
double insulation
insulation comprising both basic insulation and supplementary insulation

3.7.6
clearance
shortest distance in air between two conductive parts

~~[IEV 441-17-31, modified]~~

3.7.7
clearance to earth
clearance between any conductive parts and any parts which are earthed or intended to be earthed

[SOURCE: IEC 60050-441:1984, 441-17-33]

3.7.8
clearance between open contacts
gap
total clearance between the contacts, or any conductive parts connected thereto, of a pole of a ~~mechanical switching device~~ CBE in the open position

[SOURCE: IEC 60050-441:1984, 441-17-34, modified – "mechanical switching device" has been replaced by "CBE".]

3.7.9
isolating distance
<of a pole of a CBE> clearance between contacts meeting the safety requirements specified for disconnectors

[SOURCE: IEC 60050-441:1984, 441-17-35, modified – "mechanical switching device" has been replaced by "CBE".]

3.7.10
creepage distance
shortest distance along the surface of ~~the~~ a solid insulating material between two conductive parts

~~[IEV 151-03-37]~~

[SOURCE: IEC 60050-151:2001, 151-15-50]

3.7.11
insulation coordination
mutual correlation of insulation characteristics of electrical equipment taking into account the expected micro-environment and other influencing stresses

3.7.12
impulse withstand voltage
highest peak value of an impulse voltage of prescribed form and polarity, which does not cause breakdown under specified conditions

3.7.13
power-frequency withstand voltage
RMS value of a power-frequency sinusoidal voltage which does not cause insulation breakdown under specified conditions

3.7.14
pollution
~~any~~ addition of foreign matter, solid, liquid or gaseous (for example, ionized gases) that may affect dielectric strength or surface resistivity of the insulation

3.7.15
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 ~~2.5.1~~ 4.6.2 of IEC 60664-1:2007).

3.7.16
overvoltage category
conventional number based on limiting or controlling the values of prospective overvoltages occurring in a circuit and depending on the means employed to influence the overvoltages

3.7.17
homogeneous field
electric field which has an essentially constant voltage gradient between electrodes (uniform field) such as that between two spheres where the radius of each sphere is greater than the distance between them

3.7.18
inhomogeneous field
electric field which ~~has~~ does not have an essentially constant voltage gradient between electrodes (non-uniform field)

3.7.19
macro-environment
environment of the room or other location in which the equipment is installed or used

3.7.20
micro-environment
immediate environment of the insulation which particularly influences the dimensioning of creepage distances

3.8 Definitions related to operation of CBEs

3.8.1
operation
transfer of the moving contact(s) from the open position to the closed position or vice versa

Note 1 to entry: If a distinction is necessary, an operation in the electrical sense (for example, make or break) is referred to as a switching operation and an operation in the mechanical sense (for example, close or open) is referred to as a mechanical operation.

[SOURCE: IEC 60050-441:1984, 441-16-01, modified – "from one position to an adjacent position" has been replaced by "from the open position to the closed position or vice versa" and Note 1 has been deleted.]

3.8.2
operating cycle
succession of operations from one position to another and back to the first position

[SOURCE: IEC 60050-441:1984, 441-16-02, modified – "through all other positions, if any" has been deleted.]

3.8.3
operating sequence
succession of specified operations with specified time intervals

[SOURCE: IEC 60050-441:1984, 441-16-03]

3.8.4
temporary duty
duty in which the main contacts of an equipment remain closed for periods insufficient to reach thermal equilibrium, the on-load periods being separated by off-load periods of sufficient duration to restore equality of temperature with the cooling medium

3.8.5
uninterrupted duty
duty in which the main contacts of a CBE remain closed whilst carrying a steady current without interruption for long periods (which could be weeks, months or even years)

3.8.6
intermittent duty
duty with on-load periods, in which the main contacts of an equipment remain closed, having a definite relationship to off-load periods, both periods being too short to allow the equipment to reach thermal equilibrium

3.8.7
closing operation
operation by which a CBE is brought from the open position to the closed position

[SOURCE: IEC 60050-441:1984, 441-16-08, modified – "device" has been replaced by "CBE".]

3.8.8
opening operation
operation by which a CBE is brought from the closed position to the open position

[SOURCE: IEC 60050-441:1984, 441-16-09, modified – "device" has been replaced by "CBE".]

3.8.9
trip-free CBE
CBE, the contacts of which return to, and remain in, the open position when the automatic opening operation is initiated after the initiation of the closing operation even if the closing command is maintained

Note 1 to entry: CBEs of this design may be referred to as positively trip-free.

[SOURCE: IEC 60050-441:1984, 441-16-31, modified – "device" has been replaced by "CBE".]

3.8.10
cycling trip-free CBE
CBE, the moving contacts of which return to the open position when the automatic opening operation is initiated after the initiation of the closing operation, and which will then reclose repeatedly and momentarily, whilst the closing command is maintained

3.8.11
non-trip-free CBE
CBE, the moving contacts of which will not open when the automatic opening operation is initiated if the closing command is maintained

Note 1 to entry: For conditions of use of non-trip-free CBEs, see 4.8.3.

3.9 Definitions related to the operating characteristic of CBEs

3.9.1
tripping time
time interval from the instant at which the associated tripping current begins to flow in the main circuit to the instant when this current is interrupted (in all poles)

3.9.2
tripping characteristic
time-current characteristic above which a CBE must have tripped

~~[IEV 441-17-13, modified]~~

3.9.3
non-tripping characteristic
time-current characteristic below which a CBE does not trip

3.9.4
tripping zone
time-current zone limited by the characteristics of 3.9.2 and 3.9.3

Note 1 to entry: This zone takes into account the manufacturing and performance tolerances of the CBE.

3.9.5
self-resetting time
time interval from the instant at which the contacts of the main circuit open to the instant when they reclose

3.10 Definitions related to characteristic quantities

3.10.1
rated value
stated value of any one of the characteristic quantities that serve to define the working conditions for which the CBE is designed and built

~~[IEV 151-04-03, modified]~~

3.10.2
limiting value
<in a specification>~~the greatest or smallest admissible value of one of the quantities [IEV 151-04-02]~~

greatest or smallest admissible value of a quantity

[SOURCE: IEC 60050-151:2001, 151-16-10, modified – "component, device, equipment or system" has been deleted.]

3.10.3
rating
set of rated values and operating conditions

~~[IEV 151-04-04]~~

[SOURCE: IEC 60050-151:2001, 151-16-11]

3.10.4
prospective current
current that would flow in a circuit if each pole of a CBE were replaced by a conductor of negligible impedance

[SOURCE: IEC 60050-441:1984, 441-17-01, modified – "the switching device or the fuse" has been replaced by "a CBE".]

3.10.5
switching capacity
making and breaking capacity
value of current that a CBE is capable of making and breaking at a stated voltage under prescribed conditions of use and operation

3.10.6
short-circuit making and breaking capacity
prospective current expressed as its RMS value, which a CBE is designed to make, to carry for its opening time and to break under specified conditions

3.11 Definitions concerning coordination of CBEs and SCPDs associated in the same circuit

3.11.1
short-circuit protective device
SCPD
overcurrent protective means intended to protect a circuit or parts of a circuit against short-circuit currents by interrupting them

3.11.2
back-up protection
overcurrent coordination of two overcurrent protective devices in series where an SCPD ensures the overcurrent protection with or without the assistance of the CBE and prevents any excessive stress on the CBE under prescribed conditions

3.11.3
overcurrent discrimination
selectivity
coordination of the relevant characteristics of a CBE and its SCPD such that on the incidence of overcurrents within stated limits the CBE opens the circuit while the SCPD does not operate

[SOURCE: IEC 60050-441:1984, 441-17-15, modified – “overcurrent protective device" has been replaced by "CBE" and “SCPD".]

3.11.4
selectivity limit current
I_s
~~selectivity limit current (see figure F.1) is a~~ limiting value of current

– below which the CBE completes its breaking operation in time to prevent the SCPD from starting its operation (i.e. selectivity is ensured), and

– above which the CBE may not complete its breaking operation in time to prevent the SCPD from starting its operation (i.e. selectivity is not ensured)

SEE: Figure F.1.

3.11.5
conditional short-circuit current
value of short-circuit current which a CBE protected by an SCPD in series can withstand under specified conditions of use and behaviour

3.11.6
electrodynamic contact separation
lowest value of peak current which causes a contact separation while the mechanism remains closed

3.11.7
short-time withstand current
<of a CBE> value of current which a CBE can satisfactorily withstand for a specified time without suffering any damage impairing its further use

~~[IEV 441-17-17, modified]~~

3.11.8
take-over current
current coordinate of the intersection between the tripping characteristics of two overcurrent protective devices in series for operating times greater than or equal to 0,05 s

Note 1 to entry: For operating times less than 0,05 s, the two overcurrent devices in series are considered as an association (see Annex F).

[SOURCE: IEC 60050-441:1984, 441-17-16, modified – "time-current characteristics of two overcurrent protective devices" has been replaced by "tripping characteristics of two overcurrent protective devices in series for operating times greater than or equal to 0,05 s" and Note 1 to entry has been added.]

3.12 Definitions related to terminals and terminations

3.12.1
termination
connection between two or more conductive parts which can only be made by a special process

Note 1 to entry: The special process may be welding, soldering or the preparation of the conductors by a special purpose tool.

3.12.2
terminal
conductive part of a device provided for re-usable electrical connection without the use of a special process

3.12.2.1
terminal for unprepared conductors
terminal which does not require a special preparation of the conductor other than stripping and reshaping the conductor before its introduction into the terminal or the twisting of a stranded conductor to consolidate the end

3.12.2.2
terminal for prepared conductors
terminal which requires special preparation of the conductor such as the use of cable lugs, eyelets or similar devices

3.12.2.3
terminal for internal conductors
factory-wiring terminal
terminal for the connection of internal conductors of the equipment

Note 1 to entry: CBEs are normally, but not necessarily, provided with terminals for internal conductors.

3.12.3
screw-type terminal
terminal for the connection and subsequent disconnection of a conductor or the interconnection of two or more conductors capable of being dismantled, the connection being made, directly or indirectly, by means of screws or nuts of any kind

3.12.4
pillar terminal
screw-type terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw(s)

Note 1 to entry: The clamping pressure may be applied direct by the shank of the screw or through an intermediate clamping element to which pressure is applied by the shank of the screw.

Note 2 to entry: Examples of pillar terminals are shown in Annex E.

3.12.5
screw terminal
screw-type 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.

Note 2 to entry: Examples of screw terminals are shown in Annex E.

3.12.6
stud terminal
screw-type terminal in which the conductor is clamped under a nut

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

Note 2 to entry: Examples of stud terminals are shown in Annex E.

3.12.7
saddle terminal
screw-type terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts

Note 1 to entry: Examples of saddle terminals are shown in Annex E.

3.12.8
lug terminal
screw terminal or a stud terminal, designed for clamping a cable lug or a bar by means of a screw or nut

Note 1 to entry: Examples of lug terminals are shown in Annex E.

3.12.9
screwless terminal
terminal for the connection and/or interconnection and subsequent disconnection of one or more conductors, the connection being made, directly or indirectly, by means other than screws

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

– terminals requiring fixing of special devices to the conductors before clamping them into terminals, for example flat quick-connect terminals;
– 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.

Examples of screwless terminals are shown in Figures E.5 to E.14.

3.12.9.1
universal screwless terminal
screwless terminal intended for the connection of all types of conductors

3.12.9.2
non-universal screwless terminal
screwless terminal intended for the connection of certain types of conductors only

~~NOTE~~ EXAMPLES push-wire clamping unit for solid conductors only; push-wire clamping unit for rigid solid and rigid stranded conductors only

3.12.10
flat quick-connect termination
electrical connection consisting of a male tab and a female connector which can be inserted and withdrawn without the use of a tool

3.12.11
male tab
portion of a quick-connect termination which receives the female connector

Note 1 to entry: Examples of male tabs are shown in Figure E.6.

3.12.12
female connector
portion of a quick-connect termination which is pushed onto the male tab

Note 1 to entry: An example of a female connector is shown in Figure E.14.

3.12.13
detent
dimple (depression) or hole in the male tab which engages a raised portion on the female connector to provide a latch for the mating parts

3.12.14
solder termination
conductive part of a CBE provided to enable a termination to be made by means of soldering

3.12.15
external conductor
field-wiring conductor
~~any~~ cable, cord, core or conductor, a part of which is external to equipment in or on which the CBE is mounted

3.12.16
integrated conductor
conductor which is used to permanently interconnect parts of a CBE

3.12.17
internal conductor
factory-wiring conductor
any cable, cord, core or conductor, which is internal to equipment but is neither an external nor an integrated conductor

3.12.18
tapping screw
screw manufactured from a material having a greater resistance to deformation when applied by rotary insertion to a hole in a material having a lesser resistance to deformation

Note 1 to entry: The screw is made with a tapered thread, the taper being applied to the core diameter of the thread at the end section of the screw. The thread produced by application of the screw is formed securely only after sufficient revolutions have been made to exceed the number of threads on the tapered section.

3.12.19
thread-forming screw
tapping screw having an uninterrupted thread

Note 1 to entry: It is not a function of this thread to remove material from the hole.

Note 2 to entry: An example of a thread-forming screw is shown in Figure 1.

3.12.20
thread-cutting screw
tapping screw having an interrupted thread

Note 1 to entry: The thread is intended to remove material from the hole.

Note 2 to entry: An example of a thread-cutting screw is shown in Figure 2.

3.13 Definitions related to tests

3.13.1
type test
test of one or more devices made to a certain design to show that the design meets certain specifications

~~[IEV 151-04-15]~~

3.13.2
routine test
test to which each individual device is subjected during and/or after manufacture to check whether its complies with certain criteria

~~[IEV 151-04-16, modified]~~

3.13.3
special test
test, additional to type tests and routine tests, made either at the discretion of the manufacturer or according to an agreement between manufacturer and user

4 Classification

4.1 General

CBEs are classified according to the criteria given in 4.2 to 4.11.

4.2 Quantity of poles

– the number of poles;

– the number of protected poles.

NOTE The pole which is not a protected pole ~~may~~ can be an unprotected pole or a switched neutral.

4.3 Method of mounting

– surface type;

– flush type;

– panel-mounting type;

– integral-mounting type.

NOTE 1 Panel-mounting types comprise snap-on types and flange types.

NOTE 2 Integral-mounting types are types which are kept in place by fixation means and do not require any other mounting means.

4.4 Method of connection

– CBEs, the connections of which are not associated with the mechanical mounting;
– CBEs, one or more connections of which are associated with the mechanical mounting, for example:
  - plug-in type;
  - bolt-on type;
  - screw-in type;
  - solder-in type.

NOTE Some CBEs ~~may~~ can be of the plug-in type or bolt-on type on the line side only, the load terminals being usually suitable for wiring connection.

4.5 Method of operation

4.5.1 CBEs for automatic interruption and non-automatic (manual) resetting only (R-type).

4.5.2 CBEs for automatic interruption and non-automatic (manual) resetting, provided with means for manual operation designed for occasional manual switching, but not designed for regular manual switching operations under normal load conditions (M-type).

4.5.3 CBEs for automatic interruption and non-automatic (manual) resetting, provided with means for manual operations and designed for regular manual switching operations under normal load conditions (S-type) (see note of 5.2.3).

4.5.4 CBEs for automatic interruption and automatic resetting (J-type).

~~NOTE~~ J-type CBEs ~~may~~ can be provided with means for manual operation also. In this case, the relevant requirements concerning the other types are applicable.

4.6 Mode of tripping

4.6.1 CBEs tripping by current (overcurrent)

Mode of tripping	*Designation*
– thermal	TO
– thermal-magnetic	TM
– magnetic	MO
– hydraulic-magnetic	HM
– electronic-hybrid	EH

NOTE Electronic-hybrid type means an electronically controlled device associated with any of the other modes of tripping.

4.6.2 CBEs tripping by ~~overcurrent and~~ voltage

Mode of tripping	*Designation*
– overvoltage	OV
– undervoltage	UV

~~**4.5.3 CBE-switch**~~

~~*Mode of tripping*~~ ~~*Designation*~~

– without tripping means X
– tripping by voltage Y
– tripping by mechanical means Z

4.7 Influence of the ambient temperature

4.7.1 CBEs, the operation of which is temperature dependent.

4.7.2 CBEs, the operation of which is not temperature dependent.

4.8 Trip-free behaviour

4.8.1 Trip-free (positively trip-free).

4.8.2 Cycling trip-free.

4.8.3 Non-trip-free. CBEs of the non-trip-free type are not intended to be used for short-circuit duty.

NOTE Attention is drawn to the fact that CBEs of the non-trip-free type should not be installed where access is possible without the use of a tool.

4.9 Influence of the mounting position

4.9.1 Independent of the mounting position.

4.9.2 Dependent on the mounting position.

4.10 Electrical performance

4.10.1 For general use, including inductive circuits.

4.10.2 For use in substantially resistive circuits only.

4.11 Suitability for isolation

– not suitable for isolation;
– suitable for isolation (see Annex K).

5 Characteristics of CBEs

5.1 List of characteristics

The characteristics of a CBE shall be stated in the following terms, as applicable:

– number of poles, protected poles (see 4.2) and neutral path if any;
– method of mounting (see 4.3);
– method of connection (see 4.4);
– method of operation (see 4.5);
– rated quantities (see 5.2);
– operating characteristics (see 3.9).

5.2 Rated quantities

5.2.1 General

Rated quantities are specified in 5.2.2 to 5.2.7. Unless otherwise specified, all values of current and voltage are RMS values.

5.2.2 Rated voltages

5.2.2.1 General

A CBE is defined by the rated voltages defined in 5.2.2.2 to 5.2.2.5.

5.2.2.2 Rated operational voltage of a CBE (U_e)

The rated operational voltage (hereinafter referred to as "rated voltage") of a CBE is the value of voltage to which the performance is referred.

NOTE The same CBE ~~may~~ can be assigned a number of rated voltages and associated rated switching capacities (see 5.2.5).

5.2.2.3 Rated insulation voltage (U_i)

The rated insulation voltage of a CBE is the value of voltage to which dielectric tests, clearances and creepage distances are referred.

Unless otherwise stated, the rated insulation voltage is the value of the maximum rated voltage of the CBE. In no case shall the maximum rated voltage exceed the rated insulation voltage.

5.2.2.4 Rated impulse withstand voltage (U_{imp})

The peak value of an impulse voltage of prescribed form and polarity which the CBE is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred.

The rated impulse withstand voltage of an equipment shall be equal to or higher than the values stated for the transient overvoltages occurring in the circuit in which the equipment is fitted.

The correlations between the rated voltages of supply systems and the rated impulse withstand voltages are given in Annex H.

Impulse withstand test voltages for the verification of the insulation coordination are given by Table 21.

5.2.2.5 Rated voltage of undervoltage and zero voltage releases (U_n)

The rated voltage of undervoltage and/or zero voltage releases with respect to the value of voltage to which the performance is referred.

5.2.3 Rated current (I_n)

A current assigned by the manufacturer (in accordance with Table 11 or Table 12 according to the declared performance) as the current which the CBE is designed to carry in uninterrupted duty (see 3.8.5) at a specified reference ambient air temperature.

The standard reference ambient air temperature is (23 ± 2) °C.

If the reference ambient air temperatures are different from the standard value, the derating factor as given in the manufacturer's literature ~~has to~~ shall be applied (see 7.2).

NOTE For S-type CBEs, a rated current different from that assigned in accordance with Table 11 ~~may~~ can be stated by the manufacturer for inductive loads.

5.2.4 Rated frequency

The power frequency for which the CBE is defined and to which the values of the other characteristics correspond.

5.2.5 Rated switching capacity (rated making and breaking capacity)

The value of switching capacity (see 3.10.5) assigned to the CBE by the manufacturer.

NOTE It is expressed by a value of current (RMS if AC).

5.2.6 Rated conditional short-circuit current (I_{nc})

5.2.6.1 General

The value of the conditional short-circuit current (see 3.11.5) if assigned to the CBE by the manufacturer.

~~NOTE 1 This standard gives only values of rated conditional a.c. short-circuit currents. Values for rated conditional d.c. short-circuit currents are under consideration.~~

NOTE ~~2~~1 For the purpose of this document, two categories of performance are specified (see 5.2.6.2 and 5.2.6.3).

NOTE 2 The manufacturer can decide not to assign a value of I_{nc} to the CBE, in which case the relevant tests are omitted.

5.2.6.2 Rated conditional short-circuit current performance category PC1 (I_{nc1})

The value of rated conditional short-circuit current, if assigned by the manufacturer, for which the prescribed conditions do not include the fitness of the CBE for its further use. See 9.12.4.2.

5.2.6.3 Rated conditional short-circuit current, performance category PC2 (I_{nc2}) ~~(optional)~~

The value of rated conditional short-circuit current, if assigned by the manufacturer, for which the prescribed conditions do include the fitness of the CBE for its further use. See 9.12.4.3.

5.2.7 Rated short-circuit capacity (I_{cn})

The rated short-circuit capacity of a CBE is the value of current assigned to the CBE by the manufacturer, according to 3.10.6.

The rated short-circuit capacity shall not be less than

– 6 I_n for AC,
– 4 I_n for DC.

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage

Preferred values of rated voltage are as follows.

– AC:

60 V, 120 V, 240 V/120 V, 220 V, 230 V, 240 V, 380 V/220 V, 400 V/230 V, 415 V/240 V, 380 V, 400 V, 415 V, 440 V;

NOTE In IEC 60038, the network voltage value of 400 V/230 V AC has been standardized. This value ~~should~~ will progressively replace the values 380V /220 V and 415 V/240 V.

– DC:

12 V, 24 V, 48 V, 60 V, 120 V, 240 V, 250 V.

5.3.2 Standard rated frequencies

Standard rated frequencies are: 50 Hz, 60 Hz and 400 Hz.

5.3.3 Standard values of rated conditional short-circuit current

Standard values of rated conditional short-circuit current are:

300 A, 600 A, 1 000 A, 1 500 A, 3 000 A.

6 Marking and other product information

Each CBE shall be marked in a durable manner with the following:

a) manufacturer's name or trade mark;

b) type designation or serial number;

c) rated voltage(s);

d) rated current (coded reference is permissible: for example, current value without the symbol A, following the type designation);

If the CBE is intended for resistive load only, this shall be stated in the manufacturer's catalogue.

e) rated frequency, if the CBE is designed for a frequency other than both 50 Hz and 60 Hz;

f) reference ambient air temperature for CBEs calibrated for a reference ambient air temperature different from the standard value (see 5.2.3) – for example, T40 for a reference ambient air temperature of 40 °C;

g) operating voltage limit(s) (of a voltage-sensitive CBE);

h) the symbol μ, if the CBE~~s~~ is of a type with a contact gap less than the specified clearance ~~shall be marked with the symbol μ~~;

i) method of operation R, M, S or J (see 4.5);

k) mode of tripping (see 4.6);

l) degree of trip-free behaviour (see 4.8);

m) overvoltage category, if different from II; and pollution degree, if different from 2 (see 8.1.3);

n) rated conditional short-circuit current, performance category PC1 (I_{nc1});

o) rated conditional short-circuit current, performance category PC2 (I_{nc2}), if relevant;

p) rated impulse withstand voltage;

q) rated short-circuit capacity I_{cn}, if applicable (see 5.2.6);

r) self-resetting time;

s) symbol of suitability for isolation  (IEC 60417-6169-1:2012-08, modified) on the device, when applicable.

If, on small apparatus, the available space is insufficient for all the listed markings, at least a), b) and, if applicable, g), h) and s) shall be marked on the device, and, if possible, c) and d), whilst the other information shall be given in the manufacturer's catalogue.

NOTE Visibility from the front – though desirable – is not compulsory for CBEs, because CBEs are specified by OEMs for their equipment on the basis of the information provided by the CBE manufacturers. Due to lack of space on the usually small CBEs, it may not be possible to have the marking on the front part visible after installation. If the CBE is not marked on a visible position the manufacturer can inform the OEM to mark his equipment accordingly.

The manufacturer shall declare the conditions for the installation of CBEs (especially CBEs classified to 4.8.3) in his catalogue, where applicable.

For CBEs other than those operated by means of push-buttons, the open position shall be indicated by the symbol ○ (IEC 60417-5008:2002-10) and the closed position by the symbol | (IEC 60417-5007:2002-10).

For CBEs operated by means of two push-buttons, the push-button designed for the opening operation only shall be red and/or be marked with the symbol ○.

~~NOTE~~ National symbols additional to ○ and | are ~~allowed~~ acceptable.

Red shall not be used for any other push-button, but may be used for other types of actuators, for example, handles, rockers, provided the ON and OFF positions are clearly identified.

If it is necessary to distinguish between the supply and the load terminals, the former shall be indicated by arrows pointing towards the CBE and the latter by arrows pointing away from the CBE.

~~NOTE~~ Other national or international indications, for example 1, 3, 5 for the supply terminals and 2, 4, 6 for the load terminals, are ~~allowed~~ acceptable.

Terminals intended exclusively for the neutral shall be indicated by the letter "N".

Terminals intended for the protective conductor, if any, shall be indicated by the symbol ⏚ (IEC 60417~~-2~~-5019:2002-10).

Compliance is checked by inspection and by the test of 9.3.

Wherever possible, CBEs shall be provided with a wiring diagram unless the correct mode of connection is evident.

On the wiring diagram, the terminals shall be indicated by the symbol **o** (IEC 60617-S00017:2001-07).

The marking shall be durable and easily legible, and shall not be placed on screws, washers or other removable parts.

7 Standard conditions for operation in service

7.1 General

CBEs complying with this document shall be capable of ~~coperating~~ operating under the following standard conditions.

7.2 Ambient air temperature

7.2.1 Reference ambient air temperature *T* for calibration

The standard value of the reference ambient air temperature is (23 ± 2) °C.

CBEs may, however, be calibrated for a different reference ambient air temperature of T °C. In this case, they ~~have to~~ shall be marked in accordance with Clause 6 f).

7.2.2 Limits of ambient air temperature for operation in service

For standard conditions (reference ambient air temperature T = 23 °C), the ambient air temperature does not exceed +40 °C and its average over a period of 24 h does not exceed +35 °C. The lower limit of the ambient air temperature is –5 °C.

For CBEs with a reference ambient air temperature T exceeding 23 °C, the upper limit is assumed to be (T + 10) °C. The lower limits shall be taken from the information provided by the manufacturer.

7.3 Altitude

The altitude of the site of installation does not exceed 2 000 m (6 600 ft).

For installations at higher altitudes, it is necessary to take into account the reduction of the dielectric strength and of the cooling effect of the air.

CBEs intended to be so used shall be specially designed, or used according to an agreement between manufacturer and user.

Information given in the manufacturer's catalogue may take the place of such an agreement.

7.4 Atmospheric conditions

The air is clean and its relative humidity does not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidities may be permitted at lower temperatures, for example, 90 % at +20 °C.

Care should be taken by appropriate means (for example draining holes) of moderate condensation which may occasionally occur due to variations in temperature.

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 General

A CBE shall be so designed and constructed that, in normal use, its performance is reliable and without danger to the user or surroundings.

In general, this is checked by carrying out all the relevant tests specified.

8.1.2 Mechanism

The moving contacts of a multi-pole CBE shall be mechanically coupled in such a way that all protected and unprotected poles make and break substantially together, whether operated manually or automatically, even if an overload occurs on one pole only. The manufacturer shall indicate in his literature if a CBE is trip-free, cycling trip-free or non-trip-free.

A CBE, with the exception of J-type CBEs without means for manual operation, shall be provided with means for indicating its closed and open positions which shall be easily discernible when fitted with its cover(s) or cover-plate(s), if any. When the operating means is used to indicate the position of the contacts, it shall have two distinct rest positions corresponding to the position of the contacts, and the operating means, when released, shall automatically take up the position corresponding to that of the moving contacts; for automatic opening, a third distinct position of the operating means may be provided.

The action of the mechanism shall not be influenced by the position of enclosures or covers and shall be independent of any removable part.

Operating means shall be securely fixed on their shafts and it shall not be possible to remove them without the aid of a tool. Operating means directly fixed to covers are allowed.

Compliance with the above requirements is checked by inspection and by manual test.

Additional requirements for the mechanism of CBEs suitable for isolation are given in K.8.1.2.

8.1.3 Clearances and creepage distances (see Annex B)

8.1.3.1 General

CBEs shall be so constructed that the clearances and creepage distances are adequate to withstand the electrical, mechanical and thermal stresses taking into account the environmental influences that may occur during the anticipated life of the CBE.

NOTE 1 The requirements and tests are based on IEC 60664-1.

It is assumed that for CBEs the following conditions are generally applicable:

– overvoltage category II;
– pollution degree 2.

NOTE 2 CBEs ~~may~~ can be designed for other overvoltage categories and pollution degrees.

NOTE 3 A creepage distance cannot be less than the associated clearance so that the shortest creepage distance possible is equal to the required clearance.

Additional requirements for clearance and creepage distances for CBEs suitable for isolation are given in K.8.1.3.

8.1.3.2 Clearances

8.1.3.2.1 General

The clearances of the CBE shall be dimensioned to withstand the rated impulse withstand voltage declared by the manufacturer according to 5.2.2.4, taking into account the rated voltage and the overvoltage category as shown by Table H.1.

Dimensions according to Table 1 are deemed to meet the impulse withstand voltage test.

NOTE Correlations between rated voltages of supply systems and the line-to-neutral voltage relevant for determining the rated impulse voltage are given in Annex H.

8.1.3.2.2 Clearances for basic insulation

The clearances for basic insulation shall not be less than the values shown in Table 1. Smaller clearances may be used, if the CBE meets the impulse withstand voltage test in 9.7.6 but only if the parts are rigid or located by mouldings or if the construction is such that there is no likelihood of the distance being reduced by distortion, by movement of the parts or during mounting, connection and service in normal use to a value so that the CBE no longer complies with the impulse withstand voltage test.

Compliance is checked by measurement or, if necessary, by the test of 9.7.6.

8.1.3.2.3 Clearances for functional insulation

The clearances for functional insulation shall not be less than those specified in Table 1. Smaller clearances may be used under the conditions prescribed for basic insulation.

Compliance is checked by measurement or, if necessary, by the test of 9.7.6.

8.1.3.2.4 Clearances for supplementary insulation

The clearances for supplementary insulation shall not be less than those specified for basic insulation in 8.1.3.2.2 except that smaller clearances than those given in Table 1 are not allowed.

Compliance is checked by measurement.

NOTE Supplementary insulation is used in conjunction with basic insulation.

8.1.3.2.5 Clearances for reinforced insulation

Clearances for reinforced insulation shall not be less than those specified in Table 1.

Compliance is checked by measurement.

Table 1 – Minimum clearances for basic and reinforced insulation

Rated impulse withstand voltage	Minimum clearance [d] mm					
	For basic insulation pollution degree			For reinforced insulation pollution degree		
V [a]	1	2 (see 8.1.3)	3	1	2 (see 8.1.3)	3
330	0,01	0,2 [b c]	0,8 [c]	0,04	0,2 [b c]	0,8 [c]
500	0,04	0,2 [b c]	0,8 [c]	0,10	0,2 [b c]	0,8 [c]
800	0,10	0,2 [b c]	0,8 [c]	0,5	0,5	0,8 [c]
1 500	0,5	0,5	0,8 [c]	1,5	1,5	1,5
2 500	1,5	1,5	1,5	3	3	3
4 000	3	3	3	5,5	5,5	5,5
6 000	5,5	5,5	5,5	8	8	8

[a] This voltage is

– for functional insulation: the maximum impulse voltage expected to occur across the clearance;

– for basic insulation directly exposed to, or significantly influenced by, transient overvoltage from the low-voltage supply: the rated impulse withstand voltage of the CBE;

– for basic insulation not directly exposed to, or significantly influenced by, transient overvoltage from the low-voltage supply: the highest impulse voltage that can occur in the circuit.

[b] For printed wiring material within the CBE, the values for pollution degree 1 apply, except that the value shall not be less than 0,04 mm.

[c] Minimum clearance values based on experience rather than on fundamental data.

[d] CBEs with a contact gap less than the specified minimum clearance are permitted but shall be marked with the symbol µ.

8.1.3.2.6 Clearances across micro-disconnection

Clearances across micro-disconnection shall be dimensioned to withstand temporary overvoltages (see 3.4.4).

Compliance is checked by the test of 9.11.1.3.

8.1.3.2.7 Clearances across full-disconnection

Clearances across full-disconnection shall be dimensioned to withstand transient overvoltages. They shall not be less than those specified in Table 1 for basic insulation. Smaller distances may be used if the CBE after the tests of 9.9 and 9.11 is capable to withstand the test voltage appropriate to the impulse withstand voltage test across the open contacts.

Compliance is checked by measurement or by the test of 9.7.6.

8.1.3.3 Creepage distances

8.1.3.3.1 General

The creepage distances of the CBE shall not be less than those appropriate for the voltage which is expected to occur in normal use, taking into account the material group and the pollution degree.

8.1.3.3.2 Creepage distances for basic insulation

Creepage distances for basic insulation shall not be less than those specified in Table 2.

NOTE Creepage distances cannot be less than the associated clearance.

The relationship between material group and proof tracking index (PTI) values is as follows:

Material group I	600	≤	PTI		
Material group II	400	≤	PTI	<	600
Material group III a	175	≤	PTI	<	400
Material group III b	100	≤	PTI	<	175

For printed circuit materials comparative tracking index (CTI) values apply.

NOTE The CTI values are obtained in accordance with IEC 60112, using solution A.

Compliance is checked by measurement.

8.1.3.3.3 Creepage distances for functional insulation

Creepage distances for functional insulation shall not be less than those specified in Table 2.

Compliance is checked by measurement.

NOTE For glass, ceramics and other inorganic materials, which are not subject to tracking, creepage distances need not be greater than their associated clearance.

Table 2 – Minimum creepage distances

Working voltage across creepage distance	**Printed circuit boards** [f] **Pollution degree**		**Minimum creepage distance for basic insulation** **Pollution degree** [e]						
	1 [b]	**2** [c]	**1**[b]	**2** (see 8.1.3)			**3**		
				Material group			**Material group**		
				I	**II**	**III**[d]	**I**	**II**	**III** [d]
V	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	0,025	0,04	0,08	0,04	0,04	0,04	1,0	1,0	1,0
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,025	0,04	0,10	0,45	0,45	0,45	1,1	1,1	1,1
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,025	0,04	0,125	0,50	0,50	0,50	1,25	1,25	1,25
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,04	0,063	0,20	0,63	0,9	1,25	1,6	1,8	2,0
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,1	0,16	0,25	~~0,74~~ 0,71	1,0	1,4	1,8	2,0	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,4	0,32	0,8	1,1	1,6	2,0	2,2	2,5
~~208~~ 200	0,4	0,63	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,0	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500[a]	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0

[a] For higher working voltages, the values of Table 4 of IEC 60664-1:2007 apply.

[b] Material groups I, II, III a and III b.

[c] Material groups I, II, III a.

[d] Material group III includes III a and III b.

[e] Within the CBE, micro-environment is deemed to apply.

[f] For printed circuit boards with coating complying with IEC 60664-3, these values need not be applied.

8.1.3.3.4 Creepage distances of supplementary insulation

Creepage distances of supplementary insulation shall not be less than those specified for basic insulation.

Compliance is checked by measurement.

8.1.3.3.5 Creepage distances for reinforced insulation

Creepage distances for reinforced insulation shall not be less than twice those specified for basic insulation.

Compliance is checked by measurement.

8.1.4 Screws, current-carrying parts and connections

8.1.4.1 Connections, whether electrical or mechanical, shall withstand the mechanical stresses occurring in normal use.

Screwed connections are considered as checked by the tests of 9.8, 9.9, 9.11, 9.13 and 9.14.

8.1.4.2 Electrical connections shall be so designed that contact pressure is not transmitted through insulating material other than ceramic, pure mica or other material with characteristics no less suitable, unless there is sufficient resilience in the metal parts to compensate for any possible shrinkage or yielding of the insulating material.

Compliance is checked by inspection.

NOTE The suitability of the material is assessed with respect to dimensional stability.

8.1.4.3 Current-carrying parts and contacts intended for protective conductors shall be either of

– copper;
– an alloy containing at least 58 % copper for parts worked cold, or at least 50 % copper for other parts; or
– other metal or suitably coated metal, no less resistant to corrosion than copper and having mechanical properties no less suitable.

NOTE New requirements, to be verified by a test for determining the resistance to corrosion, are under consideration. These requirements should permit other materials to be used if suitably coated.

This requirement does not apply to contacts, magnetic circuits, heater elements, bimetals, shunts, parts of electronic devices nor to screws, nuts, washers, clamping plates and similar parts of terminals.

8.1.5 Screw-type and screwless terminals

8.1.5.1 Terminals shall be such that the conductors may be connected so as to ensure that the necessary contact pressure is available.

Compliance is checked by inspection and by the test of 9.5.2.

8.1.5.2 Terminals shall be fixed in such a way that the terminal will not work loose when the conductor is connected or disconnected.

Compliance is checked by inspection, by measurement and by the test of 9.4.1.

8.1.5.3 Terminals for connection of external conductors (see 3.12.15) shall allow the connection of copper conductors having nominal cross-sectional areas as shown in Table 3.

Terminals for conductors, internal conductors (see 3.12.17) and integrated conductors (see 3.12.16) shall allow the connection of copper conductors of the largest and smallest diameters specified by the manufacturer shall be used. If not specified, Table 3 is applicable.

Examples of possible shapes and possible dimensions of terminals are shown in Annex E.

Compliance is checked by inspection and by fitting conductors of the declared types with the smallest and largest cross-sectional areas specified.

Table 3 – Connectable cross-sectional areas of external copper conductors for screw-type and screwless terminals

Rated current A	Range of nominal cross-sections to be clamped[a] mm^2		
Up to and including 6	0,5	to	1,0
Above 6 up to and including 13	0,75	to	1,5
Above 13 up to and including 20	1,0	to	2,5
Above 20 up to and including 25	1,5	to	4
Above 25 up to and including 32	2,5	to	6
Above 32 up to and including 50	4	to	10
Above 50 up to and including 63	6	to	16
Above 63 up to and including 80	10	to	25
Above 80 up to and including 100	16	to	35
Above 100 up to and including 125	25	to	50

~~NOTE~~ [a] Accommodation of lower and higher cross-sectional areas is permitted.

8.1.5.4 Terminals for unprepared copper conductors which are suitable for connection of (external) flexible conductors shall be located or shielded so that, if a wire of a flexible conductor escapes from a terminal when the conductors are fitted, there is no risk of contact between live parts and accessible metal parts, and, for CBEs for class II appliances, between live parts and metal parts separated from accessible metal parts by supplementary insulation only.

Compliance is checked by inspection and by the test of 9.5.

8.1.5.5 The means for clamping the conductors in the terminals shall not serve to fix any other component, although they may hold the terminals in place or prevent them from turning.

Compliance is checked by inspection and by the test of 9.5.1.

8.1.5.6 Terminals shall be so designed that the insertion of the conductor is prevented by a stop if further insertion may reduce the creepage distance and/or clearances or influence the mechanism of the CBE.

Compliance is checked by inspection.

8.1.5.7 Terminals shall be so designed that they clamp the conductor without undue damage to the conductor itself.

Compliance is checked by inspection and by the test of 9.5.3.

8.1.5.8 Terminals shall be so designed that they make connection reliably between metal surfaces and without undue damage to the conductor.

Compliance is checked by inspection and by the tests of 9.4 and 9.5.

8.1.5.9 Terminals shall clamp the conductor between metal surfaces, except that for terminals intended to be used in circuits carrying a current not exceeding 0,2 A, one of the surfaces may be non-metallic.

8.1.5.10 Terminals for rated currents up to and including 32 A, intended for connection of external conductors, shall allow the connection of unprepared copper conductors.

Compliance is checked by inspection.

8.1.5.11 Terminals for prepared copper conductors shall be suitable for their purpose when the connection is made as specified by the manufacturer in his literature.

Compliance is checked by inspection and by the test of 9.5.4.

8.1.5.12 Screw-type terminals shall have adequate strength. Screws and nuts for clamping the conductors shall have a metric ISO thread or a thread comparable in pitch and mechanical strength.

Compliance is checked by inspection and by the tests of 9.4 and 9.5.2.

NOTE Provisionally, SI, BA and UN threads ~~may~~ can be used as they are considered as practically equivalent in pitch and mechanical strength to metric ISO thread.

8.1.5.13 Clamping screws or nuts of terminals intended for connection of protective conductors shall be adequately secured against accidental loosening.

Compliance is checked by inspection and by the test of 9.5.1.

In general, the designs of terminals according to Figures E.1 to E.4 provide sufficient resilience to comply with this requirement. For other designs, special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, may be necessary.

8.1.5.14 Screws and nuts of terminals intended for connection of external conductors shall be in engagement with a metal thread and the screw shall not be of the tapping type.

8.1.5.15 For pillar terminals, the distance between the clamping screw and the end of the conductor when fully inserted shall be at least as specified in Table 4.

The minimum distance between the clamping screw and the end of the conductor applies only to pillar terminals in which the conductor cannot pass right through.

Table 4 – Minimum distance between clamping screw and the end of conductor when fully inserted

Rated current A	Minimum values mm	
	With one clamping screw	**With two clamping screws**
Up to and including 6	1,5	1,5
Above 6 up to and including 13	1,5	1,5
Above 13 up to and including ~~16~~ 20	1,8	1,5
Above 20 up to and including 25	1,8	1,5
Above 25 up to and including 32	2,0	1,5
Above 32 up to and including 50	2,5	2,0
Above 50 up to and including 80	3,0	2,0
Above 80 up to and including 100	4,0	3,0
Above 100 up to and including 125	Under consideration	Under consideration

Compliance is checked by measurement after a solid conductor of the largest cross-sectional area specified by the manufacturer has been fully inserted and clamped with the torque indicated in Table 15.

8.1.5.16 Screwless terminals (see Figure E.5), unless otherwise specified by the manufacturer, shall accept conductors as indicated in Table 3, in which case no marking is necessary.

If a screwless terminal can accept only solid conductors, this shall be either clearly marked on the end product, for connecting purposes, by "sol", or indicated on the smallest package unit, or in technical information and/or catalogues of the manufacturer.

If a screwless terminal can accept only rigid (solid and stranded) conductors, this shall be either clearly marked on the end product, for connecting purposes, by the letter "r", or indicated on the smallest package unit or in technical information and/or catalogues of the manufacturers.

Compliance is checked by inspection and by the test of 9.4.1.

8.1.5.17 Screwless terminals shall withstand the mechanical stress occurring in normal use. The connection or disconnection of conductors shall be made as follows:

– on universal terminals, by the use of a general purpose tool or by the device integral with the terminal and designed for being open for the insertion or withdrawal of the conductors;

– on push wire terminals, by simple insertion. For the disconnection of the conductors, an operation other than a pull on the conductor shall be necessary.

The use of a general purpose tool or a convenient device, integral with the terminal, is allowed in order to "open" it and to assist the insertion or the withdrawal of the conductor.

Compliance is checked by inspection and by the test of 9.4.

8.1.5.18 Screwless terminals shall allow the proper connection of conductors.

~~NOTE 1 This type of terminal should not be used for rated currents higher than 16 A.~~

The manner of insertion and disconnection of the conductors shall be obvious, or instructions shall be provided by the manufacturer.

NOTE Examples of screwless terminals are shown in Figure E.5.

The intended disconnection of the conductor shall require an operation, other than a pull at the conductor, such that it can be effected manually with or without the help of a tool in normal use.

Openings for the use of a tool intended to assist the insertion or disconnection shall be clearly distinguishable from the opening for the conductor.

Compliance is checked by inspection, by measurement and by insertion of the appropriate flexible and/or rigid conductors of cross-sectional areas according to Table 3.

8.1.5.19 Screwless terminals intended to be used for the interconnection of more than one conductor shall be designed so that, after the insertion, the operation of the clamping means of one of the conductors is independent of the operation of the clamping means of the other conductor. During the disconnection, the conductors may be disconnected either simultaneously or separately.

Compliance is checked by inspection and by tests with any combination as specified by the manufacturer.

8.1.6 Solder terminations

8.1.6.1 Solder terminations shall have sufficient solderability.

Compliance is checked by applying the test of 9.4.2.1.

8.1.6.2 Material adjacent to the solder terminations shall have sufficient resistance to soldering heat.

Compliance is checked by applying the test of 9.4.2.2.

8.1.6.3 Solder terminations shall be provided with means for mechanically securing the conductor in position independently of the solder.

Such means may be provided by

– a hole suitable for hooking in the conductor;
– shaping the edges of the terminal to allow the conductor to be wrapped around the terminal before soldering;
– a clamping means adjacent to the solder connection.

NOTE Solder terminations for connection on printed circuit boards are not considered in this document.

Compliance is checked by inspection.

8.1.7 Flat quick-connect male tabs (Figures E.6 to E.13)

8.1.7.1 Male tabs shall comply with the dimensions of Tables 5, 6 and 7.

~~NOTE Other dimensions according to existing valid national standards are allowed for a transitional period of 10 years.~~

Table 5 – Dimensions of tabs in millimetres – Dimensions *A*, *B*, *C*, *D*, *E*, *F*, *J*, *M*, *N*, *P* and *Q*

Nominal size		*A*	*B* min	*C*	*D*	*E*	*F*	*J* [a]	*M*	*N*	*P*	*Q* min
2,8 × 0,5	dimple	0,6 0,3	7,0	0,54 0,47	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°	1,7 1,4	1,4 1,0	1,4 0,3	8,1
	hole	0,6 0,3	7,0	0,54 0,47	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°			1,4 0,3	8,1
2,8 × 0,8	dimple	0,6 0,3	7,0	0,84 0,77	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°	1,7 1,4	1,4 1,0	1,4 0,3	8,1
	hole	0,6 0,3	7,0	0,84 0,77	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°			1,4 0,3	8,1
4,8 × 0,8	dimple	1,0 0,7	6,2	0,84 0,77	4,80 4,60	2,8 2,3	1,5 1,3	12° 8°	1,7 1,4	1,5 1,2	1,8 0,7	7,3
	hole	1,0 0,6	6,2	0,84 0,77	4,90 4,67	3,4 3,0	1,5 1,3	12° 8°			1,8 0,7	7,3
6,3 × 0,8	dimple	1,0 0,7	7,8	0,84 0,77	6,40 6,20	4,1 3,6	2,0 1,6	12° 8°	2,5 2,2	2,0 1,8	1,8 0,7	8,9
	hole	1,0 0,5	7,8	0,84 0,77	6,40 6,20	4,7 4,3	2,0 1,6	12° 8°			1,8 0,7	8,9
9,5 × 1,2	hole	1,3 0,7	12,0	1,23 1,17	9,60 9,40	5,5 4,5	2,0 1,7	14° 6°			2,0 1,0	13,1

[a] The soldering of wires to the tab and the relevant dimensional modifications, if necessary, are under consideration.

Table 6 – Dimensions of tabs in millimetres – Dimensions *H*, *I*, *T*, *K*, *R*, *G*, *L*, *S* and *U*

Nominal size		*H*	*I*	*T* [a]	*K*	*R*	*G*	*L*	*S*	*U*
2,8 × 0,5	dimple				1,7 max.	7,0 max.				
	hole	1,7 max.	2,7 max.							
2,8 × 0,8	dimple				1,7 max.	7,0 max.				
	hole	1,7 max.	2,7 max.	1 min.						
4,8 × 0,8	dimple				1,7 max.	6,2 max.	1,6 max.	0,7 ± 0,1	1,0 ± 0,2	0,5 ± 0,2
	hole	2,2 max.	4,2 max.	2 min.			1,6 max.	0,7 ± 0,1	1,0 ± 0,2	
6,3 × 0,8	dimple				2,5 max.	7,8 max.	2,9 max.	1,0 ± 0,1	1,0 ± 0,2	0,5 ± 0,2
	hole	3,5 max.	5,5 max.	2 min.			2,9 max.	1,0 ± 0,1	1,0 ± 0,2	
9,5 × 1,2	dimple				4 max.	12,0 max.	2,9 max.	1,5 ± 0,1	1,4 ± 0,2	0,7 ± 0,2
	hole	5 max.	7,5 max.	2,5			2,9 max.	1,5 ± 0,1	1,4 ± 0,2	

[a] If Figures E.10 and E.11 are combined, the dimension *T* ~~must~~ shall be greater than the actual value of the dimension *G* plus the thickness *C* of the material.

If not otherwise specified in Table 7, the dimensions *E*1 and *F*1 shall comply with the equivalent dimensions according to Tables 5 and 6 for the larger size of the male tab, and the dimensions *B*2, *E*2 and *F*2 with the smaller size of the male tab.

Examples of designs and dimensions of flat quick-connect terminations are shown in Figures E.6 to E.13.

8.1.7.2 Male tabs may have an optional detent for latching. Round dimple detents, rectangular dimple detents and hole detents shall be located in the hatched area along the centre-line of the male tab as indicated in Figure E.10.

NOTE Male tabs ~~may~~ can have a larger hole to allow soldering.

Table 7 – Dimensions in millimetres of combined male tabs for two different sizes of female connectors

Nominal size mm	Types according to figures				
	*E*1	*F*1	*B*2	*E*2	*F*2
2,8 × 0,8			6 min.	2,0 to 2,4	1,3 to 1,5
6,3 × 0,8	4,0 to 4,5	1,6 to 1,9			

8.1.7.3 Provisions for non-reversible restrictions may be located in the area "LG" of Figure E.11 and "KR" of Figure E.12 along the centre-line of the male tab.

~~NOTE~~ If Figures E.10 and E.11 are combined, *T* shall be greater than the actual value of *G* plus the thickness *C* of the material. For the value of *T*, *G* and *C*, see Tables 5 and 6.

NOTE Male tabs according to Figure E.12 are not designed to have a hole or a dimple according to the values of *E* and *F* of Table 5.

8.1.7.4 Male tabs shall be so designed as to allow the correct insertion and withdrawal of one of the female connectors shown in Figure E.14 without damage which could impair the further use of the CBE.

Compliance is checked by the test of 9.4.3.1.

8.1.7.5 Male tabs shall be securely retained.

Compliance is checked by the mechanical overload force test of 9.4.3.2.

8.1.7.6 Male tabs as indicated in Figure E.13 may have a design which allows the connection of two different sizes of female connectors.

8.1.7.7 Male tabs of similar size and design and dimensionally similar to those shown in Tables 5 and 6 shall be allowed if they are able to pass the compliance test with the female connector shown in Figure E.14.

An example of a female connector and possible dimensions are given in Figure E.14.

Compliance is checked by the test of 9.4.3.

8.1.7.8 Male tabs which do not have the dimension criteria shown in 8.1.7.1 and 8.1.7.7 are allowed only if the dimensions and shapes are so different as to prevent any mating with the female connector shown in Figure E.14.

8.1.7.9 Male tabs shall be adequately spaced to allow the connection of the appropriate uninsulated female connectors.

Compliance is checked by applying to each different male tab design/configuration an appropriate female connector according to the manufacturer's instructions in the most severe orientation; during this operation, no strain or distortion shall occur to any of the male tabs or to their adjacent parts, nor shall the creepage distances or clearances be reduced to values less than those specified in 8.1.3.

NOTE A non-reversible stop ~~may~~ can be included so that a female connector can only be applied in one direction, so that the female connector cannot be inserted in the reversed position.

For male tabs complying with Figure E.11 or Figure E.12, an appropriate female connector is that shown in Figure E.14.

8.2 Protection against electric shock

Parts of the CBE accessible after installation in equipment shall provide protection against electric shock.

Compliance is verified by the tests of 9.6.

Completion of the protection against electric shock after installation of the CBE is the responsibility of the equipment manufacturer.

8.3 Temperature-rise

8.3.1 Temperature-rise limits

The temperature-rises of the parts of a CBE, measured under the conditions specified in 9.8.2, shall not exceed the values specified in Table 8.

Table 8 – Temperature-rise values for CBEs for different reference ambient air temperatures (*T*)

Parts [a] [b]	Temperature rise (*K*) according to *T* [e]		
	T = 23 °C [f] (standard value)	*T* = 40 °C [f]	*T* = 55 °C [f]
Terminals [c]	60 [d]	50 [d]	35 [d]
External parts liable to be touched during manual operation, including operating means of insulating material	55	40	25
External metallic parts of operating means	35	25	10
Other external parts, including that face of the CBE in direct contact with the mounting surface	70	60	45

[a] No value is specified for the contacts, since the design of most CBEs is such that a direct measurement of the temperature of those parts cannot be made without the risk of causing alterations or displacements of parts likely to affect the reproducibility of the tests.
The 28-day test (see 9.9) is considered to be sufficient for checking indirectly the behaviour of the contacts with respect to undue overheating in service.

[b] No value is specified for parts other than those listed, but no damage shall be caused to adjacent parts of insulating materials, and the operation of the CBE shall not be impaired.

[c] For plug-in type CBEs, the terminals of the base on which the CBE is installed.

[d] Higher values are permitted for terminals for conductors inside the equipment where the CBE is intended to be installed. Relevant information on those values shall be made available to the equipment manufacturer.

[e] For other values of *T*, the admissible temperature-rise can be determined by interpolation between the values (*T* + *K*) obtained by the sum of the values shown in the table.

[f] Tolerance ±2 °C.

~~NOTE The temperature-rise values are taken from table 4a of IEC 60950.~~

Compliance is checked by tests of 9.8.

8.3.2 Ambient air temperature

The temperature-rise limits given in Table 8 are applicable only if the ambient air temperature remains between the limits given in 7.2.2.

8.4 Dielectric properties

8.4.1 Dielectric strength at power frequency

CBEs shall have adequate dielectric properties at power frequency.

Compliance is checked by the tests of 9.7.1, 9.7.2 and 9.7.3, with samples in new condition.

After the verification of electrical operational capability of 9.11, the CBEs shall withstand the test of 9.7.3 but at a test voltage 0,75 times the voltage indicated in 9.7.5 and without the previous humidity treatment of 9.7.1.

8.4.2 Clearances for insulation coordination

The clearances of CBEs shall satisfy the requirements of insulation coordination.

Compliance shall be checked by measurement of the clearances as specified in 8.1.3, or by the impulse withstand voltage test specified in 9.7.6.

Requirements for isolating capability of CBEs suitable for isolation are given in K.8.4.2.

8.5 Conditions for automatic operation

8.5.1 Standard time-current zone

The tripping zone (see 3.9.4) is defined by the information given by the manufacturer in his catalogue (see Annex A). It refers to the reference conditions as specified in 9.2.

NOTE 1 The tripping characteristic of a CBE is intended to ensure adequate protection of the equipment, without premature operation.

The operating zone of a CBE shall be stated for one CBE without enclosure, mounted in still air.

NOTE 2 Conditions of temperature and mounting different from the ones stated (type of enclosure, grouping of more CBEs in the same enclosure, etc.) ~~may~~ can affect the operating zone of a CBE.

The manufacturer shall be prepared to make available the characteristics related to specified ambient temperatures different from the standard reference ambient temperature of (23 ± 2) °C, and to give information on the variation of the tripping characteristic due to deviations from other reference conditions, for example, for mounting in planes other than vertical.

A representation of the operating zone is given by Figure A.1. For a CBE with thermal, thermal magnetic, magnetic, or hydraulic-magnetic mode of tripping, the manufacturer shall state the following values:

– the test currents indicated in Table 9, as multiples of the rated current ~~(mI_n)~~;

– the times (t_1, t_2, t_3, t_4~~, t_5 and t_6~~) indicated in Table 9, where applicable.

Table 9 – Time-current operating characteristics

Test current	Initial conditions	Time, t	Required result
I_{nt}	Cold [a]	1 h	No tripping
I_t	Immediately following the non-tripping test	≤ 1 h	Tripping
$2I_n$	Cold [a]	$t_1 \leq t \leq t_2$	Tripping
$6I_n$	Cold [a]	$t_3 \leq t \leq t_4$	Tripping
~~mI_n [b]~~	~~Cold [a]~~	~~$t_5 \leq t \leq t_6$~~	~~Tripping~~
I_{ni}	Cold [a]	0,1 s	No tripping
I_i	Cold [a]	< 0,1 s	Tripping

[a] The term "cold" means without previous loading (see Annex A).

~~[b] Optional test.~~

NOTE 3 Values for mode of tripping of electronic hybrid CBEs are under consideration.

8.5.2 Tripping characteristic

8.5.2.1 General

The tripping characteristic of a CBE shall be contained within the zone defined in 8.5.1.

NOTE Conditions of temperature and mounting different from those specified in 9.2 may affect the tripping characteristic of a CBE.

8.5.2.2 Effect of single-pole loading of a multi-pole CBE on the tripping characteristic

When a CBE with more than one protected pole is loaded on only one of the protected poles, starting from cold, it shall trip within the conventional time with a current equal to:

– 1,1 times the conventional tripping current (see 3.3.6), for two-pole CBEs with two protected poles;
– 1,2 times the conventional tripping current, for three-pole and four-pole CBEs.

The conventional time is 1 h.

Compliance is checked by the test of 9.10.4.

8.5.2.3 Effect of the ambient air temperature on the tripping characteristic

If applicable, the manufacturer shall state the factor by which the rated current has to be increased or reduced if the device is operated at ambient temperatures deviating from the reference value (see 5.2.3).

8.5.3 Operating limits of overvoltage releases

Overvoltage releases are tested at the operating limits indicated by the manufacturer.

Compliance is checked by the test of 9.11.5.

8.5.4 Operating limits of undervoltage and zero-voltage releases

Undervoltage and zero-voltage releases are tested at the operating limits according to Table 10.

Table 10 – Operating limits of undervoltage and zero-voltage releases (for AC and DC)

Type of release	Hold level	Trip level	Reset level [a]	Withstand level
Undervoltage release	$U \geq 0{,}7$ ~~U_e~~ U_n	$U \leq 0{,}35$ ~~U_e~~ U_n	$U \geq 0{,}85$ ~~U_e~~ U_n	$U = 1{,}1$ ~~U_e~~ U_n
Zero-voltage release	$U \geq 0{,}7$ ~~U_e~~ U_n	$U \leq 0{,}1$ ~~U_e~~ U_n	$U \geq 0{,}85$ ~~U_e~~ U_n	$U = 1{,}1$ ~~U_e~~ U_n

[a] For electrically resetting devices, the threshold operating value.

~~NOTE~~ Other values may be agreed upon between manufacturer and user.

The headings of the columns of Table 10 have the following meaning.

– Hold level: the voltage at which or above which a release shall not open automatically.
– Trip level: the voltage at which or below which a release shall open automatically.
– Reset level: the voltage at which or above which a release shall reset when actuated.
– Withstand level: the voltage which a release is capable of withstanding in continuous service.

Compliance is checked by the tests of 9.11.6.1 and 9.11.6.3.

8.5.5 Electrical endurance of undervoltage releases

The manufacturer shall provide information concerning electrical endurance of undervoltage releases in his literature.

Compliance is checked by the test of 9.11.6.2.

8.6 Electrical performance and behaviour at rated short-circuit capacity

A CBE shall be capable of performing an adequate number of operating cycles.

Compliance is checked by the tests of 9.11.

It is required that a CBE be able to make and to break any value of current up to and including the value corresponding to the rated switching capacity at rated frequency, at a voltage equal to 105 % (± 5 %) of the rated operational voltage and at any power factor not less than the appropriate lower limit of the range stated in Tables 11 or 12 according to the performance.

8.7 Performance under conditional short-circuit current conditions

A CBE shall withstand the stresses due to short-circuit currents when associated with a specified SCPD without manifestations such as emission of flames, sparks or hot ionized gases, which may constitute a risk for the operator or the equipment.

Compliance is checked by the tests of 9.12.

8.8 Resistance to mechanical shock and impact

A CBE shall have adequate mechanical behaviour so as to withstand the stresses imposed during installation and use.

Compliance is checked by the test of 9.13 (under consideration).

8.9 Resistance to heat

A CBE shall be sufficiently resistant to heat.

Compliance is checked by the test of 9.14.

8.10 Resistance to abnormal heat and to fire

External parts of a CBE made of insulating material shall not be likely to ignite and to spread fire if current-carrying parts in its vicinity under fault or overload conditions attain a high temperature.

Compliance is checked by inspection and by the test of 9.15.

8.11 Resistance to tracking

Parts of insulating material retaining in position live parts of CBEs shall be of material resistant to tracking.

Compliance is checked by inspection and by the test of 9.16.

8.12 Resistance to rusting

Ferrous parts shall be adequately protected against rusting.

Compliance is checked by the test of 9.17.

Table 11 – Test conditions for electrical performance for CBEs intended for general use, including inductive circuits

Section	Test concerning behaviour at	Type according to method of operation (see 4.4)	Test conditions			Requirements			
			Number of operating cycles	Time of open position s	Test voltage	AC Test current	AC Power factor	DC Test current	DC Time constant ms
1	Rated current Low overloads	M S R, J	500 a 50	15 20 b	U_e	I_n I_n 2 I_n	0,55 to 0,65	I_n I_n 2 I_n	2 to 3
2	Rated switching capacity	M S R, J	40	60 to 80 b	1,05 U_e	6 I_n	0,55 to 0,65	4 I_n	2 to 3
3	Rated short-circuit capacity I_{cn} (optional)	R, J, M, S for $I_{cn} \le$ 500 A a.c.	The tests shall be performed as specified in IEC 60898 under the following conditions: – single-pole CBEs are tested according to 9.12.11.2 of IEC 60898, the circuit being calibrated at I_{cn} instead of 500 A; – multi-pole CBEs are tested on each pole as above and then submitted to the multi-pole test of 9.12.11.3 at I_{cn} instead of 1 500 A.					$I_{cn} \le$ 500 A	2 to 3
		R, J, M, S for 500 A < I_{cn} ≤ 1 500 A a.c.	The tests shall be performed as specified in IEC 60898 under the following conditions: – single-pole CBEs are tested according to 9.12.11.2 of IEC 60898 (500 A), and successively as specified in 9.12.11.3 of IEC 60898, the circuit being calibrated at I_{cn}; – multi-pole CBEs are tested on each pole according to 9.12.11.2 of IEC 60898, and successively as specified in 9.12.11.3 of IEC 60898, the circuit being then calibrated at I_{cn}.					$I_{cn} \le$ 1 000 A I_{cn} > 1 000 A	2 to 3 4 to 6
		R, J, M, S for I_{cn} > 1 500 A a.c.	The tests shall be performed as specified in 9.12.11 of IEC 60898					I_{cn} > 1 500 A	4 to 6
		R, J, M, S d.c.	3	300 to 360	1,05 U_e			I_{cn}	5

a The manufacturer shall state the number, in accordance with the classification of the appliance, taken from the preferred values 3 000, 10 000, 30 000, 50 000, and 100 000.

b Determined by the time required to reset the device.

Section	Test concerning behaviour at	Type according to method of operation (see 4.5)	Test conditions: Number of opera-ting cycles	Test conditions: Time of open position s	Test conditions: Test voltage	Requirements AC: Test current	Requirements AC: Power factor	Requirements DC: Test current	Requirements DC: Time constant ms
1	Rated current	M	500	15		I_n	0,55	I_n	2
		S	[a]	20	U_e	I_n	to	I_n	to
	Low overloads	R, J	50	[b]		2 I_n	0,65	2 I_n	3
2	Rated switching capacity	M					0,55		2
		S	40	60 to 80	1,05 U_e	6 I_n	to	4 I_n	to
		R, J		[b]			0,65		3
3.1	Rated short-circuit capacity I_{cn}	M, S, R, J	3	300 to 360	1,05 U_e	6 I_n [c]		4 I_n [c]	
						6 I_n $< I_{cn} \leq$ 1 500 A	0,93 to 0,98	4 I_n $< I_{cn} \leq$ 1 000 A	2 to 3
						1 500 A $< I_{cn} \leq$ 3 000 A	0,85 to 0,9	1 000 A $< I_{cn} \leq$ 3 000 A	4 to 6
3.2 [d]	Test verifying the suitability for use in IT systems	M, S, R, J	2	300 to 360	*105 % of the rated voltage upper value*	6 I_n	0,93 to 0,98	–	–
						$I_{cn} > 6\ I_n$: 1,2 × I_i	0,93 to 0,98	–	–

[a] The manufacturer shall state the number, in accordance with the classification of the appliance, taken from the preferred values 3 000, 10 000, 30 000, 50 000, and 100 000.

[b] Determined by the time required to reset the device.

[c] Test is covered by section 2.

[d] Only relevant for CBEs marked with 230/400, 120/240, etc.

Table 12 – Test conditions for electrical performance of CBEs used in essentially resistive circuits only (see Clause 6, item d)

Section	Test concerning behaviour at	Type according to method of operation (see 4.4)	Test conditions			Requirements			
						AC		DC	
			Number of operating cycles	Time of open position s	Test voltage	Test current	Power factor	Test current	Time constant ms
1	Rated current Low overloads	M S R, J	500 a 50	15 20 b	U_e	I_n I_n 2 I_n	0,95 to 1	I_n I_n 2 I_n	0 to 0,5
2	Rated switching capacity	M, S, R, J	40	60 to 80 b	1,05 U_e	6 I_n	0,95 to 1	4 I_n	0 to 0,5
3	Rated short-circuit capacity I_{cn} (optional)	M, S, R, J	3	300 to 360	1,05 U_e	I_{cn}	0,93 to 0,98	I_{cn} ≤ 1 000 A I_{cn} > 1 000 A	1 to 2 2 to 3

[a] The manufacturer shall state the number, in accordance with the classification of the appliance, taken from the preferred values 3 000, 10 000, 30 000, 50 000 and 100 000.

[b] Determined by the time required to reset the device.

Section	Test concerning behaviour at	Type according to method of operation (see 4.5)	Test conditions			Requirements			
			Number of opera-ting cycles	Time of open position s	Test voltage	AC		DC	
						Test current	Power factor	Test current	Time constant ms
1	Rated current	M	500	15	U_e	I_n	0,95	I_n	0
		S	[a]	20		I_n	to	I_n	to
	Low overloads	R, J	50	[b]		2 I_n	1	2 I_n	0,5
2	Rated switching capacity	M, S, R, J	40	60 to 80 [b]	1,05 U_e	6 I_n	0,95 to 1	4 I_n	0 to 0,5
3.1	Rated short-circuit capacity I_{cn}	M, S, R, J	3	300 to 360	1,05 U_e	6 I_n [c]		4 I_n [c]	
						6 I_n < I_{cn} ≤ 3 000 A	0,93 to 0,98	4 I_n < I_{cn} ≤ 1 000 A	1 to 2
								1 000 A < I_{cn} ≤ 3 00 A	2 to 3
3.2 [d]	Test verifying the suitability for use in IT systems	M, S, R, J	2	300 to 360	*105 % of the rated voltage upper value*	6 I_n	0,95 to 1	–	–
						I_{cn} > 6 I_n 1,2 × I_i	0,95 to 1	–	–

[a] The manufacturer shall state the number, in accordance with the classification of the appliance, taken from the preferred values 3 000, 10 000, 30 000, 50 000 and 100 000.

[b] Determined by the time required to reset the device.

[c] Test is covered by section 2.

[d] Only relevant for CBEs marked with 230/400, 120/240, etc.

9 Tests

9.1 Type tests and sequences

9.1.1 *The characteristics of a CBE are verified by means of type tests.*

The type tests required by this document are listed in Table 13.

Table 13 – List of type tests

Tests	Subclause
Indelibility of marking	9.3
Reliability of terminals, current-carrying parts and connections	9.4
Reliability of terminals for external conductors	9.5
Protection against electric shock	9.6
Dielectric properties	9.7
Temperature-rise	9.8
28-day test	9.9
Tripping characteristics	9.10
Electrical operational ~~performance~~ capability	9.11
Conditional short-circuit ~~capacity~~ current	9.12
Resistance to mechanical shock and impact	9.13
Resistance to heat	9.14
Resistance to abnormal heat and fire	9.15
Resistance to tracking	9.16
Resistance to rusting	9.17

Additional tests for CBEs suitable for isolation are given in K.9.7.7.

9.1.2 For certification purposes type tests are carried out in test sequences.

The test sequences and the number of samples to be submitted are stated in Annex C.

Unless otherwise specified, each type test (or sequence of type tests) shall be made on CBEs in a clean and new condition.

9.2 Test conditions

The CBE is mounted individually, vertically and in free air at an ambient temperature of (23 ± 2) °C, unless otherwise specified, and is protected against undue external heating or cooling.

Unless otherwise specified, the CBE is wired with the appropriate cable specified in Table 14 and is mounted complete on a metal support unless the device is intended to be used in a non-metallic enclosure only. In this case, the CBE is mounted in a way corresponding as closely as possible to that in actual use.

Unless otherwise specified tests are carried out at the rated frequency ± 5 Hz.

During the tests no maintenance or dismantling of the samples is allowed.

For the tests of 9.8, 9.9 and 9.10 the CBE is connected as follows:

a) the connections are single-core, PVC-insulated copper conductors according to IEC 60227;

b) the test is carried out with single-phase current, with all poles connected in series, except for the test according to 9.10.3;

c) the connections are in free air and spaced at not less than the distance between the terminals;

d) the minimum length of each connection is

- *1 m for cross-sections up to and including 10 mm²;*
- *2 m for cross-sections larger than 10 mm².*

The tightening torques to be applied to the terminal screws are two-thirds of those specified in Table 15.

Table 14 – Standard cross-sections of copper conductors corresponding to the rated currents

Standard cross-section mm²	1	1,5	2,5	4	6	10	16	25	35	50
Values of the rated current A	6	> 6 to 13	> 13 to 20	> 20 to 25	> 25 to 32	> 32 to 50	> 50 to 63	> 63 to 80	> 80 to 100	> 100 to 125

9.3 Test of indelibility of marking

The test is made by rubbing the markings by hand for 15 s with a piece of cotton soaked with water and again for 15 s with a piece of cotton soaked with petroleum spirit.

NOTE 1 The petroleum spirit used is defined as a solvent hexane with a content of aromatics of maximum 0,1 % volume percentage, a kauri-butanol value of 29, an initial boiling-point of approximately 65 °C, a dry-point of approximately 69 °C and a density of approximately 0,65 g/cm³.

Marking made by impressing, moulding or engraving is not subjected to this test.

After this test the marking shall be easily legible. The marking shall also remain easily legible after all the tests of this document. It shall not be possible to remove labels easily, and these shall show no curling.

NOTE 2 A revision of this test is under consideration.

9.4 Test of reliability of terminals, current-carrying parts and connections

9.4.1 Screw type and screwless terminals

9.4.1.1 General

Compliance with the requirements of 8.1.5.3 is checked by the insertion of the largest conductor, after the insulation has been removed and the end of the rigid stranded and of the flexible conductors have been reshaped. The stripped end of the conductor shall be able to enter completely within the terminal without use of undue force.

9.4.1.2 Screw-type terminals

Compliance with the requirements of 8.1.4 is checked by inspection and, for screws and nuts which are operated when connecting the CBE, by the following test.

The screws and nuts are tightened and loosened

- *ten times for screws in engagement with a thread of insulating material (see 8.1.4.2);*
- *five times in all other cases.*

Screws or nuts in engagement with a thread of insulating material are completely removed and inserted each time.

The test is made by means of a suitable test screwdriver or spanner applying a torque as shown in Table 15.

The screws and nuts shall not be tightened in jerks.

The conductor is moved each time the screw or nut is loosened.

Table 15 – Screw-thread diameter and applied torques

Nominal diameter of the thread mm	Torque N.m		
	I	II	III
Up to and including 2,8	0,2	0,4	0,4
Above 2,8 up to and including 3,0	0,25	0,5	0,5
Above 3,0 up to and including 3,2	0,4	0,6	0,6
Above 3,2 up to and including 3,6	0,6	0,8	0,8
Above 3,6 up to and including 4,1	0,7	1,2	1,2
Above 4,1 up to and including 4,7	0,8	1,8	1,8
Above 4,7 up to and including 5,3	0,8	2,0	2,0
Above 5,3 up to and including 6,0	1,2	2,5	3,0
Above 6,0 up to and including 8,0	2,25	3,5	6,0
Above 8,0 up to and including 10,0	–	4,0	10,0

Column I applies to screws without heads if the screw, when tightened, does not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the diameter of the screw.

Column II applies to other screws which are tightened by means of a screwdriver.

Column III applies to screws and nuts which are tightened by means other than a screwdriver.

Where a screw has a hexagonal head with a slot for tightening with a screwdriver and the values in column II and III are different, the test is made twice, first applying to the hexagonal head the torque specified in column III and then, on another sample, applying the torque specified in column II by means of a screwdriver. If the values in column II and III are the same, only the test with the screwdriver is made.

During the test, the screwed connections shall not work loose and there shall be no damage, such as breakage of screws or damage to the head slot, threads, washers or stirrups, that will impair the further use of the CBE.

Moreover, enclosures and covers shall not be damaged.

9.4.1.3 Screwless terminals

Compliance with the requirements of 8.1.5.3 is checked by inspection and, for screwless terminals which are operated when connecting the CBE, by the following test.

The terminals are fitted with each type of conductor according to their design that is:

– *solid only;*
– *solid and rigid-stranded;*
– *solid, rigid-stranded and flexible.*

Each conductor of the largest cross-section for which the terminal is intended to be used is inserted and subsequently disconnected.

This test is performed five times.

New conductors are used each time, except for the fifth time, when the conductor used for the fourth insertion is clamped at the same place. For each insertion, the conductors are either pushed as far as possible into the terminal or are inserted so that adequate connection is obvious. After each insertion the conductor is twisted through 90° and subsequently disconnected. After these tests, the terminals shall not be damaged in such a way as to impair their further use.

9.4.2 Solder terminations

9.4.2.1 Solderability test

Compliance with the requirements of 8.1.6.1 is checked by the test according to IEC 60068-2-20, test Ta. If not otherwise specified by the manufacturer, method 1 (solder bath at 235 °C) is applicable.

9.4.2.2 Resistance to soldering heat

Compliance with the requirements of 8.1.6.2 is checked by applying the test according to IEC 60068-2-20, test Tb. If not otherwise specified by the manufacturer, method 1B (solder bath at 350 °C) is applicable.

The solder terminations shall be immersed in the solder bath down to a depth of 2,0 mm to 2,5 mm from the housing of the CBE and shall remain immersed for 5 s ± 1 s.

After the test the solder terminations shall not have worked loose or have been displaced in a manner impairing their further use.

Compliance is checked by inspection.

9.4.3 Flat quick-connect male tabs

9.4.3.1 Insertion and withdrawal test

Table 16 – Insertion and withdrawal forces

Nominal size mm	Insertion force maximum N	Withdrawal force minimum N
2,8	53	5
4,8	67	9
6,3	80	18
9,5	100	20

Compliance with the requirement of 8.1.7 is checked by using the female connector as shown in Figure E.14. The male tab shall be slowly and steadily inserted and withdrawn six times at a rate of travel of approximately 1 mm/s.

The insertion and withdrawal forces shall be within the limits as specified in Table 16.

Insertion and withdrawal force measurements shall be made with any suitable testing device providing accurate alignment and being capable of holding the reading.

9.4.3.2 Mechanical push/pull test

An axial force, equal to that shown in Table 17, is applied smoothly once only with a suitable test apparatus. No damage which could impair further use shall occur to the tab or to the CBE.

Compliance is checked by inspection.

Table 17 – Push/pull force

Nominal size mm	**Push/pull forces** N
2,8	58
4,8	73
6,3	88
9,5	110

9.5 Test of reliability of terminals for external conductors (see 3.12.15)

9.5.1 *Compliance with the requirements of 8.1.5 is checked by inspection, by the test of 9.4, where a rigid copper conductor having the largest cross-sectional area specified in Table 3 is placed in the terminal (for nominal cross-sectional areas exceeding 6 mm^2, a rigid stranded conductor is used; for other nominal cross-sectional areas, a solid conductor is used) and by the tests of 9.5.2, 9.5.3 and 9.5.4.*

These last tests are made by means of a suitable test screwdriver or spanner applying a torque as shown in Table 15.

9.5.2 *The terminals are fitted with copper conductors of the smallest and largest cross-sectional areas specified in Table 3, solid or stranded, whichever is the more unfavourable.*

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, and in the position most likely to assist the wire to escape.

Screws, if any, are then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 15. Each conductor is then subjected to a pull of the value shown in Table 18. The pull is applied without jerks, for 1 min, in the direction of the axis of the conductor space.

Table 18 – Pulling forces

Cross-section of conductor accepted by the terminal mm^2	**Up to 1,5**	**Up to 4**	**Up to 6**	**Up to 10**	**Up to 16**	**Up to 50**
Pull N	40	50	60	80	90	100

During the test, the conductor shall not move noticeably in the terminal.

9.5.3 *The terminals are fitted with copper conductors of the smallest and largest cross-sectional areas specified in Table 3, solid or stranded, whichever is the more unfavourable. If it is a screw-type terminal, the screws are tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 15. The terminal screws are then loosened and that part of the conductors which may have been affected by the terminal is inspected.*

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 or stirrups, which will impair the further use of the terminal.

After the test the conductors shall show no undue damage or severed wires.

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

9.5.4 *The terminals are fitted with a rigid stranded copper conductor having the make-up shown in Table 19.*

Table 19 – Make-up of conductors for the test of 9.5.4

Range of nominal cross-sections to be clamped mm²	Rigid stranded conductor	
	Number of wires	Diameter of wires mm
0,5 to 1,5 [a]	7	0,50
0,75 to 2,5 [a]	7	0,67
1 to 4 [a]	7	0,85
1,5 to 6 [a]	7	1,04
2,5 to 10	7	1,35
4 to 16	7	1,70
10 to 25	7	2,14
16 to 35	19	1,53
25 to 50	Under consideration	

[a] If the terminal is intended to clamp solid conductors only (see note of Table 3), the test is not made.

Before insertion in the terminal, the wires of the conductors are suitably reshaped.

The conductor is inserted into the terminal until the conductor reaches the bottom of the terminal or just projects from the far side of the terminal and in the position most likely to assist a wire to escape. The clamping screw or nut, if any, is then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 15.

After the test, no wire of the conductor shall have escaped outside the clamping unit in such a way as to reduce the required creepage distances and clearances.

9.6 Test of protection against electric shock

A CBE is intended to be used integrated into equipment (for example an appliance). Therefore this test cannot be carried out on an individual CBE, unless restricted to areas which can be touched when installed in accordance with the manufacturer's instructions.

The test is made with the standard test finger, Figure 4, on such parts of a CBE which may be touched when installed. CBEs with screw-type or screwless terminals are fitted with the conductors of the smallest and largest cross-sectional areas specified in Table 3. The standard test finger ~~must~~ 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. The test finger is applied in every possible bending position of a real finger, an electrical contact indicator being used to show contact with live parts.

It is recommended that a lamp be used for the indication of contact and that the voltage be not less than 40 V.

9.7 Test of dielectric properties

9.7.1 Resistance to humidity

9.7.1.1 Preparation of the CBE for test

The test ~~has to~~ shall be made on the CBE itself without any enclosure.

If, in special cases, an integral enclosure is used, the inlet openings, if any, are left open; if knock-outs are provided, one of them is opened.

NOTE The term "integral enclosure" means that the CBE cannot function normally without it.

Parts which can be removed without the aid of a tool are removed and subjected to the humidity treatment with the main part; spring lids are kept open during this treatment.

9.7.1.2 Test conditions

The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %.

The temperature of the air in which the sample is placed is maintained within ±1 °C of any convenient value T between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the sample is brought to a temperature between T and T + 4 °C.

9.7.1.3 Test procedure

The sample is kept in the cabinet for 48 h.

NOTE ~~1~~ A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water having a sufficiently large contact surface with the air.

~~NOTE 2~~ In order to achieve the specified conditions within the cabinet, it is recommended to ensure constant circulation of the air inside and, in general, to use a cabinet which is thermally insulated.

9.7.1.4 Condition of the CBE after test

After this treatment, the sample shall show no damage within the meaning of this document and shall withstand the tests of 9.7.2 and 9.7.3.

9.7.2 Insulation resistance of the main circuit

The CBE having been treated as specified in 9.7.1, the insulation resistance is measured 5 s after application of a DC voltage of approximately 500 V, consecutively as follows:

a) *with the CBE in the open position, between each pair of the terminals or terminations which are electrically connected together when the CBE is in the closed position, on each pole in turn;*

   NOTE 1 This test is not applicable to J-type CBEs without means for manual operation.

b) *with the CBE in the closed position, between each pole in turn and the others connected together; for the test between phases, electronic components connected to the main circuit may be disconnected during the test;*

c) *with the CBE in the closed position, between all poles connected together and the frame, including a metal foil in contact with the outer surface of the internal enclosure of insulating material, if any;*

d) *between metal parts of the mechanism and the frame;*

e) *for a CBE with a metal enclosure having an internal lining of insulating material, between the frame and a metal foil in contact with the inner surface of the lining of insulating material, including bushings and similar devices.*

The tests a), b) and c) are carried out after having connected all auxiliary circuits to the frame.

NOTE 2 The term "frame" includes

- all accessible metal parts and a metal foil in contact with the surfaces of insulating material which are accessible after installation as for normal use;
- the surface on which the base of the CBE is mounted, covered if necessary, with metal foil;
- screws and other devices for fixing the base to its support;
- screws for fixing covers which have to be removed when mounting the CBE, metal parts of operating means referred to in 8.1.2.

If the CBE is provided with a terminal intended for the interconnection of protective conductors, this is connected to the frame.

For the measurement according to items a) to e) the metal foil is applied in such a way that the sealing compound, if any, is effectively tested.

The insulation resistance shall be not less than

- *2 MΩ for the measurements according to items a) and b);*
- *5 MΩ for the other measurements.*

9.7.3 Dielectric strength of the main circuit

After a CBE has passed the tests of 9.7.2, the test voltage specified in 9.7.5 is applied for 1 min between the parts indicated in 9.7.2.

Initially, no more than half the prescribed voltage is applied, then it is raised to the full value within 5 s.

No flashover or breakdown shall occur during the test.

Glow discharges without drop in the voltage are neglected.

9.7.4 Dielectric strength of the auxiliary circuits

For these tests, the main circuit shall be connected to the frame. The test voltage specified in 9.7.5 shall be applied for 1 min as follows:

a) *between all the auxiliary circuits which are not normally connected to the main circuit, connected together, and the frame of the CBE;*

b) *where appropriate, between each part of the auxiliary circuits which may be isolated from the other parts of the auxiliary circuits, and these other parts connected together.*

No flashover or breakdown shall occur during the test.

9.7.5 Value of test voltage

The test voltage shall have practically sinusoidal waveform and a frequency between 45 Hz and 65 Hz.

The values of the test voltage, applied as indicated in items a), b), c), d) and e) of 9.7.2, shall be in accordance with Table 20.

The source of the test voltage shall be capable of supplying a short-circuit current of at least 0,2 A.

No overcurrent tripping device of the transformer shall operate when the current in the output circuit is lower than 100 mA.

Table 20 – Test voltages

Rated voltage or working voltage V	≤ 50	> 50 ≤ 125	> 125 ≤ 250	> 250 ≤ 440
Test voltage for dielectric strength tests according to 9.7.3 and 9.7.4 a) V	500	1 000	1 500	2 000
Test voltage for dielectric strength tests according to 9.7.4 b) V	250	500	1 000	1 500

NOTE Test voltages for supplementary or reinforced insulation are under consideration.

9.7.6 Test for the verification of insulation coordination by impulse withstand voltage test

This test is used to prove the adequacy of clearances for insulation coordination, if smaller than those specified in Table 1 (see 8.1.3.2.7).

The test is carried out on a CBE installed and wired as in normal use, with the impulse voltage according to Figure 6 of IEC 60060-1:2010.

The impulses are given by a generator producing positive and negative impulses having a front time of 1,2 µs and a time to half-value of 50 µs, the tolerance being

- *±5 % for the peak value;*
- *±30 % for the front time;*
- *±5 % for the time to half-value.*

The shape of the impulses is adjusted with the CBE under test connected to the impulse generator. For this purpose, appropriate voltage dividers and voltage sensors shall be used.

Small oscillations in the impulse are allowed, provided that their amplitude near the peak of the impulse is less than 5 % of the peak value.

For oscillations on the first half of the front, amplitudes up to 10 % of the peak value are allowed.

After the CBE has passed the tests of 9.7.2, the impulse withstand test voltages specified in Table 21 are applied between the parts indicated in 9.7.2.

A first series of tests is made by applying the impulse withstand test voltage to the phase pole(s), connected together, and the neutral pole (or path) of the CBE, as applicable.

A second series of tests is made by applying the impulse withstand test voltage between the metal support, connected to the terminal(s) intended for the protective conductors(s), if any, and the phase pole(s) and the neutral pole (or path) connected together.

The impulse voltage shall be applied three times for each polarity at intervals of 1 s minimum.

There shall be no unintentional disruptive discharges during the test.

If, however, only one such disruptive discharge occurs, six additional impulses having the same polarity as that which caused the disruptive discharge are applied, the connections being the same as those with which the failure occurred.

No further disruptive discharge shall occur.

NOTE 1 The surge impedance of the test apparatus ~~should~~ can be 500 Ω; a substantial reduction of this value is under consideration.

NOTE 2 The expression "unintentional disruptive discharge" is used to cover the phenomena associated with the failure of insulation under electric stress, which include a drop in the voltage and the flowing of current.

NOTE 3 Intentional discharges cover discharges of any incorporated surge arresters.

Table 21 – Impulse withstand test voltages for verification of insulation coordination

Rated impulse withstand voltage V	Applicable impulse voltages (1,2/50 µs pulse) according to the altitude at which the test is made [a] V				
	Sea level [b]	200 m	500 m	1 000 m	2 000 m
330	350	350	350	340	330
500	550	540	530	520	500
800	910	900	900	850	800
1 500	1 750	1 700	1 700	1 600	1 500
2 500	2 950	2 800	2 800	2 700	2 500
4 000	4 800	4 800	4 700	4 400	4 000
6 000	7 300	7 200	7 000	6 700	6 000

[a] The values are taken from Table 12 of IEC 60947-1:2007.

[b] For other altitudes the impulse voltage is determined by interpolation.

9.8 Test of temperature-rise

9.8.1 Ambient air temperature

The ambient air temperature shall be measured during the last quarter of the test period by means of at least two thermometers or thermocouples symmetrically positioned around the CBE at about half its height and at a distance of about 1 m from the CBE.

The thermometers or thermocouples shall be protected against draughts and radiant heat.

9.8.2 Test procedure

The test shall be made at the reference ambient air temperature as specified in 7.2.1.

A current equal to I_n is passed simultaneously through all the poles of the CBE for a period of time sufficient for the temperature-rise to reach the steady-state value or for the conventional time, whichever is the longer (but not exceeding 8 h).

In practice, this condition is reached when the variation of the temperature-rise does not exceed 1 K per hour.

For a four-pole CBE with three protected poles, the test is first made by passing the specified current through the three protected poles only.

The test is then repeated by passing the same current through the pole intended for the connection of the neutral and the nearest protected pole.

During the test the temperature-rises shall not exceed the values shown in Table 8.

If the CBE trips before reaching steady-state thermal conditions (after the conventional time), the temperatures reached before tripping are recorded.

9.8.3 Measurement of the temperature of parts

The temperature of the different parts referred to in Table 8 shall be measured by means of fine wire thermocouples or by equivalent means at the nearest accessible position to the hottest spot.

Good heat conductivity between the thermocouple and the surface of the part under test shall be ensured.

9.8.4 Temperature-rise of a part

The temperature-rise of a part is the difference between the temperature of this part measured in accordance with 9.8.3 and the ambient air temperature measured in accordance with 9.8.1.

9.9 28-day test

The CBE is subjected to 28 cycles, each cycle comprising 21 h with a current equal to the rated current at an open-circuit voltage of at least 30 V, and 3 h without current under the test conditions of 9.2.

The CBE being in the closed position, the current is established and interrupted by an auxiliary switch. During this test the CBE shall not trip.

Immediately after the last period of current flowing, the CBE is loaded with the rated current.

The CBE shall not trip within the conventional time. The temperature-rise of the terminals is measured immediately after the conventional time has elapsed.

Such temperature-rise shall not exceed the value measured in the temperature-rise test (see 9.8) by more than 15 K.

Immediately after this measurement of the temperature-rise the current is steadily increased within 5 s to the conventional tripping current.

The CBE shall trip within the conventional time.

9.10 Test of tripping characteristics

9.10.1 General

This test is made to verify that the CBE complies with the requirements of 8.5.1.

Unless otherwise agreed between manufacturer and user the test is only made with the test currents as specified in Table 9.

For CBEs calibrated at a reference ambient air temperature other than (23 ± 2) °C, the test shall be made at that other temperature ± 2 °C.

9.10.2 Test of time-current characteristic

9.10.2.1 *A current equal to the conventional non-tripping current is passed for the conventional time through all poles, starting from cold (see Table 9).*

The CBE shall not trip.

The current is then steadily increased, within 5 s, to the tripping current.

The CBE shall trip within the conventional time.

9.10.2.2 *A current equal to 2* I_n *is passed through all poles, starting from cold.*

The opening time shall be within the limits t_1 *and* t_2 *as stated by the manufacturer (see Figures A.1a, A.1c and A.1d).*

9.10.3 Test of instantaneous tripping (of the magnetic release)

A current I_{ni} *is passed through all poles, starting from cold.*

The CBE shall not trip in a time less than or equal to 0,1 s.

Following this test, a current I_i *is passed through all poles, starting from cold.*

The CBE shall trip in a time less than 0,1 s.

9.10.4 Test of effect of single-pole loading on the tripping characteristic of multi-pole CBEs

Compliance is checked by testing the CBE connected in accordance with 9.2, under the conditions specified in 8.5.2.2.

The CBE shall trip within the conventional time.

9.10.5 Test of effect of ambient temperature on the tripping characteristic

The CBE is tested at the minimum and maximum values according to 7.2.2, at a current obtained by multiplying 2 I_n *by the derating or uprating factor stated by the manufacturer for these temperatures.*

The CBE shall trip within the limits t_1 *to* t_2 *stated by the manufacturer in accordance with Table 9.*

NOTE For hydraulic-magnetic CBEs derating factors are not applicable. The tripping time limits at temperatures other than the reference ambient air temperature will be tested according to the values given in the manufacturer's literature.

9.11 Verification of electrical operational capability

9.11.1 General requirements

9.11.1.1 General

The tests concerning the verification of the electrical performance are intended to verify that the CBE is capable of making and breaking the currents corresponding to representative conditions of use as indicated in 8.6.

9.11.1.2 Test conditions

The tests shall be made with the test voltages and test currents as indicated in Table 11 or Table 12.

The tolerances of the test quantities shall be:

Current: $^{+5}_{0}$ % *Voltage: ±5 %*

Frequency: ±5 %

The tests shall be made in test circuits as specified by Figure 3, with the current adjusted to the value specified in Tables 11 or 12, according to the declared performance, by means of resistors and reactors in series connected to the load terminals.

If air-core reactors are used, a resistor taking approximately 0,6 % of the current through the reactors shall be connected in parallel with each reactor.

If iron-core reactors are used, the iron power losses of these reactors shall not appreciably influence the recovery voltage.

For AC, the current shall have a substantially sine-wave form and the power factor shall be as indicated in Table 11 or Table 12, according to the declared performance.

For DC, the current shall be substantially free of ripples (< 5 % effective) and the time constant shall be as indicated in Table 11 or Table 12, according to the declared performance.

The CBE shall be connected using conductors of the sizes indicated in Table 14.

For devices the terminals of which are not identified as supply and load, one of the samples shall be tested with reversed connections.

9.11.1.3 Test procedure

The CBE is submitted to the number of operating cycles with a value of current as indicated in Table 11 or Table 12 according to the declared performance.

The CBE shall be operated as under intended conditions of use.

NOTE 1 Intended conditions cover the use at a reference ambient air temperature T different from the standard value.

NOTE 2 In order to reduce the number of tests, the test at the reference ambient air temperature T ~~may~~ can be carried out, with agreement of the manufacturer, at the rated current (corresponding to the standard reference ambient air temperature).

Each operating cycle shall consist of a making operation followed by a breaking operation.

During each operating cycle, the CBE shall remain open for the time specified in Table 11 or Table 12. For M-type and S-type CBEs, the time in the ON position shall not exceed 1 s, unless otherwise agreed upon between manufacturer and user.

For R-type and J-type CBEs, the ON-time shall be that required to trip the CBE.

At the end of each operating cycle the fuse F shown in Figure 3 shall not have blown.

9.11.1.4 Condition of the CBEs after test

Following the tests of 9.11.2, 9.11.3 and 9.11.4.1, the samples shall not show:

- *undue wear;*
- *discrepancy between the positions of the moving contacts and the corresponding position of the indicating device;*
- *damage of the integral enclosure, if any, permitting access to live parts by the test finger (see 9.6);*
- *loosening of electrical or mechanical connections;*
- *seepage of sealing compound, if any.*

Moreover, the CBE shall withstand the dielectric strength test according to 9.7.3 at a voltage of 0,75 times the value prescribed in 9.7.5, without the previous humidity treatment of 9.7.1.

9.11.1.5 Verification of the tripping characteristic after test

9.11.1.5.1 *For a CBE with thermal, thermal-magnetic or hydraulic-magnetic mode of tripping, following the tests of 9.11.1.3, 9.11.1.4 and 9.11.4.1:*

- *the CBE shall not trip when a current of 1,8 I_n is passed through all poles for a time t_1, starting from cold;*
- *the CBE shall trip within the time t_2, when a current of 2,2 I_n is passed through all poles, starting from cold.*

9.11.1.5.2 *For a CBE with magnetic mode of tripping only, following the tests of 9.11.1.3, 9.11.1.4 and 9.11.4.1:*

- *the CBE shall not trip when a current of 0,9 I_{ni} is passed; it shall trip when a current of 1,1 I_i is passed.*

9.11.1.5.3 *For CBEs with electronic-hybrid mode of tripping:*

Under consideration.

9.11.2 Behaviour at rated current (or under low overloads for R-type and J-type CBEs)

Since R-type and J-type CBEs cannot be tripped manually, the tests of these CBEs to carry out the breaking operation shall be performed at a low overload.

The test conditions shall be as specified in section 1 of Table 11 or Table 12 according to the declared performance.

9.11.3 Behaviour at rated switching capacity

The test conditions shall be as specified in section 2 of Table 11 or Table 12, according to the declared performance.

9.11.4 Behaviour at rated short-circuit capacity

~~*This is an optional test.*~~

9.11.4.1 Short circuit test for CBEs suitable for isolation or CBEs having a rated short-circuit capacity I_{cn} greater than 6 I_n for AC or 4 I_n for DC

The distance of the grid described in Annex H of IEC 60898-1:2015 shall be in accordance with the information given in the manufacturer's literature.

The test conditions shall be as specified in section 3 of Table 11 or Table 12 according to the declared performance, but with the sequence of operations as stated below, at the rated short-circuit current assigned to the CBE by the manufacturer.

The CBE is submitted to the following sequence of operations, at a current specified by the manufacturer:

a) for trip-free, cycling trip-free CBEs and J-type CBEs

$$O - t - CO - t - CO$$

Cycling trip-free CBEs are tested, the closing command being maintained until the three breaking operations are performed;

b) for non trip-free CBEs (see note)

$$O - t - O - t - O$$

where

O represents an opening operation;

CO represents a closing operation followed by an opening operation;

t represents the time interval between two subsequent short-circuit operations and is specified as follows:

- *for trip-free CBEs: the time as specified in section 3 of Tables 11 or Table 12;*
- *for cycling trip-free and J-type CBEs: the self-resetting time of the CBE;*
- *for non-trip-free CBEs: the time sufficient for enabling the re-closing of the CBE.*

NOTE The testing of non-trip-free CBEs is based on the reasoning that these CBEs are not intended to be closed under short-circuit conditions (see 4.8.3).

After each operation, the indicating means shall show the open position of the contacts.

9.11.4.2 Short-circuit test on CBEs for verifying their suitability for use in IT systems

This subclause applies only to CBEs according to section 3.2 of Table 11 or Table 12, as applicable.

Single-pole CBEs and each protected pole of multipole CBEs are subjected individually to a test in a circuit the connections of which are shown in Figure 3a.

The impedance Z1 (see Figure 3a) is adjusted so as to obtain a current as given in Table 11 or Table 12, section 3.2.

The sequence of operations shall be

$$O - t - CO$$

For the O operation on the first protected pole the auxiliary switch A is synchronized with respect to the voltage wave so that the circuit is closed on the point 0° on the wave for this operation. For the following O operations on the other protected poles to be tested (see Clause C.2) this point is shifted each time by 30° with respect to the point on wave of the previous test, with a tolerance of ±5°.

Following the test at $I_{cn} > 6\ I_n$ the samples shall not show:

- *undue wear;*
- *discrepancy between the positions of the moving contacts and the corresponding position of the indicating device;*
- *damage of the integral enclosure, permitting access to live parts by the test finger (see 9.6);*
- *loosening of electrical or mechanical connections;*
- *seepage of sealing compound, if any.*

Moreover, the CBE shall withstand the dielectric strength test according to 9.7.3 at a voltage of 0,75 times the value prescribed in 9.7.5, without the previous humidity treatment of 9.7.1 and the CBE shall trip within the time t_2, when a current of 2,2 I_n is passed through all poles, starting from cold.

Following the test at I_{cn} = 6 I_n the samples shall not show damage of the integral enclosure, if any, permitting access to live parts by the test finger (see 9.6); the CBE may be inoperable after the first or second operation. If the result of the first operation is such that the CBE is rendered inoperable the remaining operation need not be performed.

Moreover, the CBE shall withstand the dielectric strength test according to 9.7.3 at a voltage of 0,75 times the value prescribed in 9.7.5, without the previous humidity treatment of 9.7.1.

9.11.5 Test of overvoltage releases at operating limits

Under consideration.

9.11.6 Behaviour of undervoltage and zero-voltage releases

9.11.6.1 Verification of the operating limits of undervoltage and zero-voltage releases

The test shall be carried out on a new sample. The test condition shall be as specified in Table 10.

9.11.6.2 Electrical endurance test of undervoltage and zero-voltage release

A CBE with an undervoltage or zero-voltage release shall be tested with the number of operating cycles given in the manufacturer's literature. Each operating cycle consists of a making operation with the undervoltage or zero-voltage release energized with rated voltage, followed by an automatically breaking operation by switching off the voltage of the undervoltage or zero-voltage release by an external auxiliary switch.

9.11.6.3 Test of withstand level of undervoltage and zero-voltage releases

Under consideration.

9.12 Conditional short-circuit current tests

9.12.1 General

The test for the verification of the performance under conditional short-circuit current conditions shall be made with an SCPD of the type, rating and characteristics as specified by the manufacturer of the CBE.

For performance category PC1 the rating of the SCPD shall be at least 15 A.

The mounting of the CBE shall be as specified in 9.2.

A grid (or grids) as described in Annex H of IEC 60898-1:2015 shall be placed at a distance from each arc vent of the CBE, in accordance with the manufacturer's instructions.

The test circuit shall be set up in accordance with Figure 7, as appropriate.

For calibration the CBE and the SCPD including the connection wires according to Figure 7 shall be replaced by links of negligible impedance.

The test circuit shall be calibrated for the value of the rated conditional short-circuit current assigned to the CBE by the manufacturer at a current and power factor or time constant in accordance with Table 22.

Table 22 – Power factor and time constant of test circuit

	Test current I_{cc} A	Power factor (range)	Time constant ms
AC	$300 < I_{cc} \leq 1\,500$ $1\,500 < I_{cc} \leq 3\,000$	0,93 to 0,98 0,85 to 0,90	
DC	$I_{cc} \leq 1\,000$ $I_{cc} > 1\,000$		2,5 ± 0,5 5,0 ± 1
For testing at currents higher than 3 000 A, reference should be made to 9.12.5 of IEC 60898-1:2015.			

After calibration of the test circuit the links of negligible impedance shall be replaced by the SCPD and the CBE including the connecting wires according to Figure 7, the CBE being connected as shown in Figure 7 by means of copper conductors of length as shown in the above figures and of maximum cross-sectional area corresponding to the rated current of the CBE in accordance with Table 3.

9.12.2 Values of test quantities

All the tests concerning the verification of the rated conditional short-circuit current shall be performed with the values of current, voltage and power factor stated by the manufacturer and in accordance with the relevant tables of this document.

The value of the applied voltage is that which is necessary to produce the specified power-frequency recovery voltage. The value of the power-frequency recovery voltage in each phase shall be equal to a value corresponding to 105 % of the rated operational voltage of the CBE under test.

9.12.3 Tolerances on test quantities

The tests will be taken as valid if the RMS values recorded in the test report differ from the values specified within the following tolerances:

Current: $^{+5}_{\ 0}$ %

Voltage: ±5 % *(including power-frequency recovery voltage)*

Frequency: ±5 %.

9.12.4 Test procedure

9.12.4.1 General

The test procedure consists of a sequence of operations.

The following symbols are used for defining the sequence of operations:

O *represents an opening operation;*

CO *represents a closing operation followed by an opening operation;*

t *represents the time interval between two successive short-circuit operations and is defined as follows:*

- *if the SCPD operates: 3 min or the longer time necessary to reclose the CBE;*
- *if the SCPD does not operate:*
  - *for trip-free and non-trip-free CBEs: 3 min;*
  - *for J-type and cycling trip-free CBE's: the self-resetting time of the device.*

The actual value of t *shall be stated in the test report.*

The CBE is submitted to the following sequence of operations:

– *for trip-free, cycling trip-free and J-type CBEs*

O – t – CO – t – CO

– *for non-trip-free CBEs*

O – t – O – t – O

In the case of single-phase tests the instant of initiation of the short-circuit current for the first O operation shall be such that a maximum of let-through energy of the SCPD will occur:

– *for fuses, reference should be made preferably to IEC 60269;*
– *for circuit-breakers with energy-limiting properties, the manufacturer should make available information regarding the relevant energy limiting properties.*

The CBE shall be considered to have passed the test if

– *the earth leakage detection fuse does not open; however the SCPD may operate;*
– *there is no damage to the integral enclosure, if any, permitting access to live parts by the test finger (see 9.6);*
– *no melting of the fuse of the grid circuit (see Figure H.3 of IEC 60898-1:2015) occurs;*
– *for CBEs of category PC2 tested according to 9.12.4.3, after each operation, the indicating means shall show the open position of the contacts.*

9.12.4.2 Verification of the rated conditional short-circuit current, for performance category PC1 (I_{nc1})

The CBE is submitted to the test sequence as specified in 9.12.4.1 with a test current corresponding to the rated conditional short-circuit current.

The following conditions of the CBE after the short-circuit test are considered to be acceptable:

– *non-operability after the first or second or third operation;*
– *inability to reset;*
– *inability to trip within the specified limits;*
– *inability to indicate the position of the contacts (open or closed);*
– *welding of contacts;*
– *internal damage within the CBE.*

9.12.4.3 Verification of the rated conditional short-circuit current for performance category PC2 (I_{nc2})

Two groups of CBEs (see Tables C.2 and C.3) are submitted to the sequence of operations as specified in 9.12.4.1, with test currents as specified below:

a) *one group with a test current corresponding to the rated conditional short-circuit current;*
b) *the other group with a test current corresponding to 1,5 times the rated short-circuit capacity of the CBE (see 8.6).*

Following these tests the CBEs shall comply with the conditions specified in 9.12.4.1.

In addition the CBEs shall not show

– *discrepancy between the position of the moving contacts and the corresponding position of the indicating device;*

– *seepage of the sealing compound.*

Moreover, the CBEs shall withstand the dielectric strength test according to 9.7.3 at a voltage of 0,75 times the value prescribed in 9.7.5, without previous humidity treatment.

The CBEs shall be considered to have passed the test if, after the test, they comply with 9.11.1.4 and 9.11.1.5.

9.13 Test of resistance to mechanical shock and impact

Under consideration.

9.14 Tests of resistance to heat

9.14.1 *CBEs are kept for 1 h in a heating cabinet at a temperature of (100 ± 2) °C.*

During the test they shall not undergo any change impairing their further use, and sealing compound, if any, shall not flow to such an extent that live parts are exposed.

After the test and after the samples have been allowed to cool down to approximately room temperature, there shall be no access to live parts which are normally not accessible when the samples are mounted as in normal use, even if the standard test finger is applied with a force not exceeding 5 N.

After the test, markings shall still be legible.

Discoloration, blisters or a slight displacement of the sealing compound is disregarded, provided that safety is not impaired within the meaning of this document.

9.14.2 *External parts of a CBE made of insulating material, necessary to retain current-carrying parts and parts of the protective circuit in position, are subjected to a ball-pressure test by means of the apparatus shown in Figure 5, except that the insulating parts necessary to retain the terminals for protective conductors in a box shall be tested as specified in 9.14.3.*

The surface of the part to be tested is placed in the horizontal position on a steel plate, and a steel ball of 5 mm diameter is pressed against this part with a force of 20 N.

The test is made in a heating cabinet at a temperature of (125 ± 2) °C.

After 1 h, the ball is removed from the sample, which is then cooled down within 10 s to approximately room temperature by immersion in cold water.

The diameter of the impression caused by the ball is measured and shall not exceed 2 mm.

9.14.3 *External parts of a CBE that are made of insulating material and that are not necessary to retain current-carrying parts and parts of the protective circuit in position, even though they are in contact with them, are subjected to a ball-pressure test in accordance with 9.14.2. This test is made, however, at a temperature of (75 ± 2) °C, or at a temperature of (40 ± 2) °C plus the highest temperature-rise that was determined for the relevant part during the test of 9.8, whichever is the higher.*

For CBEs calibrated at a reference ambient air temperature other than (23 ± 2) °C, the test shall be made at the upper limit of the ambient air temperature according to 7.2.2 plus the highest temperature-rise that was determined for the relevant part during the test of 9.8, or at a temperature of (75 ± 2) °C, whichever is the higher.

NOTE 1 For the purpose of the tests of 9.14.2 and 9.14.3, the bases of surface-type CBEs are considered as external parts.

NOTE 2 The tests of 9.14.2 and 9.14.3 are not made on parts of ceramic material.

NOTE 3 If two or more of the insulating parts referred to in 9.14.2 or 9.14.3 are made of the same material, the test is carried out only on one of these parts, according to 9.14.2 or 9.14.3 respectively.

NOTE 4 The revision of this test is under consideration.

9.15 Test of resistance to abnormal heat and to fire

Compliance with the requirements of 8.10 shall be checked by means of a glow-wire test, which is performed in accordance with IEC 60695-2-10 under the following conditions:

- *for external parts of a CBE made of insulating material necessary to retain current-carrying parts and parts of the protective circuit in position, by the test made at a temperature of (960 ± 10) °C;*
- *for all other external parts made of insulating material, by the test made at a temperature of (650 ± 10) °C.*

NOTE 1 For the purpose of this test, the bases of surface-type CBEs are considered as external parts.

NOTE 2 The test is not made on parts made of ceramic material.

NOTE 3 If the insulating parts are made of the same material, the test is carried out only on one of these parts, according to the appropriate glow-wire test temperature.

The glow-wire test is applied to ensure that an electrically heated test wire under defined test conditions does not cause ignition of insulating parts or to ensure that a part of insulating material which might be ignited by the heated test wire under defined conditions has a limited time to burn without spreading fire by flame, burning parts or droplets falling down from the tested part.

The test is made on one sample.

In case of doubt, the test shall be repeated on two further samples.

The test is made by applying the glow-wire once.

The sample shall be positioned during the test in the most unfavourable position of its intended use (with the surface tested in a vertical position).

The tip of the glow-wire shall be applied to the specified surface of the test sample taking into account the conditions of the intended use under which a heated or glowing element may come into contact with the sample.

The sample is regarded as having passed the glow-wire test if

- *there is no visible flame and no sustained glowing, or*
- *flames and/or glowing at the sample extinguish within 30 s after the removal of the glow-wire.*

There shall be no ignition of the tissue paper or scorching of the pinewood board.

NOTE 4 The revision of this test is under consideration.

9.16 Test of resistance to tracking

Compliance with the requirement of 8.11 is checked, for materials other than ceramic, by the following test.

A flat surface of the part to be tested, if possible at least 15 mm × 15 mm, is placed in the horizontal position.

Two electrodes of platinum with the dimensions shown in Figure 6 are placed on the surface of the sample in the manner shown in this figure, so that the rounded edges are in contact with the sample over their whole length. The force exerted on the surface by each electrode is approximately 1 N.

The electrodes are connected to a supply source of substantially sine-wave form of a frequency between 45 Hz and 65 Hz, at a voltage corresponding to the CTI of the material (see Table 1), that is 100 V, 400 V or 600 V.

The total impedance of the circuit when the electrodes are short-circuited is adjusted by means of a variable resistor, so that the current is (1,0 ± 0,1) A, at a power factor between 0,9 and 1. An overcurrent relay, with a tripping time of at least 0,5 s, is included in the circuit.

The surface of the sample is wetted by allowing drops of solution of ammonium chloride in distilled water to fall centrally between the electrodes.

The solution has a resistivity of 400 Ω.cm at 25 °C, corresponding to a concentration of approximately 0,1 %.

The drops have a volume of 20^{+5}_{0} *mm*^{3} *and fall from a height of 30 mm to 40 mm.*

The time interval between one drop and the next is (30 ± 5) s.

No flashover or breakdown between electrodes shall occur before a total of 50 drops has fallen.

~~NOTE~~ *Care should be taken that the electrodes are clean, correctly shaped and correctly positioned before each test is started. In case of doubt, the test may be repeated, if necessary on a new set of samples.*

9.17 Test of resistance to rusting

Any grease is removed from the parts to be tested, by immersion in a cold chemical degreaser such as refined petrol, for 10 min; the parts are then immersed for 10 min in a 10 % solution of ammonium chloride in water at a temperature of (20 ± 5) °C.

Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture, at a temperature of (20 ± 5) °C.

After the parts have been dried for 10 min in a heating cabinet at a temperature of (100 ± 5) °C, their surface shall show no signs of rust.

Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.

For small springs and the like and for inaccessible parts exposed to abrasion a layer of grease may provide sufficient protection against rusting.

Such parts are only subjected to the test if there is a doubt as to the effectiveness of the grease film, and the test is then made without previous removal of the grease.

~~NOTE~~ *When using the liquid specified for the test, adequate precautions should be taken to prevent inhalation of the vapour.*

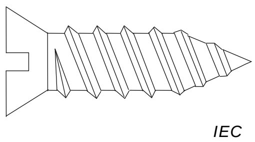


Figure 1 – Thread-forming screw

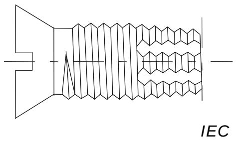


Figure 2 – Thread-cutting screw

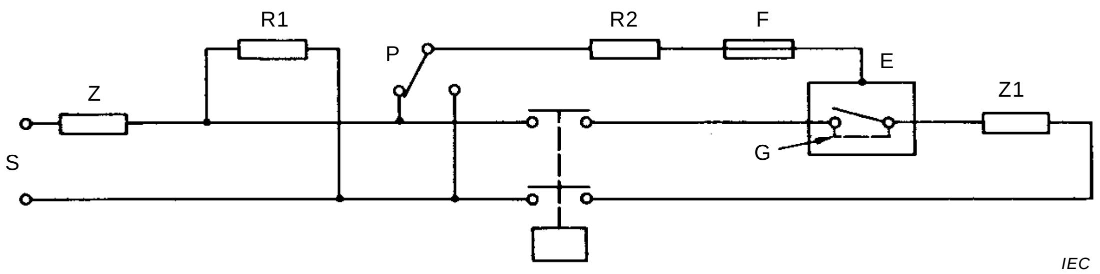


Figure 3a – Single pole CBE

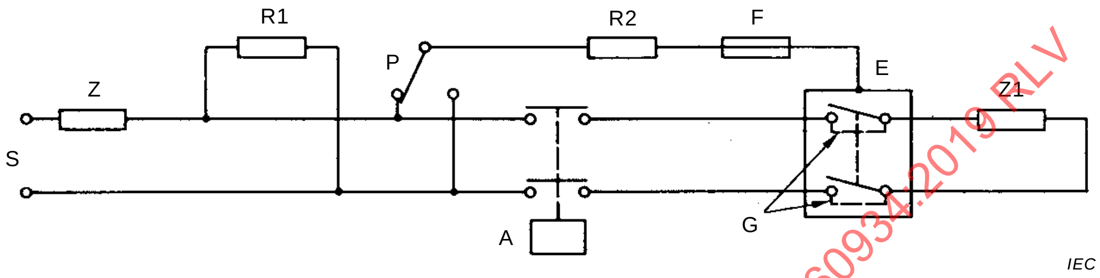


Figure 3b – Two-pole CBE

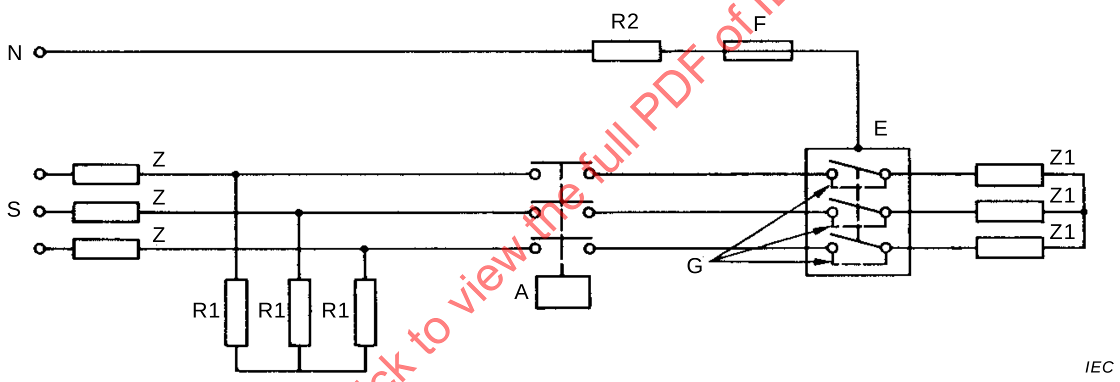


Figure 3c – Three-pole CBE or three single-pole (non-linked) CBEs

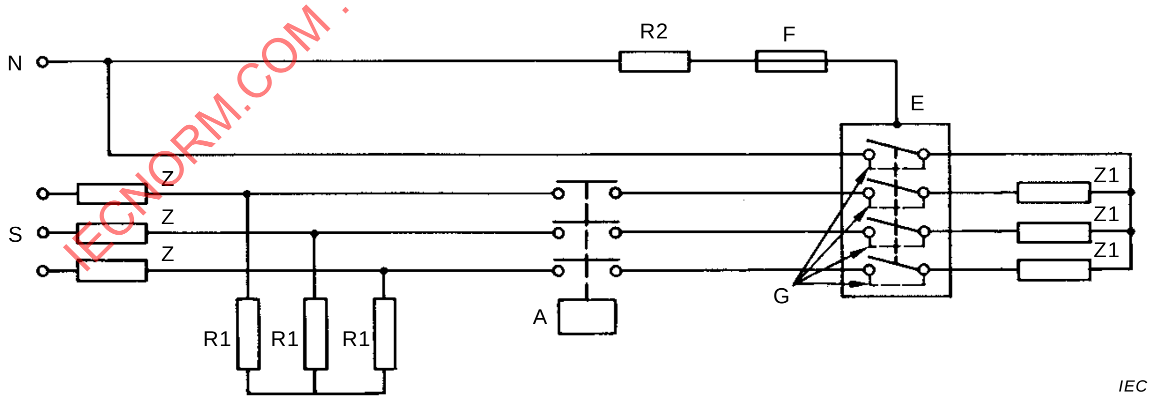


Figure 3d – Four-pole CBE

Key

S supply source

N neutral

Z impedance for adjusting the prospective current to the rated short-circuit capacity

~~Z_t~~ Z1 impedance for adjusting the test currents to values lower than the rated short-circuit capacity

~~R_t~~ R1 resistors, drawing a current of 10 A per phase

E enclosure or support

A auxiliary switch synchronized with respect to the voltage wave

G negligible impedance connection for test-circuit calibration

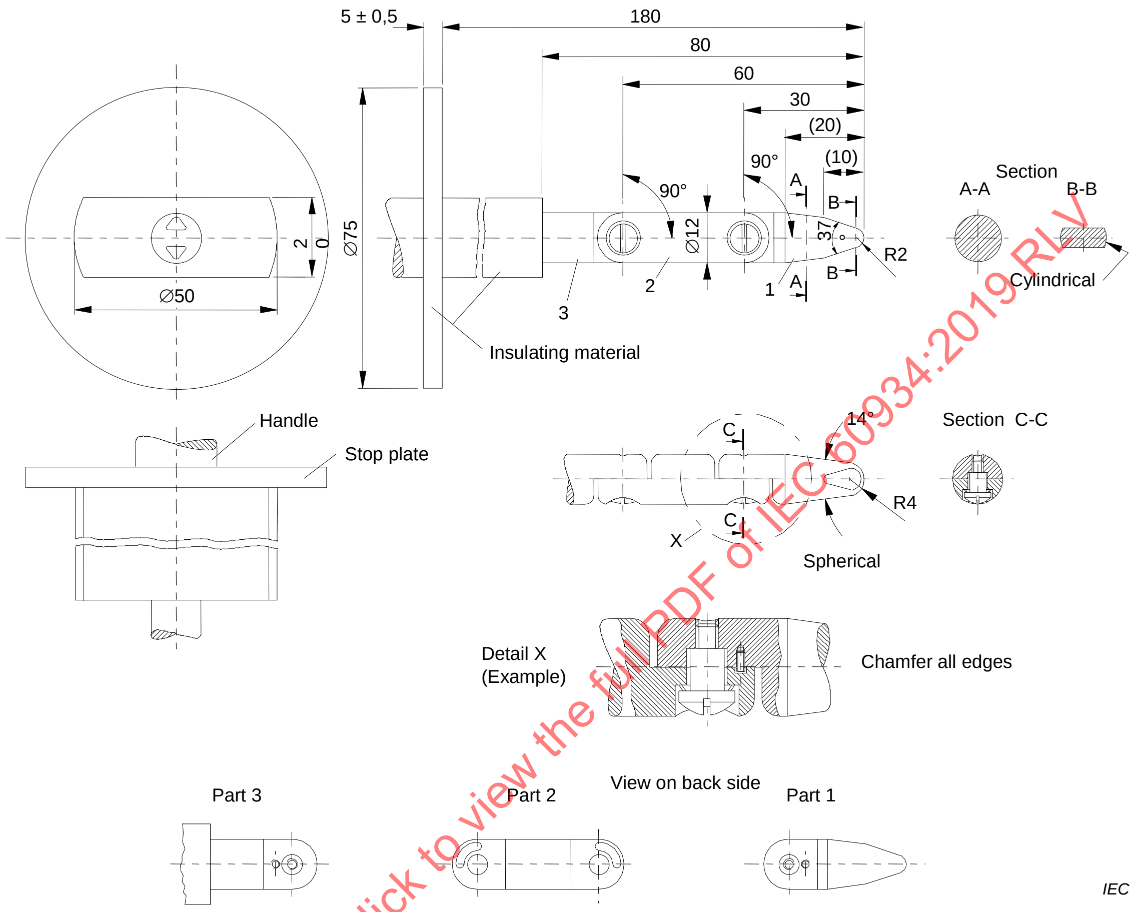
R2 resistor 0,5 Ω

F copper wire (diameter 0,1 mm, length 50 mm)

P selector switch

Figure 3 – Test circuits for overcurrent tests of CBEs

Dimensions in millimetres



Tolerances on dimensions without specific tolerance:

– on angles: $^{0}_{-10'}$

– on linear dimensions:

up to 25 mm: $^{0}_{-0,05}$

over 25 mm: ±0,2

Material of finger: for example, heat-treated steel

NOTE 1 Both joints of this finger may be bent through an angle of $90^{\circ}\,^{+10^{\circ}}_{0}$, but in one and the same direction.

NOTE 2 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~~ ensures a 90° bending angle with a 0° to +10° tolerance.

Figure 4 – Standard test finger (see IEC 60529)

Dimensions in millimetres

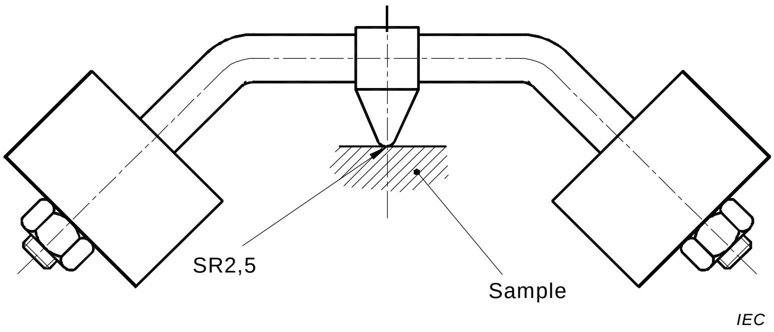


Figure 5 – Ball pressure apparatus

Dimensions in millimetres

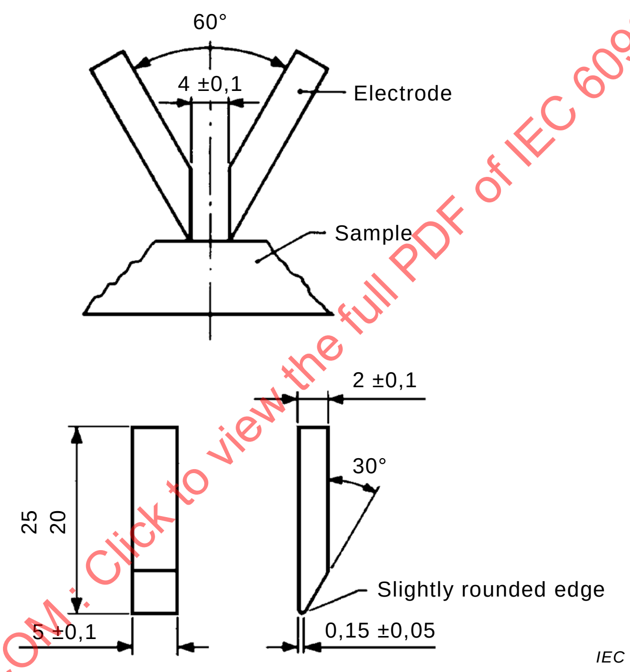


Figure 6 – Arrangements and dimensions of the electrodes for the tracking test

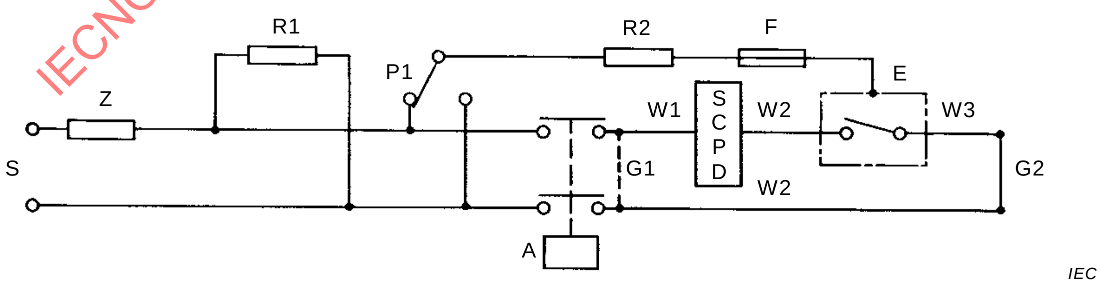


Figure 7a – Single pole CBE

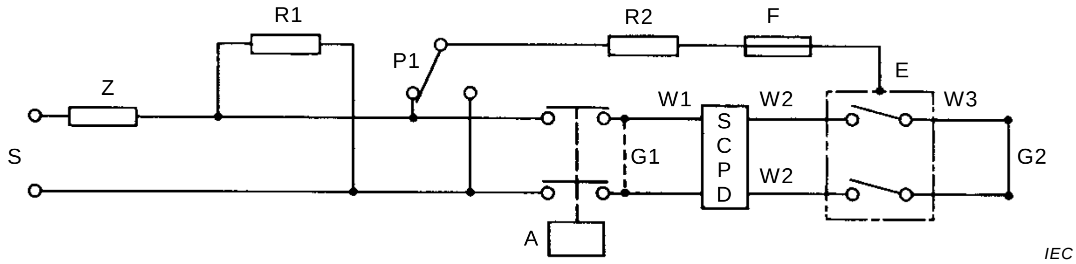


Figure 7b – Two-pole CBE

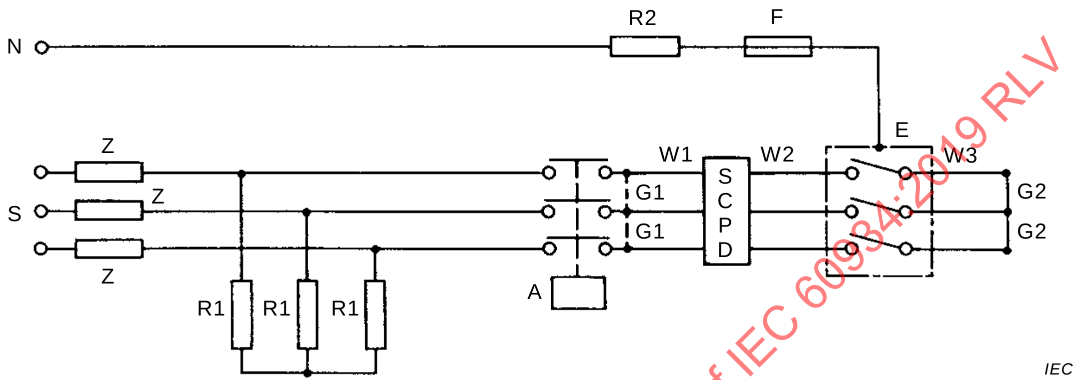


Figure 7c – Three-pole CBE or three single-pole (non-linked) CBEs

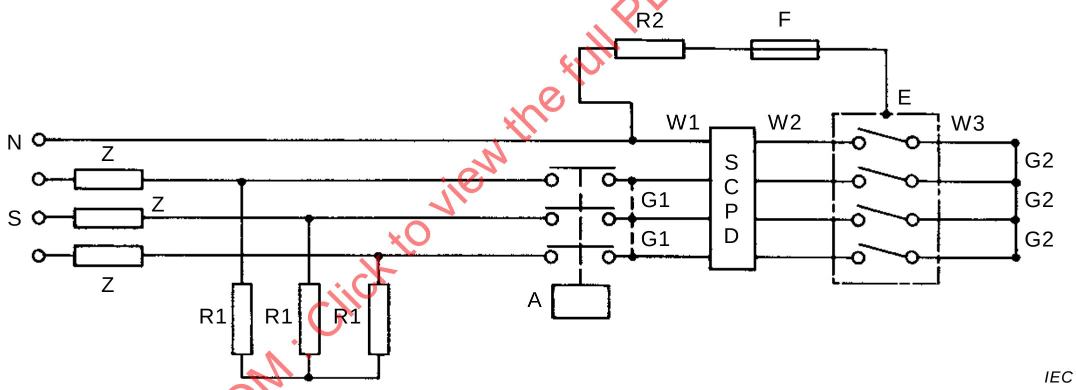


Figure 7d – Four-pole CBE

Key

S	supply source
Z	impedance for adjusting the prospective current to the rated conditional short-circuit current
R1	resistor, drawing a current of 10 A per phase
R2	resistor, 0,5 Ω
E	support of enclosure
A	auxiliary switch synchronized with respect to the voltage wave
G1	connection of negligible impedance for calibration of the test circuit
F	copper wire (diameter 0,1 mm, length 50 mm)
W1, W2	wires of length of 0,75 m each and of a cross-sectional area based on rating of SCPD
W3	wires of length of 0,75 m each and of a cross-sectional area based on rating of CBE
P1	selector switch
G2	connection of negligible impedance

Figure 7 – Test circuits for verification of the conditional short-circuit current

Annex A
(normative)

Time-current zone (see 9.10 and Table 9)

See Figure A.1.

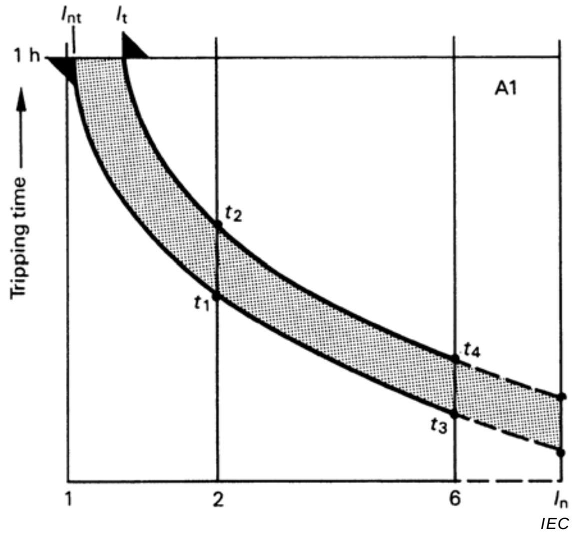


Figure A.1a – Thermal mode only

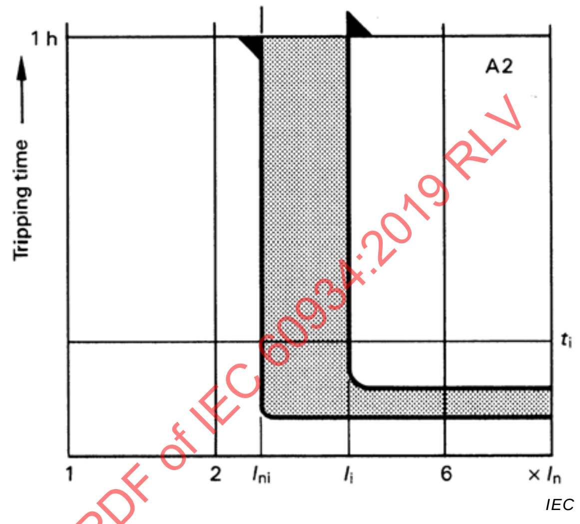


Figure A.1b – Magnetic mode only

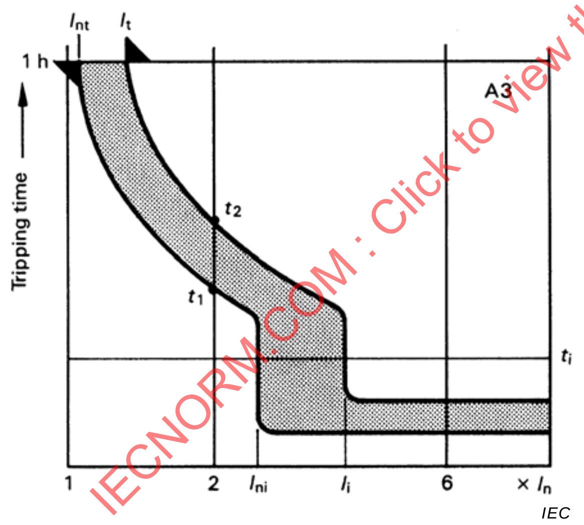


Figure A.1c – Thermal magnetic mode

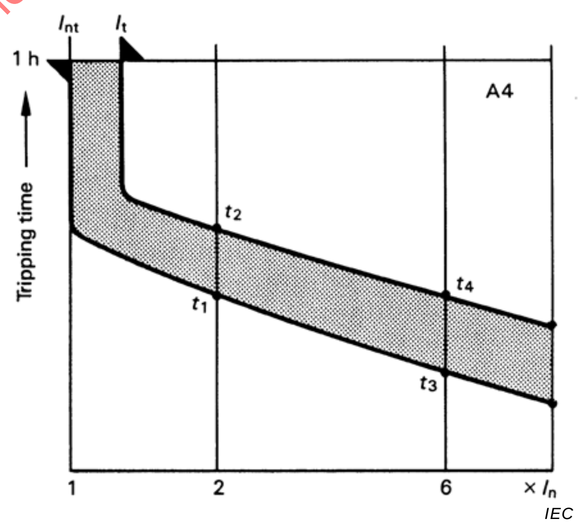


Figure A.1d – Hydraulic-magnetic mode

Key

$t_1 \dots t_4$ times, to be stated by the manufacturer

t_i instantaneous tripping time

I_n rated current

I_i instantaneous tripping current

I_{ni} instantaneous non-tripping current

I_{nt} conventional non-tripping current

I_t conventional tripping current

Figure A.1 – Time-current zone

Annex B
(normative)

Determination of clearances and creepage distances

In determining clearances and creepage distances, it is recommended that the following points be considered.

If a clearance or creepage distance is influenced by one or more metal parts, the sum of the sections should have at least the prescribed minimum value.

Individual sections less than

– 0,2 mm in length for pollution degree 2, or
– 0,8 mm in length for pollution degree 3

should not be taken into consideration in the calculation of the total length of clearances.

In determining a creepage distance:

– grooves at least 1 mm wide and 1 mm deep should be measured along their contour;
– grooves having any dimension less than these dimensions should be neglected and direct distance only measured;
– ridges less than 1 mm high should be neglected;
– ridges at least 1 mm high
  - should be measured along their contour, if they are integral parts of a component of insulating material (for instance by moulding, welding or cementing);
  - should be measured along the shorter of the two following paths: along the joint or along the profile of ridge, if the ridges are not integral parts of a component of insulating material.

The application of the foregoing recommendations is illustrated by Figures B.1a to B.1j:

– Figures B.1a, B.1b and B.1c indicate the inclusion or exclusion of a groove in a creepage distance;
– Figures B.1d and B.1e indicate the inclusion or exclusion of a ridge in a creepage distance;
– Figure B.1f indicates the consideration of the joint when the ridge is formed by an inserted insulating barrier, the outside profile of which is longer than the length of the joint;
– Figures B.1g, B.1h, B.1i and B.1j illustrate how to determine the creepage distance to fixing means situated in recesses in the surface of insulating parts.

Dimensions in millimetres

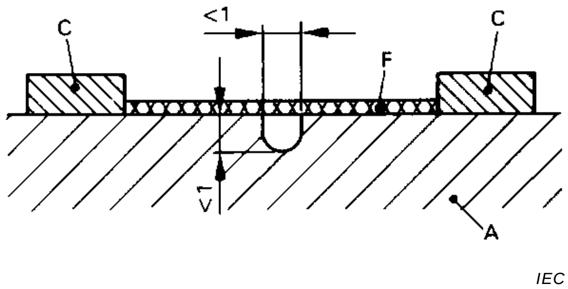


Figure B.1a

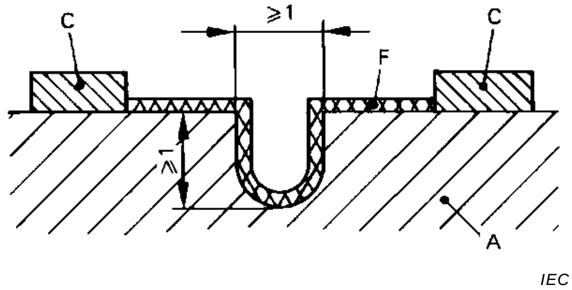


Figure B.1b

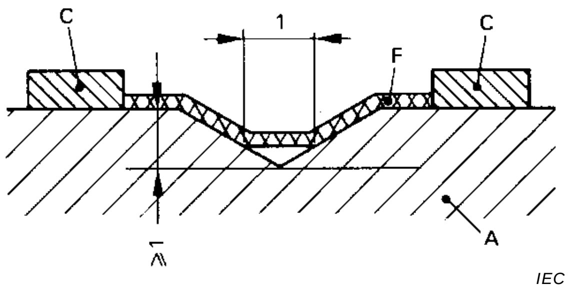


Figure B.1c

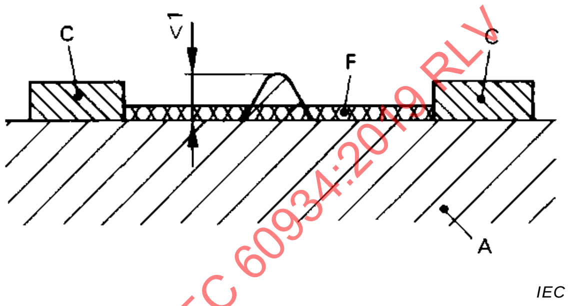


Figure B.1d

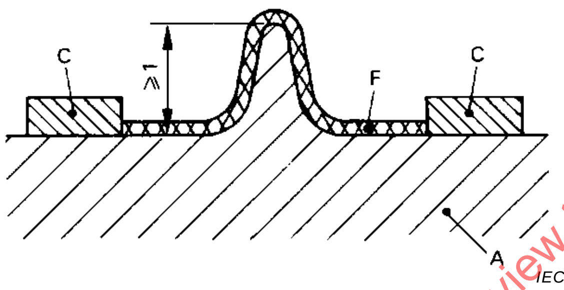


Figure B.1e

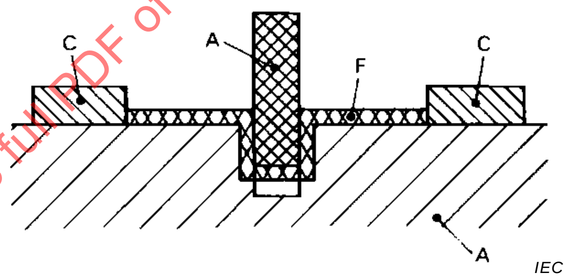


Figure B.1f

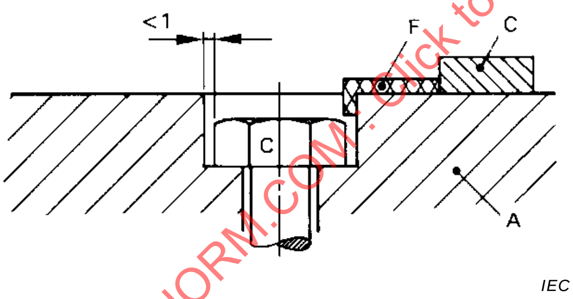


Figure B.1g

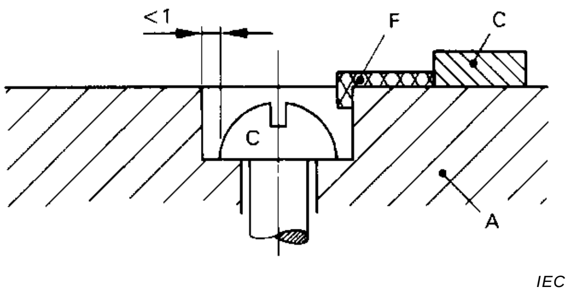


Figure B.1h

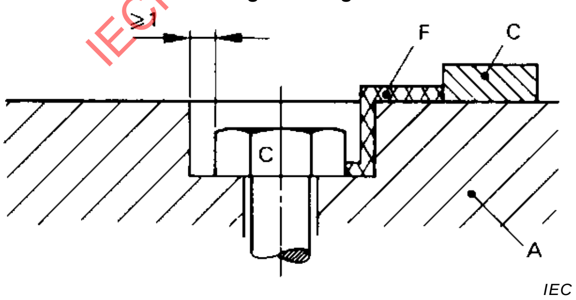


Figure B.1i

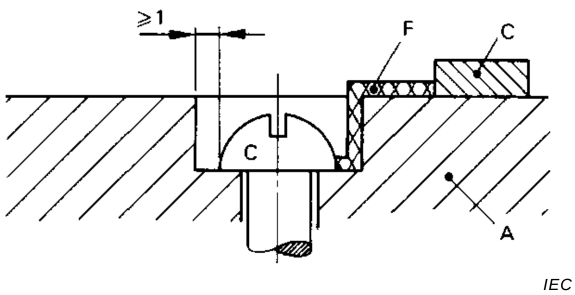


Figure B.1j

A insulating material
C conducting part
F creepage distance

Figure B.1 – Illustrations of the application of the recommendations for creepage distances

Annex C
(normative)

Test sequences and number of samples to be submitted for certification purposes

C.1 Test sequences

The tests are made according to Table C.1 of this annex, where the tests in each sequence, A to E, are carried out in the order indicated. If values for I_{nc1} and/or I_{nc2} are assigned by the manufacturer the test sequences F and/or G are carried out in addition.

Table C.1 – Test sequences

Test sequence	Clause or subclause	Test (or inspection)
A	6	Marking
	8.1	Mechanical design
	8.1.1	General
	8.1.2	Mechanism
	8.1.3	Clearances and creepage distances
	9.3	Indelibility of marking
	9.4	Reliability of terminals, current-carrying parts and connections
	9.5	Reliability of terminals for external conductors
	9.6	Protection against electric shock
	9.14	Resistance to heat
	9.15	Resistance to abnormal heat and to fire
	9.17	Resistance to rusting
B	9.7	Dielectric properties
	9.7.1	Resistance to humidity
	9.7.2	Insulation resistance of main circuit
	9.7.3	Dielectric strength of main circuit
	9.7.4	Dielectric strength of auxiliary circuits
	9.7.6	Impulse withstand voltage, if necessary
	K.9.7.7	Test of suitability for isolation, if applicable
	9.8	Temperature-rise
	9.9	28-day test
	9.16	Resistance to tracking
C	9.10	Tripping characteristics
	9.11.2	Behaviour at rated current
	9.11.1.4	Condition of the CBE after test
	9.11.1.5	Verification of tripping characteristic after test
D	9.10.2.2	Time-current characteristic
	9.11.3	Behaviour at rated switching capacity
	9.11.1.4	Condition of the CBE after test
	9.11.1.5	Verification of tripping characteristic after test
E	9.10.2.2	Time-current characteristic
~~(optional)~~	9.11.4.1	~~Behaviour under~~ Short circuit test for CBEs suitable for isolation or CBEs having a rated short-circuit capacity I_{cn} greater than 6 I_n for AC or 4 I_n for DC
	9.11.1.4	Condition of the CBE after test
	K.9.7.7.2	Verification of leakage currents, if applicable
	9.11.1.5	Verification of tripping characteristic after test
F	9.10.2.2	Time-current characteristic
	9.12.4.2	Rated conditional short-circuit current for performance category PC 1 (I_{nc1})
G	9.10.2.2	Time-current characteristics
~~(optional)~~	9.12.4.3	Rated conditional short-circuit current for performance category PC 2 (I_{nc2})
	9.11.1.4	Condition of the CBE after test
	K.9.7.7.2	Verification of leakage currents, if applicable
	9.11.1.5	Verification of tripping characteristic after test

C.2 Number of samples to be submitted for full test procedure

If a single type of CBE is submitted for test, the number of samples to be submitted to the different test series shall be as indicated in Table C.2, where the minimum performance criteria are also indicated.

If all samples submitted according to the second column of Table C.2 pass the tests, compliance with the standard is proved. If only the minimum number given in the third column passes the test, additional samples, as shown in the fourth column, shall be tested and all shall then satisfactorily complete the test sequence.

For a CBE having more than one rated current, two separate sets of the same CBE shall be submitted to each series: one set at the maximum rated current, and the other at the minimum rated current.

Table C.2 – Number of samples for full test procedure

Test sequence	Number of samples	Minimum number of samples which shall pass the test	Number of samples for repeated tests [a]
A	1	1	–
B	3	2	3
C	3	2	3
D	3	2	3
E [b]	3	2	3
F	3	2	3
G	2 × 3	2 × 2	2 × 3

[a] In case of repeated tests, all test results shall be acceptable.

[b] Additional set of samples for verification of suitability of CBE for use in IT systems.

C.3 Number of samples to be submitted for simplified test procedure in case of submitting simultaneously a series of CBEs of the same basic design

If a series of CBEs of the same basic design is submitted for test, the number of samples to be tested may be reduced according to Table C.3. CBEs are considered to be of the same basic design if

a) all parts are the same, except those that have to be different because of a different current rating. For many designs, such differing parts are, for instance bimetals, coils and connections between these parts;

b) only the shape of the housing differs;

c) multi-pole CBEs are either composed of single-pole CBEs or are built up from the same components as the single-pole CBEs, having the same overall dimensions per pole;

d) the omission of parts belonging for instance to auxiliary or control circuits obviously does not influence the performance;

e) only the terminations differ. If appropriate, CBEs may be subjected to the temperature-rise test (see 9.8).

Table C.3 – Reduction of samples for simplified test procedure

Sequence of tests	Number of samples as the function of the number of poles [a]			
	1 pole [b]	2 pole [c]	3 pole	4 pole [d]
A [h]	1 max. rating 1 min. rating	1 max. rating	1 max. rating	1 max. rating
B	3 max. rating	3 max. rating [e]	3 max. rating [f]	3 max. rating
C	3 max. rating	3 max. rating [e]	3 max. rating [f]	3 max. rating
D	3 max. rating	3 max. rating	3 max. rating	3 max. rating
E [g,i]	3 max. rating 3 min. rating	3 max. rating 3 min. rating	3 max. rating 3 min. rating	3 max. rating 3 min. rating
F [g]	3 max. rating 3 min. rating	3 max. rating 3 min. rating	3 max. rating 3 min. rating	3 max. rating 3 min. rating
G [g]	2 × 3 max. rating 2 × 3 min. rating	2 × 3 max. rating 2 × 3 min. rating	2 × 3 max. rating 2 × 3 min. rating	2 × 3 max. rating 2 × 3 min. rating

[a] If a test is to be repeated according to the minimum performance criteria of Clause C.2, a new set of samples is used for the relevant test sequence. The results of the repeated tests shall be acceptable.

[b] If only the multi-pole CBEs are submitted, this column shall also apply to the set of samples with the smallest number of poles.

[c] Also applicable to CBEs with 1 protected pole and a neutral pole.

[d] Also applicable to CBEs with 3 protected poles and a neutral pole.

[e] This test shall be omitted in cases where 3-pole or 4-pole CBEs are tested.

[f] This test shall be omitted in cases where 4-pole CBEs are tested.

[g] If considered appropriate, taking into account the limitation of the short-circuit current due to the internal CBE impedance, an intermediate rating may be tested instead of the minimum rating.

[h] When multi-pole CBEs are submitted, a maximum of four screw-type terminals for external conductors are subjected to the tests of 9.5.

[i] Additional set of samples with maximum rating for verification of suitability of CBE for use in IT systems.

Annex D
(normative)

Correspondence between ISO and AWG copper conductors

See Table D.1.

Table D.1 – Correspondence between ISO and AWG conductor cross-sections

ISO size [a] mm^2	**AWG** [b]	
	Size	**Cross-section** mm^2
1	18	0,82
1,5	16	1,3
2,5	14	2,1
4	12	3,3
6	10	5,3
10	8	8,4
16	6	13,3
25	3	26,7
35	2	33,6
50	0	53,5

~~NOTE 1~~ [a] In general, ISO sizes apply.

~~NOTE 2~~ [b] On request of the manufacturer, AWG sizes may be used.

Annex E
(normative)

Examples of terminals

Some examples of designs of terminals are given in Figures E.1 to E.14. The conductor location shall have a diameter suitable for accepting solid rigid conductors and a cross-sectional area suitable for accepting rigid stranded conductors (see 8.1.5).

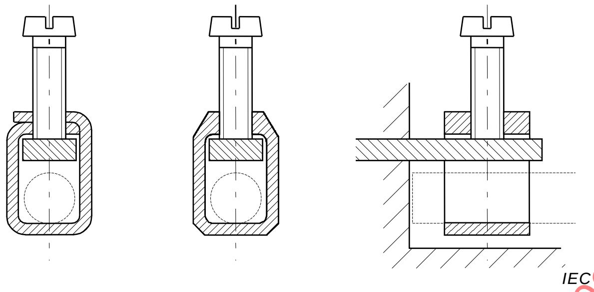


Figure E.1a – Terminals with stirrup

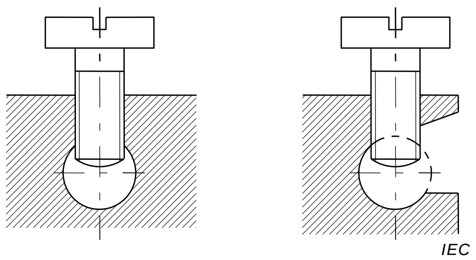


Figure E.1b – Terminals without pressure plate

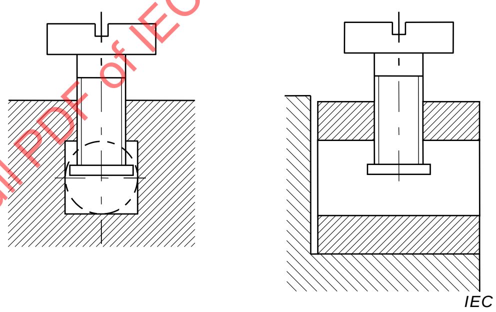


Figure E.1c – Terminals with pressure plate

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 a terminal provided with a stirrup.

Figure E.1 – Examples of pillar terminals

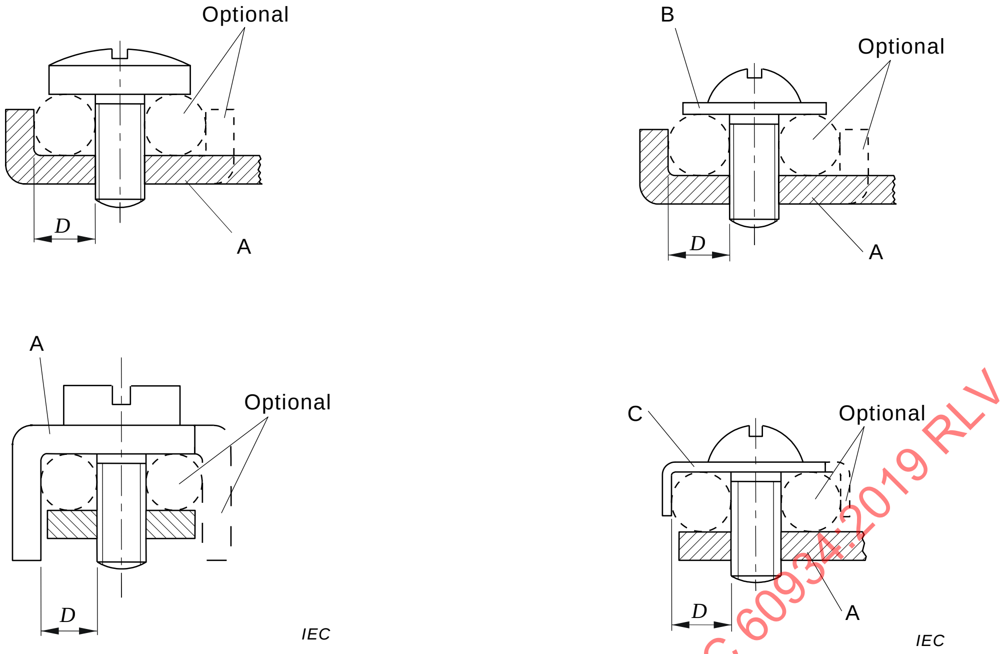


Figure E.2a – Screw terminals

Screw not requiring washer or clamping plate

Screw requiring washer, clamping plate or anti-spread device

FigureE.2b – Stud terminals

A fixed part

B washer or clamping plate

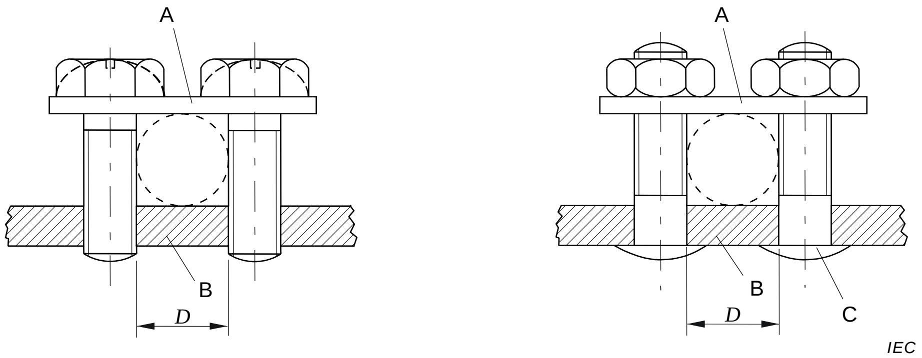
C anti-spread device

D conductor space

E stud

The part which retains the conductor in position may be of insulating material, provided the pressure necessary to clamp the conductor is not transmitted through the insulating material.

Figure E.2 – Examples of screw terminals and stud terminals



A saddle

B fixed part

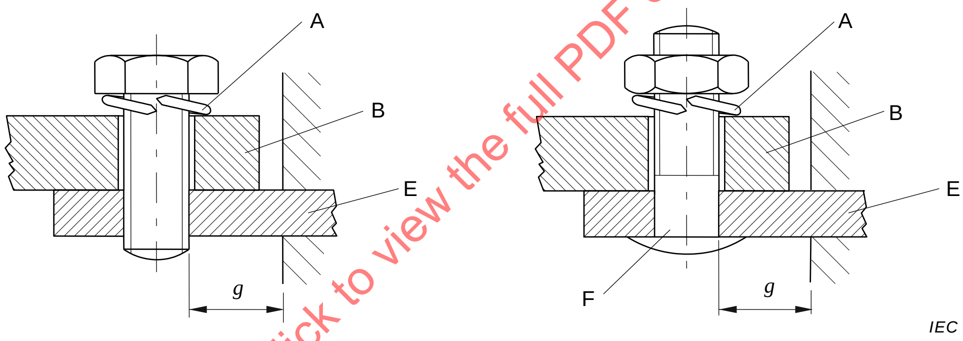
C stud

D conductor space

The two faces of the saddle may be of different shapes to accommodate conductors of either small or large cross-sectional area, by inverting the saddle.

The terminals may have more than two clamping screws or studs.

Figure E.3 – Examples of saddle terminals



A locking means

B cable lug or bar

E fixed part

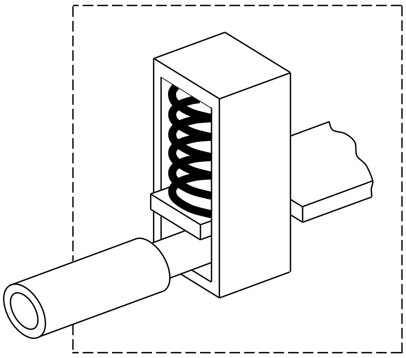
F stud

g distance

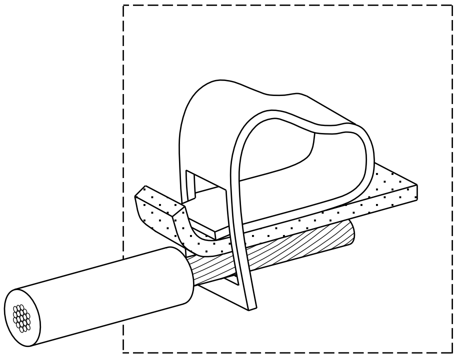
For this type of terminal, a spring washer or equally effective locking means shall be provided and the surface within the clamping area shall be smooth.

For certain types of equipment, the use of lug terminals of sizes smaller than that required is allowed.

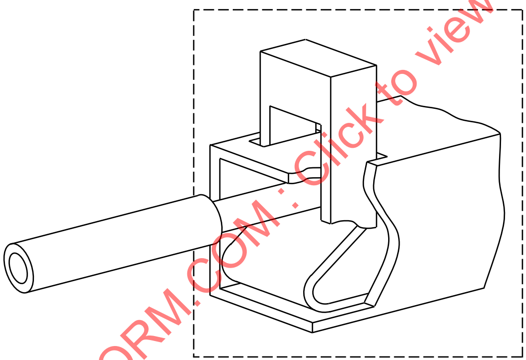
Figure E.4 – Examples of lug terminals



Screwless-type terminal with indirect pressure



Screwless-type terminal with direct pressure



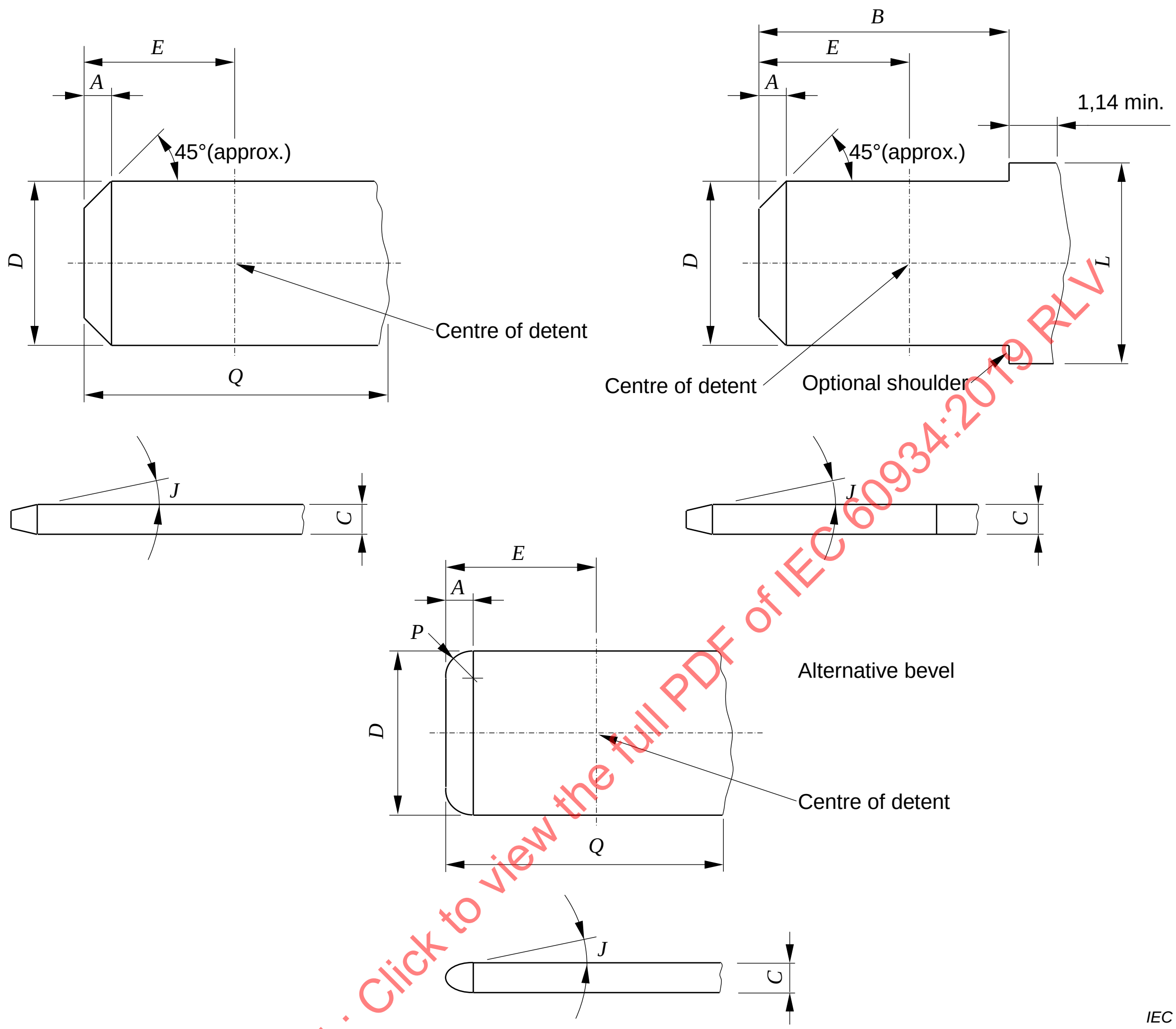
Screwless-type terminal with actuating element

IEC

Figure E.5 – Examples of screwless terminals

The dimensions for the flat quick-connect male tabs in Figures E.6 to E.13 are given in 8.1.7.

Dimensions in millimetres



~~NOTE 1~~ Bevel A of 45° need not be a straight line if it is within the confines shown.

~~NOTE 2~~ Dimension L is not specified and may vary according to the application (for example fixing).

~~NOTE 3~~ Dimension C of tabs may be produced from more than one layer of material provided that the resulting tab complies in all respects with the requirements of this document.

A radius on the longitudinal edge of the tab is permissible.

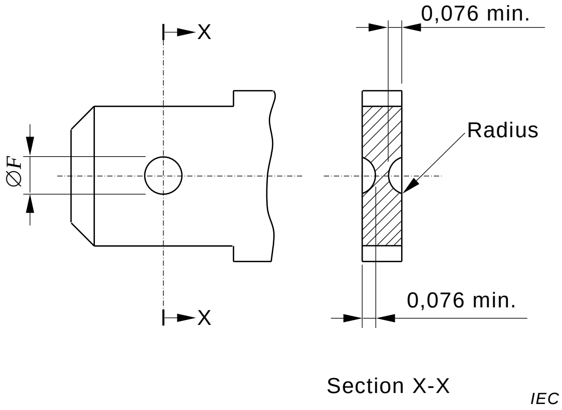
~~NOTE 4~~ The sketches are not intended to govern the design except with regard to the dimensions shown.

~~NOTE 5~~ The thickness C of the male tab may vary beyond Q or beyond B + 1,14 mm.

~~NOTE 6~~ All portions of the tabs shall be flat and free of burrs or raised plateaux, except that there may be a raised plateau over the thickness of 0,025 mm per side, in the area defined by a line surrounding the detent and distant from it by 1,3 mm.

Figure E.6 – Dimensions of male tabs

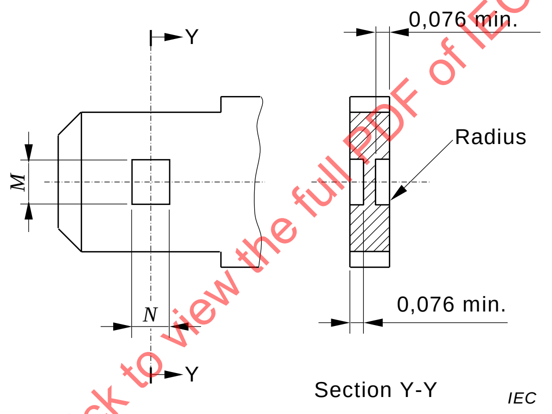
Dimensions in millimetres



The detent shall be located within 0,076 mm of the centre-line of the tab.

Figure E.7 – Dimensions of round dimple detents of male tabs (see Figure E.6)

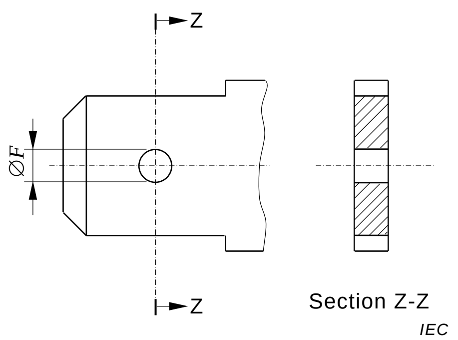
Dimensions in millimetres



The detent shall be located within 0,13 mm of the centre-line of the tab.

Figure E.8 – Dimensions of rectangular dimple detents of male tabs (see Figure E.6)

Dimensions in millimetres



The detent shall be located within 0,076 mm of the centre-line of the tab.

Figure E.9 – Dimensions of hole detents of male tabs (see Figure E.6)

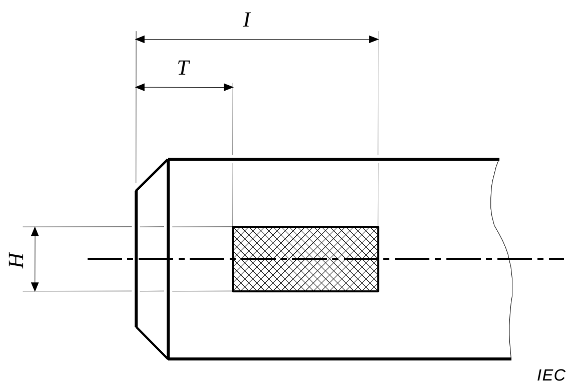


Figure E.10 – Dimensions of male tabs

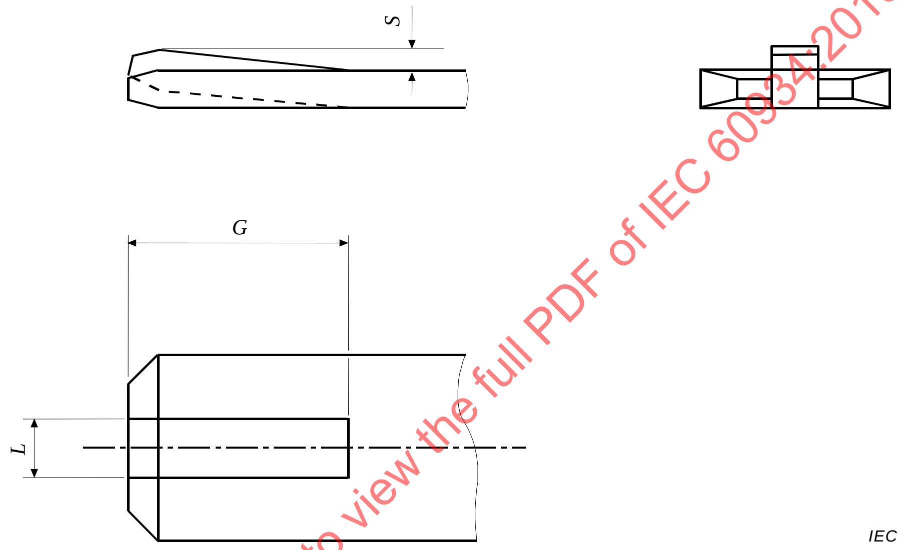


Figure E.11 – Dimensions of male tabs

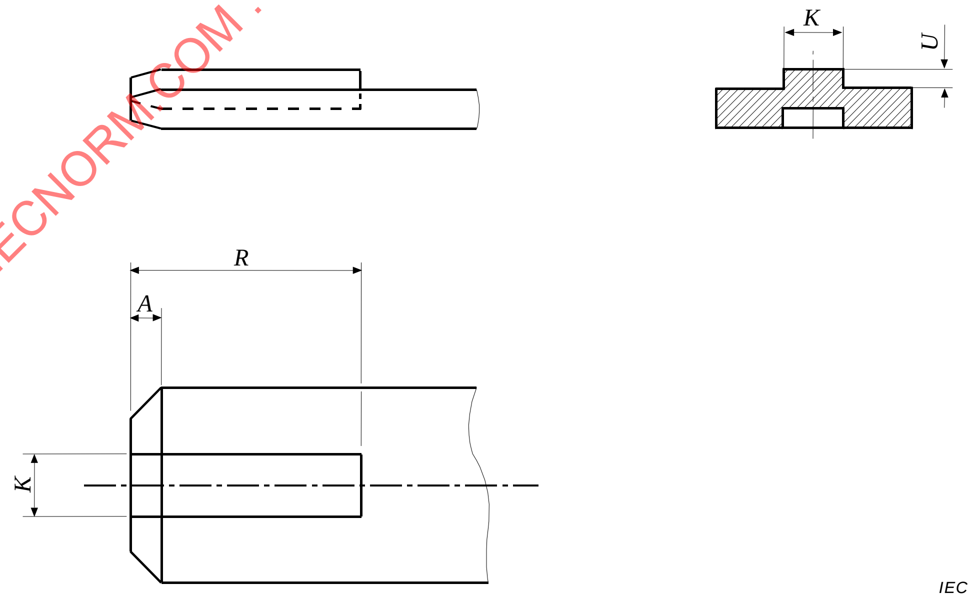


Figure E.12 – Dimensions of male tabs

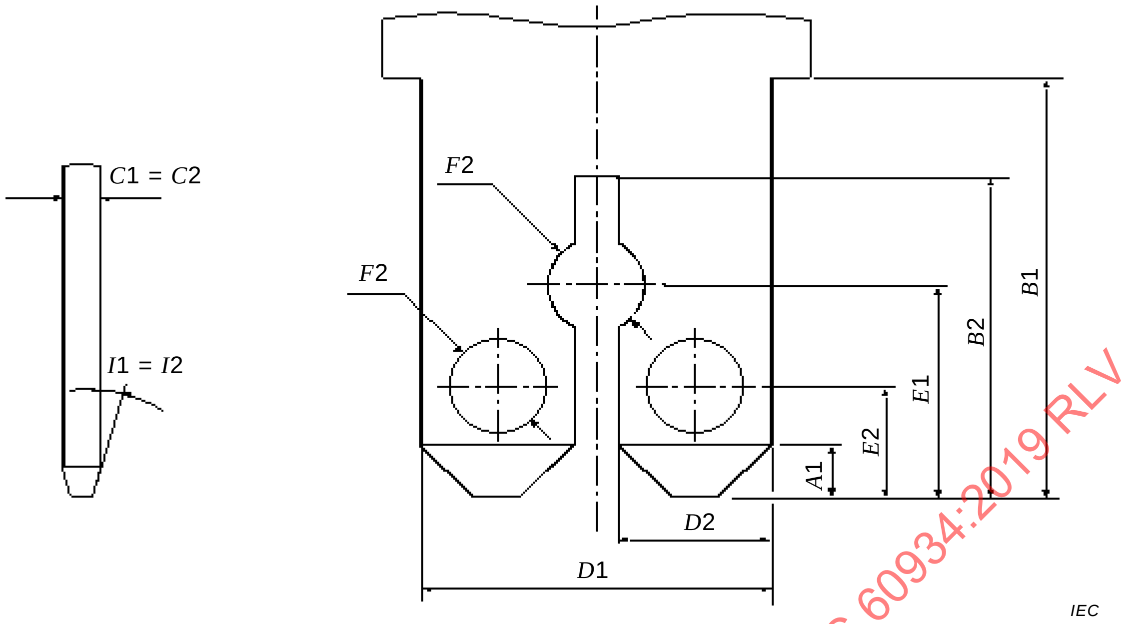
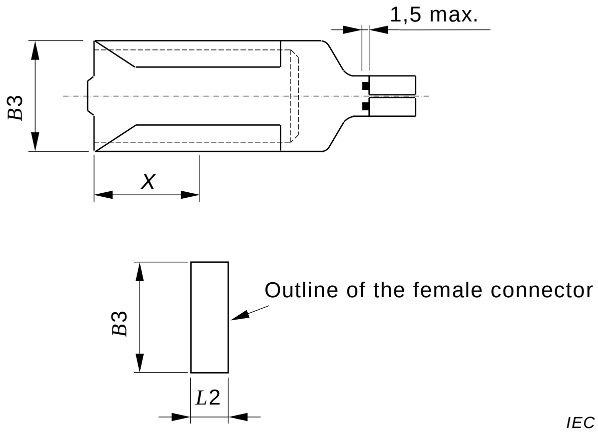


Figure E.13 – Dimensions of male tabs for two different sizes of female connectors
(see 8.1.7.1)

Dimensions in millimetres



NOTE 1 For determining female connector dimensions varying from $B3$ and $L2$, it is necessary to refer to the tab dimensions in order to ensure that in the most onerous conditions the engagement (and detent if fitted) between tab and female connector is correct.

NOTE 2 If a detent is provided, dimension X is at the manufacturer's discretion in order to meet the requirements of the performance clauses.

NOTE 3 Female connectors should be so designed that undue insertion of the conductor into the crimping area is visible or prevented by a stop in order to avoid any interference between the conductor and a fully inserted tab.

NOTE 4 The sketches are not intended to govern the design except as regards the dimensions shown.

Tab size	Dimensions of female connector			
	mm		in	
	***B*3 max**	***L*2 max**	***B*3 max**	***L*2 max**
2,8 x 0,5	3,8	2,3	0,150	0,091
2,8 x 0,8	3,8	2,3	0,150	0,091
4,8 x 0,8	6,2	2,9	0,244	0,114
6,3 x 0,8	7,8	3,5	0,307	0,138
9,5 x 1,2	11,1	4,0	0,437	0,157

Figure E.14 – Dimensions of female connectors for male tabs

Annex F
(informative)

Coordination between a CBE and a short-circuit protective device (SCPD) associated in the same circuit

F.1 ~~Introduction~~ General

In most applications, CBEs are part of an electrical system in which two or more overcurrent protective devices are associated in the same circuit.

It is therefore necessary to consider the aspects of system coordination, such as:

a) back-up protection;

b) discrimination.

Annex F deals mainly with back-up protection, but also gives guidance concerning discrimination.

Back-up protection becomes necessary whenever the prospective short-circuit current at the location of the CBE exceeds the rated short-circuit capacity of the CBE.

If a rated short-circuit capacity (see 5.2.7) is not assigned by the manufacturer, the rated switching capacity (see 5.2.5) shall be used instead of the rated short-circuit capacity.

In many locations the prospective short-circuit current is likely to exceed the rated short-circuit capacity (or the rated switching capacity, where applicable), of the CBE.

It is therefore required that, unless CBEs are capable of reliably breaking the prospective fault current, appropriate back-up protection shall be provided as an integral part of the equipment or shall be specified in the manufacturer's instructions.

If the maximum fault current exceeds the rated short-circuit capacity of the CBE, the requirements can only be satisfied if proper coordination between the CBE and the SCPD is verified.

Annex F gives guidance indicating how, on the basis of desk studies and/or tests, co-ordination may be achieved.

It also provides guidance on the type of information which should be made available to the prospective user.

F.2 ~~Scope~~ Overview

Annex F gives guidance on the coordination between a CBE and a SCPD which may be either a fuse or a circuit-breaker.

It states

– the general requirements for the coordination of a CBE with its associated SCPD;

– the requirements for the back-up protection of a CBE by a fuse or a circuit-breaker;

– the association of a CBE and an SCPD for which, under certain conditions, discrimination and/or back-up protection may be verified by desk study;

– the methods to be used for the verification of coordination by desk study;

– the tests intended to verify that the conditions for coordination have been met.

F.3 General requirements for co-ordination of a CBE with an associated SCPD

F.3.1 General considerations

A CBE connected in series with a SCPD will interrupt a short-circuit current up to the selectivity limit current I_S without the aid of the SCPD.

For currents higher than I_S, the CBE with its associated SCPD shall safely operate at all values of overcurrent up to the conditional short-circuit current I_{nc}.

For back-up protection, the following considerations apply.

a) If the value of the prospective fault current at the point of installation is less than the rated short-circuit capacity of the CBE, it may be assumed that the SCPD is only in the circuit for considerations other than those of back-up protection.

b) If the value of the prospective fault current at the point of installation exceeds the rated short-circuit capacity of the CBE, the SCPD shall be so selected as to ensure compliance with the requirements of F.3.2 and F.3.3.

F.3.2 Requirements concerning back-up protection

F.3.2.1 General behaviour

For all values of overcurrent exceeding I_S, up to and including the rated conditional short-circuit current assigned to the CBE with its associated SCPD, the making operation of the CBE as well as the breaking operation of the association shall not give rise to external manifestations which would endanger the operator or constitute a risk of fire. For CBEs of performance category 2, the association shall be such that the CBE remains fit for further use. Compliance is checked by the relevant tests of 9.12.

F.3.2.2 Take-over current

The take-over current I_B shall be not greater than the rated short-circuit capacity of the CBE alone ($I_B \leq I_{cn}$).

F.3.3 Requirements concerning discrimination

For all values of overcurrent up to the selectivity limit current I_S, the CBE shall break the current without causing a back-up circuit-breaker to open or impairing a back-up fuse for further use.

F.3.4 Required information

The verification of coordinated short-circuit protection requires information on the performance of the CBE as well as the SCPD. This information comprises the following.

For the CBE:

– type and rating;
– the operating characteristic;
– the I^2t withstand capacity;
– the rated short-circuit capacity I_{cn};
– the rated conditional short-circuit current I_{nc} (see 5.2.6);
– the current at which electrodynamic contact separation can occur;
– the current at which welding of contacts can occur.

Where the SCPD is a circuit-breaker:

– type and rating of the circuit-breaker;
– energy-limiting class, if available and applicable;
– the operating characteristics of the circuit-breaker;

NOTE This information includes the instantaneous tripping current I_i.

– the non-tripping values of the time/current-operating characteristics of the circuit-breaker;
– the rated short-circuit capacity of the circuit-breaker.

Reference should be made to the relevant IEC standard.

Where the SCPD is a fuse:

– type and rating of the fuse;
– the operating characteristic;
– the pre-arcing characteristic;
– the rated breaking capacity of the fuse.

Reference should be made to IEC 60269.

F.4 Verification of coordination

F.4.1 General considerations including the conditions for verification by desk study

If the required information according to F.3.4 is available, coordination can, for some associations, be determined by comparison of the individual characteristics, provided the CBE incorporates only overload protection and satisfies, in addition, the following two conditions:

a) the prospective short-circuit current does not exceed 1 500 A;
b) electrodynamic contact separation and contact welding do not occur at currents up to the rated conditional short-circuit current I_{nc}.

An example of an association for which coordination can be verified by desk study is shown in Figure F.1.

For the verification of short-circuit coordination, where applicable, it is recommended to use I^2t characteristics rather than the time/current characteristic.

NOTE At present, some relevant characteristics may not be available, because the standards do not specify how they should be evaluated. An example is given in F.3.2.1.

For some associations individual characteristics may be available, but some may not allow prediction of the behaviour of the association. The series connection of two magnetic circuit-breakers of comparable instantaneous trip times may serve as an example. Such an association will allow prediction of the range of discrimination by desk study, but will not permit verification of the conditional short-circuit current without tests.

F.4.2 Verification of discrimination

F.4.2.1 Verification of discrimination by desk study

For certain associations, discrimination can be verified by superimposing the relevant characteristics, drawn to the same scale. Examples are shown in

– Figure F.1 for a thermally operated CBE backed up by a thermal-magnetic circuit-breaker;
– Figure F.2 for a thermally operated CBE, backed up by a fuse;

– Figure F.3 for a thermal-magnetic CBE, backed up by a thermal-magnetic circuit-breaker;
– Figure F.4 for a hydraulic-magnetic CBE, backed up by a thermal-magnetic circuit-breaker;
– Figure F.5 for a thermally operated CBE backed up by a hydraulic-magnetic circuit-breaker.

For some associations, discrimination can not be verified at present by desk study, because the required non-operating characteristic of the back-up circuit-breaker (= unlatching characteristic) is not available. This refers to an association of an energy-limiting CBE with a conventional thermal-magnetic back-up circuit-breaker.

The curves of the tripping characteristics made available by the manufacturers presently state the limits of actual time which may elapse until the current is interrupted. These curves are referred to the prospective short-circuit current.

The required curve should show the response of the back-up circuit-breaker to current pulses shorter than a half-wave and differing from the sinusoidal shape. Such curves are not at present standardized. The use of the curves presently provided by the manufacturer of the back-up circuit-breakers would lead to wrong conclusions. Figure F.6 gives an example.

F.4.2.2 Verification of discrimination by tests

Verification by tests is necessary when the conditions described in F.3.1 are not satisfied. This applies to some associations of CBEs with back-up circuit-breakers as mentioned in F.3.2.1. It does not apply to associations of CBEs with fuses, where the pre-arcing characteristic of the fuse is available.

F.4.2.3 Verification of I_S

Tests for the verification of I_S shall be carried out in accordance with 9.12, except that the sequence of operations at each test current shall be O-t-O and the power factor shall be 0,6 ± 0,05. The test shall be repeated with higher test currents until tripping of the back-up circuit-breaker occurs. The highest value of the test current for which tripping of the back-up circuit-breaker did not occur is the selectivity limit current I_S.

One sequence of tests shall be repeated on the association with this current.

F.4.3 Verification of coordinated back-up protection

F.4.3.1 Verification of coordinated back-up protection by desk study

a) For CBEs of performance category 1 (PC1: see 5.2.6.2)

Compliance with the requirements of F.3.2.2 is not relevant, since the verification of I_B requires tests in accordance with F.4.3.2.

b) For CBEs of performance category 2 (PC2: see 5.2.6.3)

Compliance with the requirements of F.3.2 can be checked by desk study, provided the conditions of F.3.1 are satisfied and the information as listed below is available:

– operating characteristic of the CBE;
– operating characteristic of the SCPD;
– rated short-circuit capacity or, where relevant, rated switching capacity of the CBE;
– maximum I^2t value which the CBE can withstand;
– peak current, up to which contact welding will not occur;
– peak current, up to which electrodynamic contact separation will not occur.

Illustrations are given in Clause F.5.

F.4.3.2 Verification of coordinated back-up protection by tests

Compliance with the requirements of F.2.2 can be verified by the conditional short-circuit current tests in accordance with 9.12.

NOTE Subclause 9.12 states the different criteria of acceptance for the performance categories PC1 and PC2.

~~NOTE~~ The initial verification of compliance with the requirement $I_B \leq I_{cn}$ (see F.2.2.2) ~~has to~~ shall be effected by desk study.

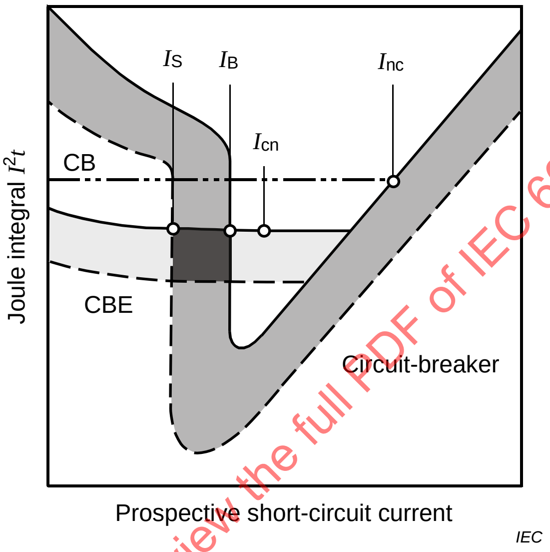
F.5 Examples of verification of coordination by desk study

In Clause F.5 illustrative examples are given to show for which associations of CBE and SCPD coordination may or may not be verified by superimposing comparable characteristics drawn to the same scale.

For some examples, time-current characteristics – suitable for showing the whole range of currents in one figure – are used; for others the I^2t versus current characteristics were taken, these being particularly suitable to cover the short-circuit range of currents.

Throughout Clause F.5, the following symbols are used:

(solid line)	Operating characteristic
(dashed line)	Non-tripping values of the time/current characteristic of the back-up circuit-breaker Pre-arcing characteristic of the back-up fuse
I^2t (dash-dot line)	Withstand capacity of a "thermal" CBE
(light grey area)	Operating zone of CBE
(dark grey area)	Operating zone of SCPD
I_{cn}	Rated short-circuit capacity (CBE)
I_B	Take-over current
I_{nc}	Rated conditional short-circuit current of the association
I_S	Selectivity limit current



Conclusion

For PC1

I_S and I_B can be determined by desk study.

I_{cn} can only be determined by tests.

For PC2

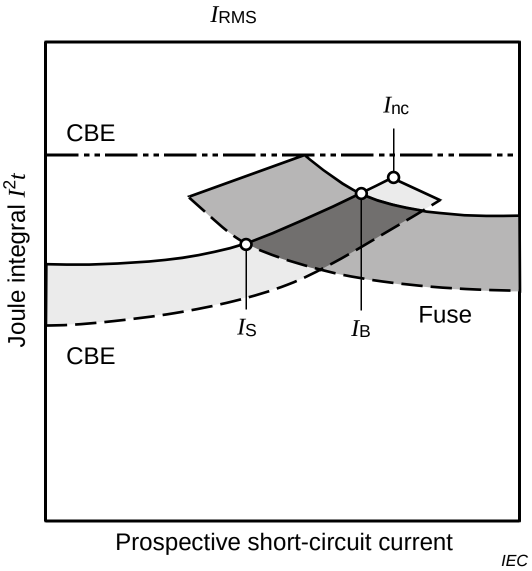
I_S and I_B can be determined by desk study.

I_{nc} can also be determined, provided contact welding does not occur below I_{nc}.

Comments

Range of test current I_T	**Behaviour of CBE and circuit-breaker**
$I_T < I_s$	CBE will interrupt, circuit-breaker will stay closed
$I_S < I_T < I_B$	CBE or circuit-breaker may interrupt. At least one device will interrupt
$I_B < I_T < I_{nc}$	CBE will not suffer thermal damage.

Figure F.1 – Thermal only CBE, backed up by thermal magnetic circuit-breaker



Conclusion

For PC1

I_S and I_B can be determined by desk study.

For PC2

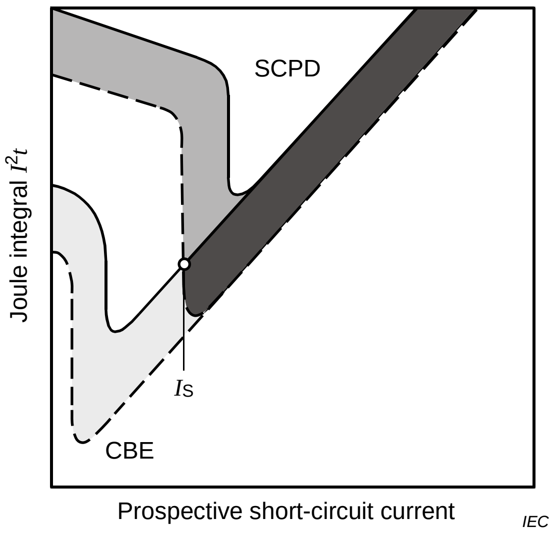
I_S and I_B can be determined by desk study.

I_{nc} is not determined by the thermal withstand capacity, but only by contact welding.

Comments

Range of test current I_T	Behaviour of CBE and fuse
$I_T < I_s$	CBE will interrupt.
$I_S < I_T < I_B$	CBE or fuse may interrupt. Fuse will be impaired.
$I_B < I_T < I_{nc}$	Only fuse will interrupt. CBE will stay closed (or may open with delay).

Figure F.2 – Thermal only CBE, backed up by a fuse



Conclusion

For PC1 and PC2

Only I_S can be determined by desk study.

Comments

Below I_S only the CBE will interrupt. Above I_S the CBE and the back-up circuit-breaker may be involved in the breaking operation.

Figure F.3 – Thermal-magnetic CBE backed up by thermal-magnetic circuit-breaker

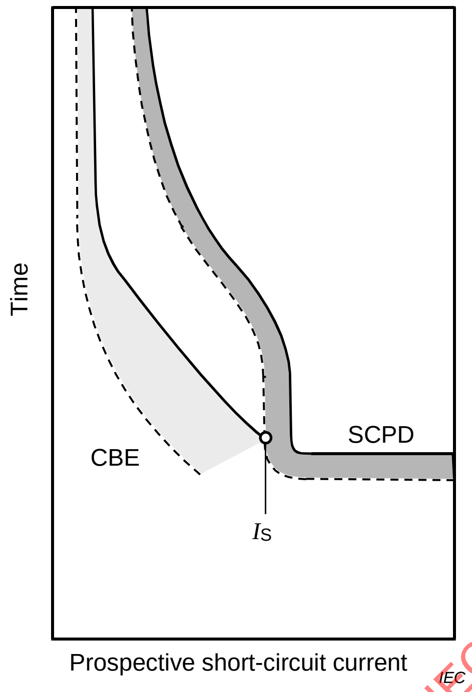
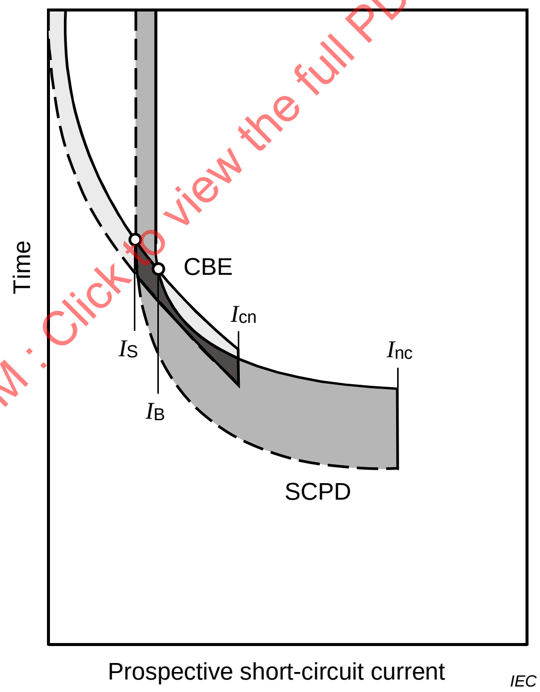


Figure F.4 – Hydraulic-magnetic CBE backed up by thermal-magnetic circuit-breaker

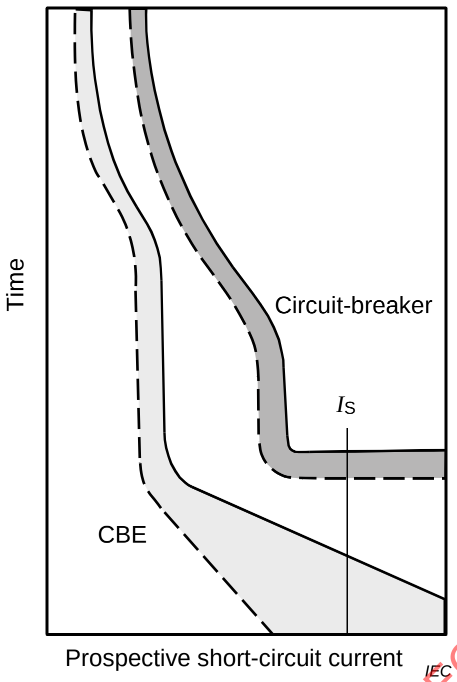


Conclusion for Figures F.4 and F.5

For PC1 and PC2

Only I_S can be determined by desk study. Back-up protection ~~has to be~~ is verified by test.

Figure F.5 – Thermal CBE backed up by a hydraulic-magnetic circuit-breaker



Comments

This presentation of two characteristics as presently provided by the manufacturers implies absolute discrimination, because the curves do not intersect.

However, a test shows that the back-up circuit-breaker in this example will delatch (and open) at a current I_S, as shown in the figure.

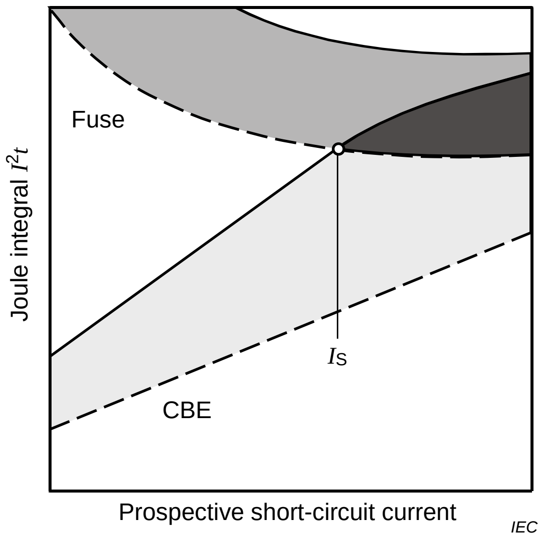
Reason:

The given characteristic of the back-up circuit-breaker does not reflect its response to pulses shorter than a half wave.

Conclusion

For an association as shown by Figure F.6 the available characteristics of the circuit-breaker do not allow the determination of I_S by desk study.

Figure F.6 – Energy-limiting CBE, backed up by thermal-magnetic circuit-breaker



Comment

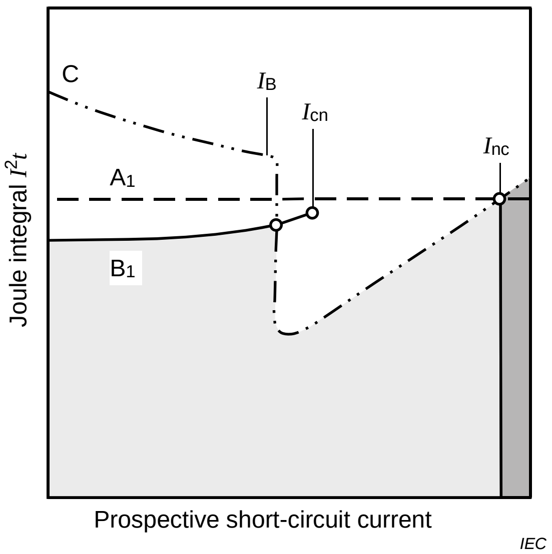
The available characteristics of this association are compatible, and this is shown by the pre-arcing characteristic of the fuse overlapping the let through I^2t characteristic of the CBE.

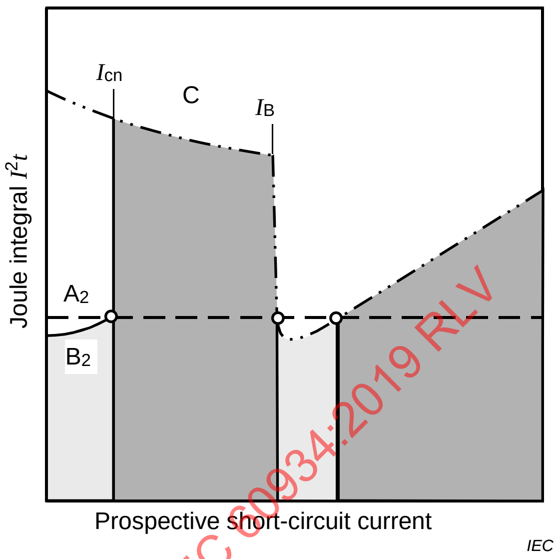
Conclusion

I_S can be determined by desk study.

Figure F.7 – Energy-limiting CBE, backed up by a fuse

The two examples in Figure F.8 show I^2t versus current characteristics of two different thermally operated CBEs of 7 A rating, backed up by the same thermal-magnetic circuit-breaker of 20 A rating.





A_1 A_2 = I^2t withstand capacities of the two CBEs

B_1 B_2 = I^2t operating characteristics of the two CBEs

C = I^2t operating characteristics of the back-up circuit-breaker

Index 1, 2 = different CBEs

Safe zone of operation S*

Unsafe zone of operation*

* According to performance category 2 (fit for further use).

Conclusion

This association provides coordinated protection up to I_{nc}.

Condition $I_B < I_{cn}$ is satisfied.

Figure F.8a – Proper coordination

Conclusion

This association does not provide coordinated protection as defined by this document.

The desk study reveals this shortcoming.

Figure F.8b – Improper coordination

Figure F.8 – Examples illustrating proper and improper coordination

Annex G
(normative)

Electromagnetic behaviour of CBEs

G.1 General

CBEs are designed specifically for being incorporated in equipment. The product standards of the various equipment specify the immunity and emission requirements the equipment has to meet, depending upon the environment where they are designed to operate. The manufacturers of equipment in designing and assembling the relevant components take into account the electromagnetic compatibility (EMC) standards (if any) for the specific equipment or the generic standards of the environment where the equipment will operate. So the EMC conditions to be fulfilled by the components (like CBEs) may differ, depending upon their incorporation in equipment. Therefore, no EMC general requirements are stated for CBEs.

Nevertheless, information shall be made available to equipment manufacturers on the electromagnetic emission and immunity characteristics of CBEs, when relevant, in order to make an appropriate choice for incorporation in the equipment to be protected.

To this purpose, Annex G gives information on EMC behaviour of CBEs depending on their design, defines the minimum EMC performances required for CBEs and states the additional information on EMC characteristics that the CBE manufacturer shall make available to the equipment manufacturer for the appropriate choice of CBEs.

G.2 Immunity

G.2.1 CBEs not incorporating electronic circuits

CBEs not incorporating electronic circuits are not sensitive to electromagnetic disturbances and, therefore, no immunity tests are required*.

The behaviour of CBEs with overvoltage or undervoltage release in case of voltage dips, short interruptions and voltage variations is verified by the tests of 8.5.4.

G.2.2 CBEs incorporating electronic circuits

a) CBEs incorporating simple rectifiers alone are not sensitive to electromagnetic disturbances and, therefore, no immunity specifications are necessary*.
b) For CBEs with releases incorporating electronic circuits other than those of G.2.2 a), the manufacturer shall indicate the performances under the following test conditions:
   – conducted fast transients (bursts), specified in IEC 61000-4-4;
   – surge (1,2/50 µs) immunity, specified in IEC 61000-4-5;
   – electrostatic discharges, specified in IEC 61000-4-2;
   – radiated high-frequency electromagnetic field, specified in IEC 61000-4-3.

These performances shall in any case be such as to satisfy the tests at the levels indicated in Table G.1 as a minimum.

* Phenomena referred to in T 1.1 of IEC 61543 are under consideration.

Table G.1 – Minimum EMC immunity performances of CBEs

Type of test	Severity level to IEC 61000-4	Values
1,2/50 µs surges IEC 61000-4-5	3	2 kV (CM) [a] 1 kV (DM) [b]
Fast transients (bursts) IEC 61000-4-~~5~~4	3	2 kV
Electromagnetic field IEC 61000-4-3	~~3~~ 2	3 V/m
Electrostatic discharges IEC 61000-4-2	3	6 kV [c] air discharge

[a] Common mode.

[b] Differential mode.

[c] Applied to the front/operating mean.

~~During the tests, the CBE may not trip.~~

The generic performance criteria as specified in IEC 61000-6-1 apply.

After the tests of Table G.1, the CBE shall meet the requirements of 8.5.1 at 2 I_n and, if applicable, of 8.5.4.

G.3 Emission

G.3.1 CBEs not incorporating electronic circuits

CBEs not incorporating electronic circuits do not generate continuous disturbances and only generate transient disturbances during switching. The frequency and the consequences of these transient disturbances are considered as part of the normal electromagnetic environment of low-voltage installations. No EMC specifications are necessary for this type of CBE.

G.3.2 CBEs incorporating electronic circuits

a) CBEs not incorporating a continuously operating oscillator do not usually generate continuous or transient disturbances except during their switching process. The frequency, the level and the consequences of such emissions are considered as part of the normal electromagnetic environment of low-voltage installations.

b) For CBEs incorporating a continuously operating oscillator the manufacturer shall indicate the performances under the test conditions of CISPR ~~22~~ 32 (0,15 MHz to 30 MHz and 30 MHz to 1 000 MHz).

Annex H
(normative)

Correlation between nominal voltage of the supply systems and the line-to-neutral voltage relevant for determining the rated impulse voltage

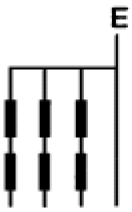
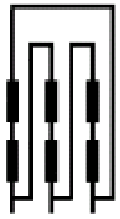
The rated impulse voltages given in Table H.1 are based on the assumption that a protective measure is necessary and that such measure is provided by the inclusion of surge arresters having a ratio of clamping voltage to minimal voltage not smaller than that specified by IEC 60099-1.

Table H.1 – Nominal voltages and corresponding rated impulse voltages

Voltage line-to-neutral	Nominal voltages of supply systems				Rated impulse voltage for equipment V Overvoltage category		
	Three-phase four-wire systems with earthed neutral	Three-phase three-wire systems earthed or unearthed	Single-phase two-wire systems a.c. or d.c.	Single-phase three-wire systems a.c. or d.c.	I	II (standard category)	III
V	V	V	V	V			
50	Not applicable	Not applicable	12,5 24 25 30 42 48	30-60	330	500	800
100	66 /115	66	60		500	800	1 500
150	120/208 [a] 127/220	115, 120, 127	110, 120	110-220 120-240	800	1 500	2 500
300	220/380, 230/400 240/415, 255/440 277/480	220, 230, 240 255, 277	220	220-440	1 500	2 500	4 000
600	347/600, 380/660 400/690, 415/720 480/830	347, 380, 400 415, 440, 480 500, 577, 600	480	480-960	2 500	4 000	6 000
1 000		660 690, 720 830, 1 000	1 000		4 000	6 000	8 000

[a] Used in the United States of America and in Canada.

Voltage line-to-neutral derived from nominal voltages AC	Nominal voltages presently used in the world	Rated impulse voltage for equipment
		Overvoltage category

or DC up to and including V	Three-phase four-wire systems with earthed neutral V	Three-phase three-wire systems unearthed V	Single-phase two-wire systems AC or DC V	Single-phase three-wire systems AC or DC V	I	II	III
							
50	Not applicable	Not applicable	12,5 24 25 30 42 48	30 to 60	330	500	800
100	66/115	66	60		500	800	1 500
150	120/208 [b] 127/220	115, 120, 127	100 [c] 110, 120	100 to 200 [c] 110 to 120 120 to 240	800	1 500	2 500
300	220/380, 230/400, 240/415, 260/440, 277/480	220, 230, 240 260, 277, 347 380, 400 [a], 415 440, 480	220	220 to 440	1 500	2 500	4 000
600	347/600, 380/660, 400/690, 417/720, 480/830	500, 577, 600	480	480 to 960	2 500	4 000	6 000
1 000		660 690, 720, 830, 1 000	1 000		4 000	6 000	8 000

[a] For 3-phase-3 wire systems derived from 3-phase-4 wire supply with earthed neutral point.

[b] Practice in the United States of America and in Canada.

[c] Practice in Japan.

Annex I
(normative)

Routine or statistical tests

I.1 General

The tests specified in Annex I are intended to reveal, as far as safety is concerned, unacceptable variations in material or manufacture.

Further tests may be made to ensure that every CBE conforms with the samples that withstood the tests of this document, according to the experience gained by the manufacturer.

Engineering and statistical analyses may show that routine tests on each CBE may not always be required, in which case tests may be made on a statistical basis.

I.2 Verification of the tripping characteristic

Unless otherwise agreed between manufacturer and customer, these routine tests shall be made in accordance with 9.10, but with the following test currents.

a) For CBEs with TO mode of tripping:
   – with a current of approximately 2 I_n, the CBE shall trip within the time limits defined by the time-current zone indicated by the manufacturer.

b) For CBEs with MO mode of tripping:
   – with a current of 0,95 I_{ni} applied for 0,1 s, the CBE shall not trip;
   – with a current of 1,05 I_i, the CBE shall trip within 0,15 s.

c) For CBEs with TM mode of tripping:
   – with the current of 0,95 I_{ni} applied for 0,1 s, the CBE shall not trip;
   – with the current of 1,05 I_i, the CBE shall trip within 0,1 s;
   – with the current of 2 I_n, the CBE shall trip within the time limits defined by the time-current zone indicated by the manufacturer.

d) For CBEs with HM mode of tripping:
   – with the currents of 2 I_n and of 6 I_n, the CBE shall trip within the time limits defined by the time-current zone indicated by the manufacturer.

e) For CBEs with EH mode of tripping:
   – with two currents specified by the manufacturer, the CBE shall trip within the time limits defined by the time-current zone indicated by the manufacturer.

I.3 Verification of dielectric strength

A voltage of substantially sine wave form, of values specified in Table 20 having a frequency of 50 Hz or 60 Hz is applied for 1 s

a) with the CBE in the open position, between the terminals which are electrically connected together when the CBE is in the closed position;

b) with the CBE in the closed position, between each pole of the CBE in turn and the other poles connected together with the CBE not incorporating electronic components, if applicable;

c) for the CBE incorporating electronic components, with the CBE in the open position, between each pole in turn and the adjacent poles, if applicable, either between incoming terminal of the poles or outgoing terminal of the poles, depending on the position of the electronic components and the other poles connected together.

No flashover or breakdown shall occur.

Alternatively, any convenient method of verification of the clearances between contacts (for example X-ray verification) may be used.

Annex J
(normative)

Additional requirements for electrical performance of E-type CBEs

Void.

~~Annex K~~
~~(normative)~~

~~Additional requirements for electrical performance of CBE-switches~~

~~**K.1** A CBE-switch shall be identical to the CBE from which it is derived except for the omission of overcurrent protection elements. For overcurrent protection, it relies on back-up devices.~~

~~**K.2** A CBE-switch shall satisfy the requirements as specified in sections 1 and 2 of tables 11 or 12, as applicable.~~

~~**K.3** A CBE-switch is considered to comply with this standard, if the CBE, from which it is derived, has been successfully tested in accordance with these requirements.~~

Annex K
(normative)

Additional requirements for CBEs suitable for isolation

K.1 General

CBEs of M-type and S-type method of operation having performance category PC2 complying with the requirements and tests of the main clauses of this document and in addition with the requirements and tests of Annex K are suitable for isolation.

The requirements of Annex K supplement, modify or replace certain of the general requirements of the main clauses.

The clause numbering in Annex K follows the pattern and corresponding references of the main clauses.

The absence of reference to a clause or subclause means that the corresponding requirements of that clause or subclause are applicable.

K.6 Marking and other product information

The manufacturer shall give the following statement in his literature: "Single pole devices may not be used for isolation.".

K.8 Requirements for construction and operation

K.8.1.2 Mechanism

CBEs suitable for isolation shall provide in the open position an isolating distance in accordance with the requirements for isolation.

The indication of the position of the main contacts shall be provided by one or more of the following means:

– the position of the actuator;

– a separate mechanical indicator.

If a separate mechanical indicator is used to indicate the position of the main contacts, this shall show the colour red for the ON-position and the colour green for the OFF-position.

When means are provided or specified by the manufacturer to lock the operating means in the open position, locking in that position shall only be possible when the main contacts are in the open position.

NOTE In the USA, the colour “green” indicates the ON-position and “red” indicates a “tripped” condition.”

CBEs shall be designed so that the actuator, front plate or cover can only be fitted in a manner which ensures correct contact position indication and locking, if provided.

Compliance is checked by inspection, taking into account the instructions of the manufacturer.

K.8.1.3 Clearances and creepage distances

It is assumed that the conditions apply for devices suitable for isolation:

– degree of pollution 2 or 3;
– overvoltage category III.

NOTE CBEs may be suitable for higher overvoltage category or a higher degree of pollution. Such CBEs should be marked in accordance with the item m) of Clause 6.

For clearances and creepage distances between live parts of different polarity and live parts and accessible parts, Tables 1 and 2 apply.

For clearances and creepage distances between parts which are separated when the main contacts of the CBE are in the open position and between circuits supplied by different sources, Table K.1 and Table K.2 apply.

The clearances of Table K.1 are determined on the basis of the test voltages for verifying isolation as shown in Table K.3 for 2 000 m, but are referred to the rated impulse withstand voltage.

Table K.1 – Minimum clearances for CBEs suitable for isolation, between live parts separated when the contacts are in the open position, as a function of the rated impulse withstand voltage

U_{imp} kV	0,8	1,5	2,5	3,0	3,5	4,0	4,5	5,5
Pollution degree 2 clearance mm	0,5	1,0	2,0	3,0	3,5	4,0	5,5	7
Pollution degree 3 clearance mm	0,8	1,0	2,0	3,0	3,5	4,0	5,5	7

Table K.2 – Minimum creepage distances for CBEs suitable for isolation, between live parts separated when the contacts are in the open position

Material group	I					II					III				
Working voltage V	63	125	250	400	500	63	125	250	400	500	63	125	250	400	500
Creepage distance for pollution degree 2 mm	1,0	2,0	4,0	5,5	7,0	1,0	2,0	4,0	5,5	7,0	1,25	2,0	4,0	5,5	7,0
Creepage distance for pollution degree 3 mm	1,6	2,0	4,0	5,5	7,0	1,8	2,1	4,0	5,6	7,1	2,0	2,4	4,0	6,3	8,0
Creepage distances cannot be smaller than the associated clearance.															

For minimum clearances distances between circuits supplied by different sources, one of which being SELV or PELV, the clearances for reinforced insulation given in Table 1 shall be used.

For minimum creepage distances between circuits supplied by different sources, one of which being SELV or PELV, the distances for reinforced insulation given in Table 1 apply also, because creepage distances shall not be smaller than the associated clearance.

K.8.4.2 Isolating capability

The CBEs covered by Annex K shall be suitable for isolation.

Compliance is checked by:

- *the verification of the minimum applicable clearances and creepage distances of Tables K.1, K.2;*
- *the tests of K.9.7.7.*

K.9.7.7 Test of suitability for isolation

K.9.7.7.1 Verification of impulse withstand voltage across the open contacts

The test is carried out on a CBE fixed on a metal support.

The impulses are given by a generator producing positive and negative impulses having a front time of 1,2 µs, and a time to half-value of 50 µs, the tolerances being:

- ±5 % for the peak value;
- ±30 % for the front time;
- ±20 % for the time to half-value.

The surge impedance of the test apparatus shall have a nominal value of 500 Ω.

The shape of the impulses is adjusted with the CBE under test connected to the impulse generator. For this purpose, appropriate voltage dividers and voltage sensors shall be used.

Small oscillations in the impulses are allowed provided that their amplitude near the peak of the impulse is less than 5 % of the peak value.

For oscillations on the first half of the front, amplitudes up to 10 % of the peak value are allowed.

The 1,2/50 µs impulse voltage according to Figure 6 of IEC 60060-1:2010 is applied between the line terminals connected together and the load terminals connected together with the contacts in the open position.

Three positive impulses and three negative impulses are applied, the interval between consecutive impulses being at least 1 s for impulses of the same polarity and being at least 10 s for impulses of the opposite polarity.

The test impulse voltage values shall be chosen in Table K.3, in accordance with the rated impulse voltage of the CBE as given in Table H.1. These values are corrected for barometric pressure and/or altitude at which the tests are carried out, according to Table K.3.

There shall be no unintentional disruptive discharges during the test.

Table K.3 – Test voltages for verifying isolation across the open contacts, as a function of the rated impulse withstand voltage and the altitude where the test is carried out

Rated impulse withstand voltage kV	Test voltage (1,2/50 µs pulse) in kV and corresponding altitudes [a]				
	Sea level	**200 m**	**500 m**	**1 000 m**	**2 000 m**
0,8 and less	1,8	1,7	1,7	1,6	1,5
1,5	2,3	2,3	2,2	2,2	2
2,5	3,5	3,5	3,4	3,2	3
3	4,4	4,3	4,2	4,1	4
3,5	5,3	5,2	5,0	4,8	4,5
4	6,2	6,0	5,8	5,6	5
4,5	7,1	6,9	6,6	6,5	6
5,5	8,9	8,7	8,5	8,2	7
6,0	9,8	9,6	9,3	9,0	8

[a] For other altitudes, the test voltage may be determined by interpolation.

K.9.7.7.2 Verification of leakage currents across open contacts

Each pole of the CBEs having been submitted to the tests specified in Table 11 or Table 12, section 3, is supplied at a voltage 1,1 times its rated operational voltage, the CBE being in the open position.

The leakage current flowing across the open contacts is measured and shall not exceed 2 mA.

Bibliography

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IEC 60050-151:2001, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic devices*

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IEC 60112:1979 2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials under moist conditions*
IEC 60112:2003/AMD1:2009

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

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

IEC 60950-1:2005, *Information technology equipment – Safety – Part 1: General requirements*
IEC 60950-1:2005/AMD1:2009
IEC 60950-1:2005/AMD2:2013

IEC 61543:1995, *Residual current-operated protective devices (RCDs) for household and similar use – Electromagnetic compatibility*
IEC 61543:1995/AMD1:2004
IEC 61543:1995/AMD2:2005

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

Circuit-breakers for equipment (CBE)

Disjoncteurs pour équipement (DPE)

IEC 60934:2019-01(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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CIRCUIT-BREAKERS FOR EQUIPMENT (CBE)

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 60934 has been prepared by subcommittee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

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

FDIS	Report on voting
23E/1084/FDIS	23E/1104/RVD

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

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

This fourth edition cancels and replaces the third edition published in 2000, Amendment 1:2007 and Amendment 2:2013. This edition constitutes a technical revision.

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

a) clarifications for type testing purposes.

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.

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

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

CIRCUIT-BREAKERS FOR EQUIPMENT (CBE)

1 Scope

This document is applicable to mechanical switching devices designed as "circuit-breakers for equipment" (CBE) for household and similar applications. CBEs according to this document are intended to provide protection to circuits within electrical equipment including its components (e.g. motors, transformers, internal wiring). This document covers also CBEs applicable for protection of electrical equipment in case of undervoltage and/or overvoltage. This document also covers CBEs which are suitable for isolation.

NOTE The term "equipment" includes appliances.

CBEs are not applicable for overcurrent protection of wiring installations of buildings.

CBEs according to this document have:

– a rated voltage not exceeding 440 V AC (between phases) and/or DC not exceeding 250 V;
– a rated current not exceeding 125 A;
– a short-circuit capacity (I_{cn}) of at least 6 × I_n (AC types) and 4 × I_n (DC types) but not exceeding 3 000 A.

CBEs may have a conditional short-circuit current (I_{nc}) rating in association with a specified short-circuit protective device (SCPD). A guide for coordination of a CBE associated in the same circuit with a SCPD is given in Annex F.

For CBEs having a degree of protection higher than IP20 according to IEC 60529, for use in locations where hazardous environmental conditions prevail (e.g. excessive humidity, heat or cold or deposition of dust) and in hazardous locations (e.g. where explosions are liable to occur), special constructions may be required.

This document contains all the requirements necessary to ensure compliance with the operational characteristics required for these devices by type tests. It also contains the details relative to test requirements and methods of testing necessary to ensure reproducibility of test results.

This document states:

a) the characteristics of CBEs;
b) the conditions with which CBEs shall comply, with reference to:
   1) their operation and behaviour in normal service;
   2) their operation and behaviour in case of overload;
   3) their operation and behaviour in case of short-circuits up to their rated short-circuit capacity;
   4) their dielectric properties;
c) the tests intended for confirming that these conditions have been met and the methods to be adopted for the tests;
d) the data to be marked on the devices;
e) the test sequences to be carried out and the number of samples to be submitted for certification purposes (see Annex C);

f) the routine tests to be carried out to reveal unacceptable variations in material or manufacture, likely to affect safety (see Annex I).

2 Normative references

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

IEC 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-20, *Environmental testing – Part 2-20: Tests – Test T: Test methods for solderability and resistance to soldering heat of devices with leads*

IEC 60227 (all parts), *Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V*

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

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

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

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

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

IEC 60898-1:2015, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 1: Circuit-breakers for a.c. operation*

IEC 61000-4-2, *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 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

CISPR 32, *Electromagnetic compatibility of multimedia equipment – Emission requirements*

3 Terms and definitions

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

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

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

3.1 Definitions related to protection and switching devices

3.1.1
circuit-breaker
mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified duration and breaking currents under specified abnormal conditions such as those of short circuit

[SOURCE: IEC 60050-441:1984, 441-14-20]

3.1.2
circuit-breaker for equipment
CBE
circuit-breaker specifically designed for the protection of equipment

Note 1 to entry: These CBEs are intended for:

– automatic interruption and non-automatic or automatic resetting;

– automatic interruption and non-automatic or automatic resetting and manual switching operation.

3.1.3
E-type CBE
void

3.1.4
fuse
device that, by the fusing of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted by breaking the current when this exceeds a given value for a sufficient time. The fuse comprises all of the parts that form the complete device

[SOURCE: IEC 60050-441:1984, 441-18-01]

3.1.5
switching device
device designed to make or break the current in one or more electric circuits

[SOURCE: IEC 60050-441:1984, 441-14-01]

3.1.6
mechanical switching device
switching device designed to close and open one or more electric circuits by means of separable contacts

[SOURCE: IEC 60050-441:1984, 441-14-02, modified – The note has been deleted.]

3.1.7
switch
mechanical switch
mechanical switching device capable of making, carrying and breaking currents under normal circuit conditions which may include specified operating overload conditions and also carrying for a specified time currents under specified abnormal circuit conditions such as those of short circuit

[SOURCE: IEC 60050-441:1984, 441-14-10, modified – The note has been deleted.]

3.1.8
disconnector
mechanical switching device which in the open position complies with the requirements specified for the isolating function

[SOURCE: IEC 60050-441:1984, 441-14-05, modified – The wording of the definition has been changed and the note deleted.]

3.1.9
disconnection
interruption of an electrical circuit in a pole so as to provide insulation between the supply and those parts intended to be disconnected from the supply

3.1.10
full-disconnection
disconnection that provides the equivalent of basic insulation by contact separation

3.1.11
micro-disconnection
disconnection that provides compliance of performance by contact separation

3.1.12
isolation
isolating function
function intended to cut off the supply from all or a discrete section of the installation by separating the installation from every source of electrical energy for reasons of safety

3.2 General terms

3.2.1
ambient air temperature
temperature, determined under prescribed conditions, of the air surrounding the complete CBE

Note 1 to entry: For example, for an enclosed CBE, it is the air outside the enclosure.

[SOURCE: IEC 60050-441:1984, 441-11-13, modified –"complete switching device or fuse" has been replaced by "CBE".]

3.2.2
applied voltage
voltage which exists across the terminals of a pole of a CBE just before the making of the current

Note 1 to entry: In the case of AC, it is the RMS value.

[SOURCE: IEC 60050-441:1984, 441-17-24, modified – "switching device" has been replaced by "CBE". Note 1 to entry has been added.]

3.2.3
main circuit
<of a CBE> all the conductive parts of a CBE included in the circuit which it is designed to close and to open

[SOURCE: IEC 60050-441:1984, 441-15-02, modified – "switching device" has been replaced by "CBE".]

3.2.4
control circuit
<of a CBE> circuit (other than a path of the main circuit) intended for the closing operation or opening operation, or both, of a CBE

[SOURCE: IEC 60050-441:1984, 441-15-03, modified – "switching device" and "device" have been replaced by "CBE".]

3.2.5
auxiliary circuit
<of a CBE> all the conductive parts of a CBE intended to be included in a circuit other than the main circuit and the control circuit of the CBE

[SOURCE: IEC 60050-441:1984, 441-15-04, modified – "switching device" and "device" have been replaced by "CBE" and the note has been deleted.]

3.2.6
pole
<of a CBE> part of a CBE associated exclusively with one, electrically separated, conducting path of its main circuit provided with contacts intended to connect and disconnect the main circuit itself and excluding those portions which provide a means for mounting and operating the poles together

[SOURCE: IEC 60050-441:1984, 441-15-01, modified – "provided with contacts intended to connect and disconnect the main circuit itself" has been added, "switching device" has been replaced by "CBE" and the note has been deleted.]

3.2.7
protected pole
pole provided with an overcurrent release

Note 1 to entry: For the definition of overcurrent release, see 3.6.2.

3.2.8
unprotected pole
pole without overcurrent release but otherwise generally capable of the same performance as a protected pole of the same CBE

Note 1 to entry: For the definition of overcurrent release, see 3.6.2.

3.2.9
neutral conductor
N
conductor electronically connected to the neutral point and capable of contributing to the transmission of electrical energy

[SOURCE: IEC 60050-826:2004, 826-14-07]

3.2.10
closed position
position in which the predetermined continuity of the main circuit of a CBE is secured

[SOURCE: IEC 60050-441:1984, 441-16-22, modified – "device" has been replaced by "CBE"]

3.2.11
open position
position in which the predetermined clearance between open contacts in the main circuit of a CBE is provided

[SOURCE: IEC 60050-441:1984, 441-16-23, modified – "device" has been replaced by "CBE"]

3.2.12
incorporated mounting
method of mounting where the user provides in his or her equipment a cavity to fix the CBE in its position

3.3 Definitions related to current

3.3.1
current
flow of electric charge through a conductor

3.3.2
rated current
current assigned by the manufacturer for a specified operating condition of the CBE

3.3.3
overcurrent
current exceeding the rated current

[SOURCE: IEC 60050-441:1984, 441-11-06]

3.3.4
overload current
overcurrent that occurs in an electrically undamaged circuit

3.3.5
short-circuit current
overcurrent resulting from a fault of negligible impedance between points intended to be at different potentials in normal service

Note 1 to entry: A short-circuit current may result from a fault or from an incorrect connection.

3.3.6
conventional tripping current
I_t
specified value of current which causes a CBE to operate within a specified time (conventional time)

3.3.7
conventional non-tripping current
I_{nt}
specified value of current which a CBE is capable of carrying for a specified time (conventional time) without tripping

3.3.8
instantaneous tripping current
I_i
value of current for which a CBE will operate automatically without intentional time-delay within a time less than 0,1 s

3.3.9
instantaneous non-tripping current
I_{ni}
value of current for which a CBE will not operate automatically without intentional time-delay within a time equal to or less than 0,1 s

3.4 Definitions related to voltage

3.4.1
rated voltage
value of voltage assigned by the manufacturer to a CBE or to its components and to which operation and performance characteristics are referred

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

3.4.2
working voltage
highest value of the AC or DC voltage across any particular insulation which can occur when a CBE is supplied at rated voltage

Note 1 to entry: Transients are disregarded.

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

3.4.3
overvoltage
voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions

3.4.4
temporary overvoltage
overvoltage at power frequency of relatively long duration

3.4.5
transient overvoltage
overvoltage with a duration of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped

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

3.4.6
temporary withstand voltage
highest value of a temporary overvoltage which does not cause breakdown of insulation under specified conditions

3.5 Definitions related to constructional elements of a CBE

3.5.1
accessible part
part which can be touched in normal use

3.5.2
conductive part
part which is capable of conducting current although it may not necessarily be used for carrying service current

[SOURCE: IEC 60050-441:1984, 441-11-09]

3.5.3
exposed conductive part
conductive part which can readily be touched and which is not normally alive, but which may become alive under fault conditions

Note 1 to entry: Typical exposed conductive parts are walls of metal enclosures, metal operating handles, etc.

[SOURCE: IEC 60050-441:1984, 441-11-10, modified – Note 1 to entry has been reworded.]

3.5.4
live part
conductor or conductive part intended to be energized in normal use, including a neutral conductor, but, by convention, not a PEN conductor or a PEM conductor or a PEL conductor

Note 1 to entry: This term does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60050-826:2004, 826-12-08]

3.5.5
detachable part
part which can be removed without the aid of a general purpose tool

3.5.6
main contact
contact included in the main circuit of a CBE, intended to carry, in the closed position, the current of the main circuit

[SOURCE: IEC 60050-441:1984, 441-15-07, modified – "mechanical switching device" has been replaced by "CBE".]

3.5.7
auxiliary contact
contact included in an auxiliary circuit of a CBE and mechanically operated by the CBE

[SOURCE: IEC 60050-441:1984, 441-15-10, modified – "of a CBE" has been added and "the switching device" has been replaced by "the CBE".]

3.5.8
control contact
contact included in a control circuit of a CBE and mechanically operated by the CBE

[SOURCE: IEC 60050-441:1984, 441-15-09, modified – "mechanical switching device" and "device" have been replaced by "CBE".]

3.5.9
form A contact
make contact
control or auxiliary contact which is closed when the main contacts of a CBE are closed and open when they are open

[SOURCE: IEC 60050-441:1984, 441-15-12, modified – The term ""a" contact" has been replaced by "form A contact". "mechanical switching device" has been replaced by "CBE".]

3.5.10
form B contact
break contact
control or auxiliary contact which is open when the main contacts of a CBE are closed and closed when they are open

[SOURCE: IEC 60050-441:1984, 441-15-13, modified – The term ""b” contact" has been replaced by "form B contact". "mechanical switching device" has been replaced by "CBE".]

3.5.11
form C contact
make-break contact
control or auxiliary contact which has a make-break three-terminal changeover element

3.5.12
actuator
part of the actuating system to which an external actuating force is applied

[SOURCE: IEC 60050-441:1984, 441-15-22, modified – The note has been deleted.]

3.5.13
actuating system
<of a CBE> all the operating means of a CBE which transmit the actuating force to the contacts

3.5.14
actuating force (moment)
force (moment) applied to an actuator necessary to complete the intended operation

[SOURCE: IEC 60050-441:1984, 441-16-17, modified – "(moment)" has been added.]

3.6 Definitions related to releases in CBEs

3.6.1
release
device, mechanically connected to or integrated into a CBE, which releases the holding means and permits the automatic opening of the CBE

[SOURCE: IEC 60050-441:1984, 441-15-17, modified – "or integrated into" has been added and "mechanical switching device" has been replaced by "CBE".]

3.6.2
overcurrent release
release which causes a CBE to open, with or without time-delay, when the current in the release exceeds a predetermined value

Note 1 to entry: In some cases, this value can depend upon the rate of rise of current.

[SOURCE: IEC 60050-441:1984, 441-16-33, modified – "permits" has been replaced by "causes" and "mechanical switching device" has been replaced by "CBE".]

3.6.3
inverse time-delay overcurrent release
overcurrent release which causes a CBE to open after a time-delay inversely dependent upon the value of the overcurrent

Note 1 to entry: Such a release may be designed so that the time-delay approaches a definite minimum for high values of overcurrent.

3.6.4
direct overcurrent release
overcurrent release directly energized by the current in the main circuit of a CBE

3.6.5
instantaneous overcurrent release
overcurrent release which operates without any intentional time-delay

3.6.6
overload release
overcurrent release intended for protection against overloads

[SOURCE: IEC 60050-441:1984, 441-16-38]

3.6.7
short-circuit release
overcurrent release intended for protection against short circuits

3.6.8
shunt release
release energized by a source of voltage

Note 1 to entry: The source of voltage may be independent of the voltage of the main circuit.

Note 2 to entry: For CBEs, shunt releases independent of the main circuit may be called "relay releases".

[SOURCE: IEC 60050-441:1984, 441-16-41, modified – Note 2 to entry has been added.]

3.6.9
undervoltage release
shunt release which causes a CBE to open, with or without time-delay, when the voltage across the terminals of the release falls below a predetermined value

[SOURCE: IEC 60050-441:1984, 441-16-42, modified – "mechanical switching device" has been replaced by "CBE".]

3.6.10
zero-voltage release
shunt release which causes a CBE to open if the supply voltage falls below 0,1 times the rated voltage

3.6.11
over-voltage release
shunt release which causes a CBE to open, with or without time-delay, when the voltage across the terminals of the release rises above a predetermined value

3.6.12
thermal overload release
inverse time-delay overload release depending for its operation, including its time-delay, on the thermal action of the current flowing in the release

[SOURCE: IEC 60050-441:1984, 441-16-39]

3.6.13
magnetic overload release
overload release depending for its operation on the force exerted by the current in the main circuit exciting the coil of an electromagnet

Note 1 to entry: Such a release usually has an inverse time-delay/current characteristic.

[SOURCE: IEC 60050-441:1984, 441-16-40]

3.7 Definitions related to insulation coordination

3.7.1
functional insulation
insulation between live parts which is necessary only for the proper functioning of the equipment

3.7.2
basic insulation
insulation applied to live parts to provide basic protection against electric shock

Note 1 to entry: Basic insulation does not necessarily include insulation used for functional purposes.

3.7.3
supplementary insulation
independent insulation applied in addition to basic insulation to provide protection against electric shock in the event of failure of basic insulation

3.7.4
reinforced insulation
single insulation system, applied to live parts, which provides a degree of protection against electric shock equivalent to double insulation

Note 1 to entry: A single insulation system does not imply that the insulation must be one homogeneous piece. It may comprise several layers which can not be tested singly as basic or supplementary or reinforced insulation.

3.7.5
double insulation
insulation comprising both basic insulation and supplementary insulation

3.7.6
clearance
shortest distance in air between two conductive parts

3.7.7
clearance to earth
clearance between any conductive parts and any parts which are earthed or intended to be earthed

[SOURCE: IEC 60050-441:1984, 441-17-33]

3.7.8
clearance between open contacts
gap
total clearance between the contacts, or any conductive parts connected thereto, of a pole of a CBE in the open position

[SOURCE: IEC 60050-441:1984, 441-17-34, modified – "mechanical switching device" has been replaced by "CBE".]

3.7.9
isolating distance
<of a pole of a CBE> clearance between contacts meeting the safety requirements specified for disconnectors

[SOURCE: IEC 60050-441:1984, 441-17-35, modified – "mechanical switching device" has been replaced by "CBE".]

3.7.10
creepage distance
shortest distance along the surface of a solid insulating material between two conductive parts

[SOURCE: IEC 60050-151:2001, 151-15-50]

3.7.11
insulation coordination
mutual correlation of insulation characteristics of electrical equipment taking into account the expected micro-environment and other influencing stresses

3.7.12
impulse withstand voltage
highest peak value of an impulse voltage of prescribed form and polarity, which does not cause breakdown under specified conditions

3.7.13
power-frequency withstand voltage
RMS value of a power-frequency sinusoidal voltage which does not cause insulation breakdown under specified conditions

3.7.14
pollution
addition of foreign matter, solid, liquid or gaseous (for example, ionized gases) that may affect dielectric strength or surface resistivity of the insulation

3.7.15
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 4.6.2 of IEC 60664-1:2007).

3.7.16
overvoltage category
conventional number based on limiting or controlling the values of prospective overvoltages occurring in a circuit and depending on the means employed to influence the overvoltages

3.7.17
homogeneous field
electric field which has an essentially constant voltage gradient between electrodes (uniform field) such as that between two spheres where the radius of each sphere is greater than the distance between them

3.7.18
inhomogeneous field
electric field which does not have an essentially constant voltage gradient between electrodes (non-uniform field)

3.7.19
macro-environment
environment of the room or other location in which the equipment is installed or used

3.7.20
micro-environment
immediate environment of the insulation which particularly influences the dimensioning of creepage distances

3.8 Definitions related to operation of CBEs

3.8.1
operation
transfer of the moving contact(s) from the open position to the closed position or vice versa

Note 1 to entry: If a distinction is necessary, an operation in the electrical sense (for example, make or break) is referred to as a switching operation and an operation in the mechanical sense (for example, close or open) is referred to as a mechanical operation.

SOURCE: IEC 60050-441:1984, 441-16-01, modified – "from one position to an adjacent position" has been replaced by "from the open position to the closed position or vice versa" and Note 1 has been deleted.]

3.8.2
operating cycle
succession of operations from one position to another and back to the first position

[SOURCE: IEC 60050-441:1984, 441-16-02, modified – "through all other positions, if any" has been deleted.]

3.8.3
operating sequence
succession of specified operations with specified time intervals

[SOURCE: IEC 60050-441:1984, 441-16-03]

3.8.4
temporary duty
duty in which the main contacts of an equipment remain closed for periods insufficient to reach thermal equilibrium, the on-load periods being separated by off-load periods of sufficient duration to restore equality of temperature with the cooling medium

3.8.5
uninterrupted duty
duty in which the main contacts of a CBE remain closed whilst carrying a steady current without interruption for long periods (which could be weeks, months or even years)

3.8.6
intermittent duty
duty with on-load periods, in which the main contacts of an equipment remain closed, having a definite relationship to off-load periods, both periods being too short to allow the equipment to reach thermal equilibrium

3.8.7
closing operation
operation by which a CBE is brought from the open position to the closed position

[SOURCE: IEC 60050-441:1984, 441-16-08, modified – "device" has been replaced by "CBE".]

3.8.8
opening operation
operation by which a CBE is brought from the closed position to the open position

[SOURCE: IEC 60050-441:1984, 441-16-09, modified – "device" has been replaced by "CBE".]

3.8.9
trip-free CBE
CBE, the contacts of which return to, and remain in, the open position when the automatic opening operation is initiated after the initiation of the closing operation even if the closing command is maintained

Note 1 to entry: CBEs of this design may be referred to as positively trip-free.

[SOURCE: IEC 60050-441:1984, 441-16-31, modified – "device" has been replaced by "CBE".]

3.8.10
cycling trip-free CBE
CBE, the moving contacts of which return to the open position when the automatic opening operation is initiated after the initiation of the closing operation, and which will then reclose repeatedly and momentarily, whilst the closing command is maintained

3.8.11
non-trip-free CBE
CBE, the moving contacts of which will not open when the automatic opening operation is initiated if the closing command is maintained

Note 1 to entry: For conditions of use of non-trip-free CBEs, see 4.8.3.

3.9 Definitions related to the operating characteristic of CBEs

3.9.1
tripping time
time interval from the instant at which the associated tripping current begins to flow in the main circuit to the instant when this current is interrupted (in all poles)

3.9.2
tripping characteristic
time-current characteristic above which a CBE must have tripped

3.9.3
non-tripping characteristic
time-current characteristic below which a CBE does not trip

3.9.4
tripping zone
time-current zone limited by the characteristics of 3.9.2 and 3.9.3

Note 1 to entry: This zone takes into account the manufacturing and performance tolerances of the CBE.

3.9.5
self-resetting time
time interval from the instant at which the contacts of the main circuit open to the instant when they reclose

3.10 Definitions related to characteristic quantities

3.10.1
rated value
stated value of any one of the characteristic quantities that serve to define the working conditions for which the CBE is designed and built

3.10.2
limiting value
<in a specification> greatest or smallest admissible value of a quantity

[SOURCE: IEC 60050-151:2001, 151-16-10, modified – "component, device, equipment or system" has been deleted.]

3.10.3
rating
set of rated values and operating conditions

[SOURCE: IEC 60050-151:2001, 151-16-11]

3.10.4
prospective current
current that would flow in a circuit if each pole of a CBE were replaced by a conductor of negligible impedance

[SOURCE: IEC 60050-441:1984, 441-17-01, modified – "the switching device or the fuse" has been replaced by "a CBE".]

3.10.5
switching capacity
making and breaking capacity
value of current that a CBE is capable of making and breaking at a stated voltage under prescribed conditions of use and operation

3.10.6
short-circuit making and breaking capacity
prospective current expressed as its RMS value, which a CBE is designed to make, to carry for its opening time and to break under specified conditions

3.11 Definitions concerning coordination of CBEs and SCPDs associated in the same circuit

3.11.1
short-circuit protective device
SCPD
overcurrent protective means intended to protect a circuit or parts of a circuit against short-circuit currents by interrupting them

3.11.2
back-up protection
overcurrent coordination of two overcurrent protective devices in series where an SCPD ensures the overcurrent protection with or without the assistance of the CBE and prevents any excessive stress on the CBE under prescribed conditions

3.11.3
overcurrent discrimination
selectivity
coordination of the relevant characteristics of a CBE and its SCPD such that on the incidence of overcurrents within stated limits the CBE opens the circuit while the SCPD does not operate

[SOURCE: IEC 60050-441:1984, 441-17-15, modified – “overcurrent protective device" has been replaced by "CBE" and “SCPD".]

3.11.4
selectivity limit current
I_s
limiting value of current

– below which the CBE completes its breaking operation in time to prevent the SCPD from starting its operation (i.e. selectivity is ensured), and
– above which the CBE may not complete its breaking operation in time to prevent the SCPD from starting its operation (i.e. selectivity is not ensured)

SEE: Figure F.1.

3.11.5
conditional short-circuit current
value of short-circuit current which a CBE protected by an SCPD in series can withstand under specified conditions of use and behaviour

3.11.6
electrodynamic contact separation
lowest value of peak current which causes a contact separation while the mechanism remains closed

3.11.7
short-time withstand current
<of a CBE> value of current which a CBE can satisfactorily withstand for a specified time without suffering any damage impairing its further use

3.11.8
take-over current
current coordinate of the intersection between the tripping characteristics of two overcurrent protective devices in series for operating times greater than or equal to 0,05 s

Note 1 to entry: For operating times less than 0,05 s, the two overcurrent devices in series are considered as an association (see Annex F).

[SOURCE: IEC 60050-441:1984, 441-17-16, modified – "time-current characteristics of two overcurrent protective devices" has been replaced by "tripping characteristics of two overcurrent protective devices in series for operating times greater than or equal to 0,05 s" and Note 1 to entry has been added.]

3.12 Definitions related to terminals and terminations

3.12.1
termination
connection between two or more conductive parts which can only be made by a special process

Note 1 to entry: The special process may be welding, soldering or the preparation of the conductors by a special purpose tool.

3.12.2
terminal
conductive part of a device provided for re-usable electrical connection without the use of a special process

3.12.2.1
terminal for unprepared conductors
terminal which does not require a special preparation of the conductor other than stripping and reshaping the conductor before its introduction into the terminal or the twisting of a stranded conductor to consolidate the end

3.12.2.2
terminal for prepared conductors
terminal which requires special preparation of the conductor such as the use of cable lugs, eyelets or similar devices

3.12.2.3
terminal for internal conductors
factory-wiring terminal
terminal for the connection of internal conductors of the equipment

Note 1 to entry: CBEs are normally, but not necessarily, provided with terminals for internal conductors.

3.12.3
screw-type terminal
terminal for the connection and subsequent disconnection of a conductor or the interconnection of two or more conductors capable of being dismantled, the connection being made, directly or indirectly, by means of screws or nuts of any kind

3.12.4
pillar terminal
screw-type terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw(s)

Note 1 to entry: The clamping pressure may be applied direct by the shank of the screw or through an intermediate clamping element to which pressure is applied by the shank of the screw.

Note 2 to entry: Examples of pillar terminals are shown in Annex E.

3.12.5
screw terminal
screw-type 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.

Note 2 to entry: Examples of screw terminals are shown in Annex E.

3.12.6
stud terminal
screw-type terminal in which the conductor is clamped under a nut

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

Note 2 to entry: Examples of stud terminals are shown in Annex E.

3.12.7
saddle terminal
screw-type terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts

Note 1 to entry: Examples of saddle terminals are shown in Annex E.

3.12.8
lug terminal
screw terminal or a stud terminal, designed for clamping a cable lug or a bar by means of a screw or nut

Note 1 to entry: Examples of lug terminals are shown in Annex E.

3.12.9
screwless terminal
terminal for the connection and/or interconnection and subsequent disconnection of one or more conductors, the connection being made, directly or indirectly, by means other than screws

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

– terminals requiring fixing of special devices to the conductors before clamping them into terminals, for example flat quick-connect terminals;

– 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.

Examples of screwless terminals are shown in Figures E.5 to E.14.

3.12.9.1
universal screwless terminal
screwless terminal intended for the connection of all types of conductors

3.12.9.2
non-universal screwless terminal
screwless terminal intended for the connection of certain types of conductors only

EXAMPLES push-wire clamping unit for solid conductors only; push-wire clamping unit for rigid solid and rigid stranded conductors only

3.12.10
flat quick-connect termination
electrical connection consisting of a male tab and a female connector which can be inserted and withdrawn without the use of a tool

3.12.11
male tab
portion of a quick-connect termination which receives the female connector

Note 1 to entry: Examples of male tabs are shown in Figure E.6.

3.12.12
female connector
portion of a quick-connect termination which is pushed onto the male tab

Note 1 to entry: An example of a female connector is shown in Figure E.14.

3.12.13
detent
dimple (depression) or hole in the male tab which engages a raised portion on the female connector to provide a latch for the mating parts

3.12.14
solder termination
conductive part of a CBE provided to enable a termination to be made by means of soldering

3.12.15
external conductor
field-wiring conductor
cable, cord, core or conductor, a part of which is external to equipment in or on which the CBE is mounted

3.12.16
integrated conductor
conductor which is used to permanently interconnect parts of a CBE

3.12.17
internal conductor
factory-wiring conductor
any cable, cord, core or conductor, which is internal to equipment but is neither an external nor an integrated conductor

3.12.18
tapping screw
screw manufactured from a material having a greater resistance to deformation when applied by rotary insertion to a hole in a material having a lesser resistance to deformation

Note 1 to entry: The screw is made with a tapered thread, the taper being applied to the core diameter of the thread at the end section of the screw. The thread produced by application of the screw is formed securely only after sufficient revolutions have been made to exceed the number of threads on the tapered section.

3.12.19
thread-forming screw
tapping screw having an uninterrupted thread

Note 1 to entry: It is not a function of this thread to remove material from the hole.

Note 2 to entry: An example of a thread-forming screw is shown in Figure 1.

3.12.20
thread-cutting screw
tapping screw having an interrupted thread

Note 1 to entry: The thread is intended to remove material from the hole.

Note 2 to entry: An example of a thread-cutting screw is shown in Figure 2.

3.13 Definitions related to tests

3.13.1
type test
test of one or more devices made to a certain design to show that the design meets certain specifications

3.13.2
routine test
test to which each individual device is subjected during and/or after manufacture to check whether its complies with certain criteria

3.13.3
special test
test, additional to type tests and routine tests, made either at the discretion of the manufacturer or according to an agreement between manufacturer and user

4 Classification

4.1 General

CBEs are classified according to the criteria given in 4.2 to 4.11.

4.2 Quantity of poles

– the number of poles;
– the number of protected poles.

NOTE The pole which is not a protected pole can be an unprotected pole or a switched neutral.

4.3 Method of mounting

– surface type;
– flush type;
– panel-mounting type;
– integral-mounting type.

NOTE 1 Panel-mounting types comprise snap-on types and flange types.

NOTE 2 Integral-mounting types are types which are kept in place by fixation means and do not require any other mounting means.

4.4 Method of connection

– CBEs, the connections of which are not associated with the mechanical mounting;

– CBEs, one or more connections of which are associated with the mechanical mounting, for example:

- plug-in type;
- bolt-on type;
- screw-in type;
- solder-in type.

NOTE Some CBEs can be of the plug-in type or bolt-on type on the line side only, the load terminals being usually suitable for wiring connection.

4.5 Method of operation

4.5.1 CBEs for automatic interruption and non-automatic (manual) resetting only (R-type).

4.5.2 CBEs for automatic interruption and non-automatic (manual) resetting, provided with means for manual operation designed for occasional manual switching, but not designed for regular manual switching operations under normal load conditions (M-type).

4.5.3 CBEs for automatic interruption and non-automatic (manual) resetting, provided with means for manual operations and designed for regular manual switching operations under normal load conditions (S-type) (see note of 5.2.3).

4.5.4 CBEs for automatic interruption and automatic resetting (J-type).

J-type CBEs can be provided with means for manual operation also. In this case, the relevant requirements concerning the other types are applicable.

4.6 Mode of tripping

4.6.1 CBEs tripping by current (overcurrent)

Mode of tripping	*Designation*
– thermal	TO
– thermal-magnetic	TM
– magnetic	MO
– hydraulic-magnetic	HM
– electronic-hybrid	EH

NOTE Electronic-hybrid type means an electronically controlled device associated with any of the other modes of tripping.

4.6.2 CBEs tripping by voltage

Mode of tripping	*Designation*
– overvoltage	OV
– undervoltage	UV

4.7 Influence of the ambient temperature

4.7.1 CBEs, the operation of which is temperature dependent.

4.7.2 CBEs, the operation of which is not temperature dependent.

4.8 Trip-free behaviour

4.8.1 Trip-free (positively trip-free).

4.8.2 Cycling trip-free.

4.8.3 Non-trip-free. CBEs of the non-trip-free type are not intended to be used for short-circuit duty.

4.9 Influence of the mounting position

4.9.1 Independent of the mounting position.

4.9.2 Dependent on the mounting position.

4.10 Electrical performance

4.10.1 For general use, including inductive circuits.

4.10.2 For use in substantially resistive circuits only.

4.11 Suitability for isolation

– not suitable for isolation;
– suitable for isolation (see Annex K).

5 Characteristics of CBEs

5.1 List of characteristics

The characteristics of a CBE shall be stated in the following terms, as applicable:

– number of poles, protected poles (see 4.2) and neutral path if any;
– method of mounting (see 4.3);
– method of connection (see 4.4);
– method of operation (see 4.5);
– rated quantities (see 5.2);
– operating characteristics (see 3.9).

5.2 Rated quantities

5.2.1 General

Rated quantities are specified in 5.2.2 to 5.2.7. Unless otherwise specified, all values of current and voltage are RMS values.

5.2.2 Rated voltages

5.2.2.1 General

A CBE is defined by the rated voltages defined in 5.2.2.2 to 5.2.2.5.

5.2.2.2 Rated operational voltage of a CBE (U_e)

The rated operational voltage (hereinafter referred to as "rated voltage") of a CBE is the value of voltage to which the performance is referred.

NOTE The same CBE can be assigned a number of rated voltages and associated rated switching capacities (see 5.2.5).

5.2.2.3 Rated insulation voltage (U_i)

The rated insulation voltage of a CBE is the value of voltage to which dielectric tests, clearances and creepage distances are referred.

Unless otherwise stated, the rated insulation voltage is the value of the maximum rated voltage of the CBE. In no case shall the maximum rated voltage exceed the rated insulation voltage.

5.2.2.4 Rated impulse withstand voltage (U_{imp})

The peak value of an impulse voltage of prescribed form and polarity which the CBE is capable of withstanding without failure under specified conditions of test and to which the values of the clearances are referred.

The rated impulse withstand voltage of an equipment shall be equal to or higher than the values stated for the transient overvoltages occurring in the circuit in which the equipment is fitted.

The correlations between the rated voltages of supply systems and the rated impulse withstand voltages are given in Annex H.

Impulse withstand test voltages for the verification of the insulation coordination are given by Table 21.

5.2.2.5 Rated voltage of undervoltage and zero voltage releases (U_n)

The rated voltage of undervoltage and/or zero voltage releases with respect to the value of voltage to which the performance is referred.

5.2.3 Rated current (I_n)

A current assigned by the manufacturer (in accordance with Table 11 or Table 12 according to the declared performance) as the current which the CBE is designed to carry in uninterrupted duty (see 3.8.5) at a specified reference ambient air temperature.

The standard reference ambient air temperature is (23 ± 2) °C.

If the reference ambient air temperatures are different from the standard value, the derating factor as given in the manufacturer's literature shall be applied (see 7.2).

NOTE For S-type CBEs, a rated current different from that assigned in accordance with Table 11 can be stated by the manufacturer for inductive loads.

5.2.4 Rated frequency

The power frequency for which the CBE is defined and to which the values of the other characteristics correspond.

5.2.5 Rated switching capacity (rated making and breaking capacity)

The value of switching capacity (see 3.10.5) assigned to the CBE by the manufacturer.

NOTE It is expressed by a value of current (RMS if AC).

5.2.6 Rated conditional short-circuit current (I_{nc})

5.2.6.1 General

The value of the conditional short-circuit current (see 3.11.5) if assigned to the CBE by the manufacturer.

NOTE 1 For the purpose of this document, two categories of performance are specified (see 5.2.6.2 and 5.2.6.3).

NOTE 2 The manufacturer can decide not to assign a value of I_{nc} to the CBE, in which case the relevant tests are omitted.

5.2.6.2 Rated conditional short-circuit current performance category PC1 (I_{nc1})

The value of rated conditional short-circuit current, if assigned by the manufacturer, for which the prescribed conditions do not include the fitness of the CBE for its further use. See 9.12.4.2.

5.2.6.3 Rated conditional short-circuit current, performance category PC2 (I_{nc2})

The value of rated conditional short-circuit current, if assigned by the manufacturer, for which the prescribed conditions do include the fitness of the CBE for its further use. See 9.12.4.3.

5.2.7 Rated short-circuit capacity (I_{cn})

The rated short-circuit capacity of a CBE is the value of current assigned to the CBE by the manufacturer, according to 3.10.6.

The rated short-circuit capacity shall not be less than

– 6 I_n for AC,
– 4 I_n for DC.

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage

Preferred values of rated voltage are as follows.

– AC:

60 V, 120 V, 240 V/120 V, 220 V, 230 V, 240 V, 380 V/220 V, 400 V/230 V, 415 V/240 V, 380 V, 400 V, 415 V, 440 V;

NOTE In IEC 60038, the network voltage value of 400 V/230 V AC has been standardized. This value will progressively replace the values 380V /220 V and 415 V/240 V.

– DC:

12 V, 24 V, 48 V, 60 V, 120 V, 240 V, 250 V.

5.3.2 Standard rated frequencies

Standard rated frequencies are: 50 Hz, 60 Hz and 400 Hz.

5.3.3 Standard values of rated conditional short-circuit current

Standard values of rated conditional short-circuit current are:

300 A, 600 A, 1 000 A, 1 500 A, 3 000 A.

6 Marking and other product information

Each CBE shall be marked in a durable manner with the following:

a) manufacturer's name or trade mark;

b) type designation or serial number;

c) rated voltage(s);

d) rated current (coded reference is permissible: for example, current value without the symbol A, following the type designation);

If the CBE is intended for resistive load only, this shall be stated in the manufacturer's catalogue.

e) rated frequency, if the CBE is designed for a frequency other than both 50 Hz and 60 Hz;

f) reference ambient air temperature for CBEs calibrated for a reference ambient air temperature different from the standard value (see 5.2.3) – for example, T40 for a reference ambient air temperature of 40 °C;

g) operating voltage limit(s) (of a voltage-sensitive CBE);

h) the symbol μ, if the CBE is of a type with a contact gap less than the specified clearance;

i) method of operation R, M, S or J (see 4.5);

k) mode of tripping (see 4.6);

l) degree of trip-free behaviour (see 4.8);

m) overvoltage category, if different from II; and pollution degree, if different from 2 (see 8.1.3);

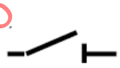
n) rated conditional short-circuit current, performance category PC1 (I_{nc1});

o) rated conditional short-circuit current, performance category PC2 (I_{nc2}), if relevant;

p) rated impulse withstand voltage;

q) rated short-circuit capacity I_{cn}, if applicable (see 5.2.6);

r) self-resetting time;

s) symbol of suitability for isolation  (IEC 60417-6169-1:2012-08, modified) on the device, when applicable.

If, on small apparatus, the available space is insufficient for all the listed markings, at least a), b) and, if applicable, g), h) and s) shall be marked on the device, and, if possible, c) and d), whilst the other information shall be given in the manufacturer's catalogue.

NOTE Visibility from the front – though desirable – is not compulsory for CBEs, because CBEs are specified by OEMs for their equipment on the basis of the information provided by the CBE manufacturers. Due to lack of space on the usually small CBEs, it may not be possible to have the marking on the front part visible after installation. If the CBE is not marked on a visible position the manufacturer can inform the OEM to mark his equipment accordingly.

The manufacturer shall declare the conditions for the installation of CBEs (especially CBEs classified to 4.8.3) in his catalogue, where applicable.

For CBEs other than those operated by means of push-buttons, the open position shall be indicated by the symbol ○ (IEC 60417-5008:2002-10) and the closed position by the symbol | (IEC 60417-5007:2002-10).

For CBEs operated by means of two push-buttons, the push-button designed for the opening operation only shall be red and/or be marked with the symbol ○.

National symbols additional to ○ and | are acceptable.

Red shall not be used for any other push-button, but may be used for other types of actuators, for example, handles, rockers, provided the ON and OFF positions are clearly identified.

If it is necessary to distinguish between the supply and the load terminals, the former shall be indicated by arrows pointing towards the CBE and the latter by arrows pointing away from the CBE.

Other national or international indications, for example 1, 3, 5 for the supply terminals and 2, 4, 6 for the load terminals, are acceptable.

Terminals intended exclusively for the neutral shall be indicated by the letter "N".

Terminals intended for the protective conductor, if any, shall be indicated by the symbol ⏚ (IEC 60417-5019:2002-10).

Compliance is checked by inspection and by the test of 9.3.

Wherever possible, CBEs shall be provided with a wiring diagram unless the correct mode of connection is evident.

On the wiring diagram, the terminals shall be indicated by the symbol ○ (IEC 60617-S00017:2001-07).

The marking shall be durable and easily legible, and shall not be placed on screws, washers or other removable parts.

7 Standard conditions for operation in service

7.1 General

CBEs complying with this document shall be capable of operating under the following standard conditions.

7.2 Ambient air temperature

7.2.1 Reference ambient air temperature T for calibration

The standard value of the reference ambient air temperature is (23 ± 2) °C.

CBEs may, however, be calibrated for a different reference ambient air temperature of T °C. In this case, they shall be marked in accordance with Clause 6 f).

7.2.2 Limits of ambient air temperature for operation in service

For standard conditions (reference ambient air temperature T = 23 °C), the ambient air temperature does not exceed +40 °C and its average over a period of 24 h does not exceed +35 °C. The lower limit of the ambient air temperature is –5 °C.

For CBEs with a reference ambient air temperature T exceeding 23 °C, the upper limit is assumed to be (T + 10) °C. The lower limits shall be taken from the information provided by the manufacturer.

7.3 Altitude

The altitude of the site of installation does not exceed 2 000 m (6 600 ft).

For installations at higher altitudes, it is necessary to take into account the reduction of the dielectric strength and of the cooling effect of the air.

CBEs intended to be so used shall be specially designed, or used according to an agreement between manufacturer and user.

Information given in the manufacturer's catalogue may take the place of such an agreement.

7.4 Atmospheric conditions

The air is clean and its relative humidity does not exceed 50 % at a maximum temperature of +40 °C. Higher relative humidities may be permitted at lower temperatures, for example, 90 % at +20 °C.

Care should be taken by appropriate means (for example draining holes) of moderate condensation which may occasionally occur due to variations in temperature.

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 General

A CBE shall be so designed and constructed that, in normal use, its performance is reliable and without danger to the user or surroundings.

In general, this is checked by carrying out all the relevant tests specified.

8.1.2 Mechanism

The moving contacts of a multi-pole CBE shall be mechanically coupled in such a way that all protected and unprotected poles make and break substantially together, whether operated manually or automatically, even if an overload occurs on one pole only. The manufacturer shall indicate in his literature if a CBE is trip-free, cycling trip-free or non-trip-free.

A CBE, with the exception of J-type CBEs without means for manual operation, shall be provided with means for indicating its closed and open positions which shall be easily discernible when fitted with its cover(s) or cover-plate(s), if any. When the operating means is used to indicate the position of the contacts, it shall have two distinct rest positions corresponding to the position of the contacts, and the operating means, when released, shall automatically take up the position corresponding to that of the moving contacts; for automatic opening, a third distinct position of the operating means may be provided.

The action of the mechanism shall not be influenced by the position of enclosures or covers and shall be independent of any removable part.

Operating means shall be securely fixed on their shafts and it shall not be possible to remove them without the aid of a tool. Operating means directly fixed to covers are allowed.

Compliance with the above requirements is checked by inspection and by manual test.

Additional requirements for the mechanism of CBEs suitable for isolation are given in K.8.1.2.

8.1.3 Clearances and creepage distances (see Annex B)

8.1.3.1 General

CBEs shall be so constructed that the clearances and creepage distances are adequate to withstand the electrical, mechanical and thermal stresses taking into account the environmental influences that may occur during the anticipated life of the CBE.

NOTE 1 The requirements and tests are based on IEC 60664-1.

It is assumed that for CBEs the following conditions are generally applicable:

– overvoltage category II;
– pollution degree 2.

NOTE 2 CBEs can be designed for other overvoltage categories and pollution degrees.

NOTE 3 A creepage distance cannot be less than the associated clearance so that the shortest creepage distance possible is equal to the required clearance.

Additional requirements for clearance and creepage distances for CBEs suitable for isolation are given in K.8.1.3.

8.1.3.2 Clearances

8.1.3.2.1 General

The clearances of the CBE shall be dimensioned to withstand the rated impulse withstand voltage declared by the manufacturer according to 5.2.2.4, taking into account the rated voltage and the overvoltage category as shown by Table H.1.

Dimensions according to Table 1 are deemed to meet the impulse withstand voltage test.

NOTE Correlations between rated voltages of supply systems and the line-to-neutral voltage relevant for determining the rated impulse voltage are given in Annex H.

8.1.3.2.2 Clearances for basic insulation

The clearances for basic insulation shall not be less than the values shown in Table 1. Smaller clearances may be used, if the CBE meets the impulse withstand voltage test in 9.7.6 but only if the parts are rigid or located by mouldings or if the construction is such that there is no likelihood of the distance being reduced by distortion, by movement of the parts or during mounting, connection and service in normal use to a value so that the CBE no longer complies with the impulse withstand voltage test.

Compliance is checked by measurement or, if necessary, by the test of 9.7.6.

8.1.3.2.3 Clearances for functional insulation

The clearances for functional insulation shall not be less than those specified in Table 1. Smaller clearances may be used under the conditions prescribed for basic insulation.

Compliance is checked by measurement or, if necessary, by the test of 9.7.6.

8.1.3.2.4 Clearances for supplementary insulation

The clearances for supplementary insulation shall not be less than those specified for basic insulation in 8.1.3.2.2 except that smaller clearances than those given in Table 1 are not allowed.

Compliance is checked by measurement.

NOTE Supplementary insulation is used in conjunction with basic insulation.

8.1.3.2.5 Clearances for reinforced insulation

Clearances for reinforced insulation shall not be less than those specified in Table 1.

Compliance is checked by measurement.

Table 1 – Minimum clearances for basic and reinforced insulation

Rated impulse withstand voltage	Minimum clearance [d] mm					
	For basic insulation pollution degree			For reinforced insulation pollution degree		
V [a]	1	2 (see 8.1.3)	3	1	2 (see 8.1.3)	3
330	0,01	0,2 [b,c]	0,8 [c]	0,04	0,2 [b,c]	0,8 [c]
500	0,04	0,2 [b,c]	0,8 [c]	0,10	0,2 [b,c]	0,8 [c]
800	0,10	0,2 [b,c]	0,8 [c]	0,5	0,5	0,8 [c]
1 500	0,5	0,5	0,8 [c]	1,5	1,5	1,5
2 500	1,5	1,5	1,5	3	3	3
4 000	3	3	3	5,5	5,5	5,5
6 000	5,5	5,5	5,5	8	8	8

[a] This voltage is

– for functional insulation: the maximum impulse voltage expected to occur across the clearance;

– for basic insulation directly exposed to, or significantly influenced by, transient overvoltage from the low-voltage supply: the rated impulse withstand voltage of the CBE;

– for basic insulation not directly exposed to, or significantly influenced by, transient overvoltage from the low-voltage supply: the highest impulse voltage that can occur in the circuit.

[b] For printed wiring material within the CBE, the values for pollution degree 1 apply, except that the value shall not be less than 0,04 mm.

[c] Minimum clearance values based on experience rather than on fundamental data.

[d] CBEs with a contact gap less than the specified minimum clearance are permitted but shall be marked with the symbol µ.

8.1.3.2.6 Clearances across micro-disconnection

Clearances across micro-disconnection shall be dimensioned to withstand temporary overvoltages (see 3.4.4).

Compliance is checked by the test of 9.11.1.3.

8.1.3.2.7 Clearances across full-disconnection

Clearances across full-disconnection shall be dimensioned to withstand transient overvoltages. They shall not be less than those specified in Table 1 for basic insulation. Smaller distances may be used if the CBE after the tests of 9.9 and 9.11 is capable to withstand the test voltage appropriate to the impulse withstand voltage test across the open contacts.

Compliance is checked by measurement or by the test of 9.7.6.

8.1.3.3 Creepage distances

8.1.3.3.1 General

The creepage distances of the CBE shall not be less than those appropriate for the voltage which is expected to occur in normal use, taking into account the material group and the pollution degree.

8.1.3.3.2 Creepage distances for basic insulation

Creepage distances for basic insulation shall not be less than those specified in Table 2.

NOTE Creepage distances cannot be less than the associated clearance.

The relationship between material group and proof tracking index (PTI) values is as follows:

Material group I	600	≤	PTI		
Material group II	400	≤	PTI	<	600
Material group III a	175	≤	PTI	<	400
Material group III b	100	≤	PTI	<	175

For printed circuit materials comparative tracking index (CTI) values apply.

NOTE The CTI values are obtained in accordance with IEC 60112, using solution A.

Compliance is checked by measurement.

8.1.3.3.3 Creepage distances for functional insulation

Creepage distances for functional insulation shall not be less than those specified in Table 2.

Compliance is checked by measurement.

NOTE For glass, ceramics and other inorganic materials, which are not subject to tracking, creepage distances need not be greater than their associated clearance.

Table 2 – Minimum creepage distances

Working voltage across creepage distance	**Printed circuit boards** [f] **Pollution degree**		**Minimum creepage distance for basic insulation** **Pollution degree** [e]							
	1 [b]	**2** [c]	**1** [b]	**2** (see 8.1.3)			**3**			
				Material group			**Material group**			
				I	**II**	**III** [d]	**I**	**II**	**III** [d]
V	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	0,025	0,04	0,08	0,04	0,04	0,04	1,0	1,0	1,0
12,5	0,025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,025	0,04	0,10	0,45	0,45	0,45	1,1	1,1	1,1
20	0,025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0,025	0,04	0,125	0,50	0,50	0,50	1,25	1,25	1,25
32	0,025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0,025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0,025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,04	0,063	0,20	0,63	0,9	1,25	1,6	1,8	2,0
80	0,063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,1	0,16	0,25	0,71	1,0	1,4	1,8	2,0	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,4	0,32	0,8	1,1	1,6	2,0	2,2	2,5
200	0,4	0,63	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,0	0,56	1,25	1,8	2,5	3,2	3,6	4,0

320	0,75	1,6	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500[a]	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0

[a] For higher working voltages, the values of Table 4 of IEC 60664-1:2007 apply.

[b] Material groups I, II, III a and III b.

[c] Material groups I, II, III a.

[d] Material group III includes III a and III b.

[e] Within the CBE, micro-environment is deemed to apply.

[f] For printed circuit boards with coating complying with IEC 60664-3, these values need not be applied.

8.1.3.3.4 Creepage distances of supplementary insulation

Creepage distances of supplementary insulation shall not be less than those specified for basic insulation.

Compliance is checked by measurement.

8.1.3.3.5 Creepage distances for reinforced insulation

Creepage distances for reinforced insulation shall not be less than twice those specified for basic insulation.

Compliance is checked by measurement.

8.1.4 Screws, current-carrying parts and connections

8.1.4.1 Connections, whether electrical or mechanical, shall withstand the mechanical stresses occurring in normal use.

Screwed connections are considered as checked by the tests of 9.8, 9.9, 9.11, 9.13 and 9.14.

8.1.4.2 Electrical connections shall be so designed that contact pressure is not transmitted through insulating material other than ceramic, pure mica or other material with characteristics no less suitable, unless there is sufficient resilience in the metal parts to compensate for any possible shrinkage or yielding of the insulating material.

Compliance is checked by inspection.

NOTE The suitability of the material is assessed with respect to dimensional stability.

8.1.4.3 Current-carrying parts and contacts intended for protective conductors shall be either of

– copper;

– an alloy containing at least 58 % copper for parts worked cold, or at least 50 % copper for other parts; or

– other metal or suitably coated metal, no less resistant to corrosion than copper and having mechanical properties no less suitable.

NOTE New requirements, to be verified by a test for determining the resistance to corrosion, are under consideration. These requirements should permit other materials to be used if suitably coated.

This requirement does not apply to contacts, magnetic circuits, heater elements, bimetals, shunts, parts of electronic devices nor to screws, nuts, washers, clamping plates and similar parts of terminals.

8.1.5 Screw-type and screwless terminals

8.1.5.1 Terminals shall be such that the conductors may be connected so as to ensure that the necessary contact pressure is available.

Compliance is checked by inspection and by the test of 9.5.2.

8.1.5.2 Terminals shall be fixed in such a way that the terminal will not work loose when the conductor is connected or disconnected.

Compliance is checked by inspection, by measurement and by the test of 9.4.1.

8.1.5.3 Terminals for connection of external conductors (see 3.12.15) shall allow the connection of copper conductors having nominal cross-sectional areas as shown in Table 3.

Terminals for conductors, internal conductors (see 3.12.17) and integrated conductors (see 3.12.16) shall allow the connection of copper conductors of the largest and smallest diameters specified by the manufacturer shall be used. If not specified, Table 3 is applicable.

Examples of possible shapes and possible dimensions of terminals are shown in Annex E.

Compliance is checked by inspection and by fitting conductors of the declared types with the smallest and largest cross-sectional areas specified.

Table 3 – Connectable cross-sectional areas of external copper conductors for screw-type and screwless terminals

Rated current A	Range of nominal cross-sections to be clamped[a] mm²		
Up to and including 6	0,5	to	1,0
Above 6 up to and including 13	0,75	to	1,5
Above 13 up to and including 20	1,0	to	2,5
Above 20 up to and including 25	1,5	to	4
Above 25 up to and including 32	2,5	to	6
Above 32 up to and including 50	4	to	10
Above 50 up to and including 63	6	to	16
Above 63 up to and including 80	10	to	25
Above 80 up to and including 100	16	to	35
Above 100 up to and including 125	25	to	50

[a] Accommodation of lower and higher cross-sectional areas is permitted.

8.1.5.4 Terminals for unprepared copper conductors which are suitable for connection of (external) flexible conductors shall be located or shielded so that, if a wire of a flexible conductor escapes from a terminal when the conductors are fitted, there is no risk of contact between live parts and accessible metal parts, and, for CBEs for class II appliances, between live parts and metal parts separated from accessible metal parts by supplementary insulation only.

Compliance is checked by inspection and by the test of 9.5.

8.1.5.5 The means for clamping the conductors in the terminals shall not serve to fix any other component, although they may hold the terminals in place or prevent them from turning.

Compliance is checked by inspection and by the test of 9.5.1.

8.1.5.6 Terminals shall be so designed that the insertion of the conductor is prevented by a stop if further insertion may reduce the creepage distance and/or clearances or influence the mechanism of the CBE.

Compliance is checked by inspection.

8.1.5.7 Terminals shall be so designed that they clamp the conductor without undue damage to the conductor itself.

Compliance is checked by inspection and by the test of 9.5.3.

8.1.5.8 Terminals shall be so designed that they make connection reliably between metal surfaces and without undue damage to the conductor.

Compliance is checked by inspection and by the tests of 9.4 and 9.5.

8.1.5.9 Terminals shall clamp the conductor between metal surfaces, except that for terminals intended to be used in circuits carrying a current not exceeding 0,2 A, one of the surfaces may be non-metallic.

8.1.5.10 Terminals for rated currents up to and including 32 A, intended for connection of external conductors, shall allow the connection of unprepared copper conductors.

Compliance is checked by inspection.

8.1.5.11 Terminals for prepared copper conductors shall be suitable for their purpose when the connection is made as specified by the manufacturer in his literature.

Compliance is checked by inspection and by the test of 9.5.4.

8.1.5.12 Screw-type terminals shall have adequate strength. Screws and nuts for clamping the conductors shall have a metric ISO thread or a thread comparable in pitch and mechanical strength.

Compliance is checked by inspection and by the tests of 9.4 and 9.5.2.

NOTE Provisionally, SI, BA and UN threads can be used as they are considered as practically equivalent in pitch and mechanical strength to metric ISO thread.

8.1.5.13 Clamping screws or nuts of terminals intended for connection of protective conductors shall be adequately secured against accidental loosening.

Compliance is checked by inspection and by the test of 9.5.1.

In general, the designs of terminals according to Figures E.1 to E.4 provide sufficient resilience to comply with this requirement. For other designs, special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, may be necessary.

8.1.5.14 Screws and nuts of terminals intended for connection of external conductors shall be in engagement with a metal thread and the screw shall not be of the tapping type.

8.1.5.15 For pillar terminals, the distance between the clamping screw and the end of the conductor when fully inserted shall be at least as specified in Table 4.

The minimum distance between the clamping screw and the end of the conductor applies only to pillar terminals in which the conductor cannot pass right through.

Table 4 – Minimum distance between clamping screw and the end of conductor when fully inserted

Rated current A	Minimum values mm With one clamping screw	Minimum values mm With two clamping screws
Up to and including 6	1,5	1,5
Above 6 up to and including 13	1,5	1,5
Above 13 up to and including 20	1,8	1,5
Above 20 up to and including 25	1,8	1,5
Above 25 up to and including 32	2,0	1,5
Above 32 up to and including 50	2,5	2,0
Above 50 up to and including 80	3,0	2,0
Above 80 up to and including 100	4,0	3,0
Above 100 up to and including 125	Under consideration	Under consideration

Compliance is checked by measurement after a solid conductor of the largest cross-sectional area specified by the manufacturer has been fully inserted and clamped with the torque indicated in Table 15.

8.1.5.16 Screwless terminals (see Figure E.5), unless otherwise specified by the manufacturer, shall accept conductors as indicated in Table 3, in which case no marking is necessary.

If a screwless terminal can accept only solid conductors, this shall be either clearly marked on the end product, for connecting purposes, by "sol", or indicated on the smallest package unit, or in technical information and/or catalogues of the manufacturer.

If a screwless terminal can accept only rigid (solid and stranded) conductors, this shall be either clearly marked on the end product, for connecting purposes, by the letter "r", or indicated on the smallest package unit or in technical information and/or catalogues of the manufacturers.

Compliance is checked by inspection and by the test of 9.4.1.

8.1.5.17 Screwless terminals shall withstand the mechanical stress occurring in normal use. The connection or disconnection of conductors shall be made as follows:

– on universal terminals, by the use of a general purpose tool or by the device integral with the terminal and designed for being open for the insertion or withdrawal of the conductors;

– on push wire terminals, by simple insertion. For the disconnection of the conductors, an operation other than a pull on the conductor shall be necessary.

The use of a general purpose tool or a convenient device, integral with the terminal, is allowed in order to "open" it and to assist the insertion or the withdrawal of the conductor.

Compliance is checked by inspection and by the test of 9.4.

8.1.5.18 Screwless terminals shall allow the proper connection of conductors.

The manner of insertion and disconnection of the conductors shall be obvious, or instructions shall be provided by the manufacturer.

NOTE Examples of screwless terminals are shown in Figure E.5.

The intended disconnection of the conductor shall require an operation, other than a pull at the conductor, such that it can be effected manually with or without the help of a tool in normal use.

Openings for the use of a tool intended to assist the insertion or disconnection shall be clearly distinguishable from the opening for the conductor.

Compliance is checked by inspection, by measurement and by insertion of the appropriate flexible and/or rigid conductors of cross-sectional areas according to Table 3.

8.1.5.19 Screwless terminals intended to be used for the interconnection of more than one conductor shall be designed so that, after the insertion, the operation of the clamping means of one of the conductors is independent of the operation of the clamping means of the other conductor. During the disconnection, the conductors may be disconnected either simultaneously or separately.

Compliance is checked by inspection and by tests with any combination as specified by the manufacturer.

8.1.6 Solder terminations

8.1.6.1 Solder terminations shall have sufficient solderability.

Compliance is checked by applying the test of 9.4.2.1.

8.1.6.2 Material adjacent to the solder terminations shall have sufficient resistance to soldering heat.

Compliance is checked by applying the test of 9.4.2.2.

8.1.6.3 Solder terminations shall be provided with means for mechanically securing the conductor in position independently of the solder.

Such means may be provided by

– a hole suitable for hooking in the conductor;
– shaping the edges of the terminal to allow the conductor to be wrapped around the terminal before soldering;
– a clamping means adjacent to the solder connection.

NOTE Solder terminations for connection on printed circuit boards are not considered in this document.

Compliance is checked by inspection.

8.1.7 Flat quick-connect male tabs (Figures E.6 to E.13)

8.1.7.1 Male tabs shall comply with the dimensions of Tables 5, 6 and 7.

Table 5 – Dimensions of tabs in millimetres – Dimensions *A*, *B*, *C*, *D*, *E*, *F*, *J*, *M*, *N*, *P* and *Q*

Nominal size		*A*	*B* min	*C*	*D*	*E*	*F*	*J* [a]	*M*	*N*	*P*	*Q* min
2,8 × 0,5	dimple	0,6 0,3	7,0	0,54 0,47	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°	1,7 1,4	1,4 1,0	1,4 0,3	8,1
	hole	0,6 0,3	7,0	0,54 0,47	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°			1,4 0,3	8,1
2,8 × 0,8	dimple	0,6 0,3	7,0	0,84 0,77	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°	1,7 1,4	1,4 1,0	1,4 0,3	8,1
	hole	0,6 0,3	7,0	0,84 0,77	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°			1,4 0,3	8,1
4,8 × 0,8	dimple	1,0 0,7	6,2	0,84 0,77	4,80 4,60	2,8 2,3	1,5 1,3	12° 8°	1,7 1,4	1,5 1,2	1,8 0,7	7,3
	hole	1,0 0,6	6,2	0,84 0,77	4,90 4,67	3,4 3,0	1,5 1,3	12° 8°			1,8 0,7	7,3
6,3 × 0,8	dimple	1,0 0,7	7,8	0,84 0,77	6,40 6,20	4,1 3,6	2,0 1,6	12° 8°	2,5 2,2	2,0 1,8	1,8 0,7	8,9
	hole	1,0 0,5	7,8	0,84 0,77	6,40 6,20	4,7 4,3	2,0 1,6	12° 8°			1,8 0,7	8,9
9,5 × 1,2	hole	1,3 0,7	12,0	1,23 1,17	9,60 9,40	5,5 4,5	2,0 1,7	14° 6°			2,0 1,0	13,1

[a] The soldering of wires to the tab and the relevant dimensional modifications, if necessary, are under consideration.

Table 6 – Dimensions of tabs in millimetres – Dimensions *H*, *I*, *T*, *K*, *R*, *G*, *L*, *S* and *U*

Nominal size		*H*	*I*	*T* [a]	*K*	*R*	*G*	*L*	*S*	*U*
2,8 × 0,5	dimple				1,7 max.	7,0 max.				
	hole	1,7 max.	2,7 max.							
2,8 × 0,8	dimple				1,7 max.	7,0 max.				
	hole	1,7 max.	2,7 max.	1 min.						
4,8 × 0,8	dimple				1,7 max.	6,2 max.	1,6 max.	0,7 ± 0,1	1,0 ± 0,2	0,5 ± 0,2
	hole	2,2 max.	4,2 max.	2 min.			1,6 max.	0,7 ± 0,1	1,0 ± 0,2	
6,3 × 0,8	dimple				2,5 max.	7,8 max.	2,9 max.	1,0 ± 0,1	1,0 ± 0,2	0,5 ± 0,2
	hole	3,5 max.	5,5 max.	2 min.			2,9 max.	1,0 ± 0,1	1,0 ± 0,2	
9,5 × 1,2	dimple				4 max.	12,0 max.	2,9 max.	1,5 ± 0,1	1,4 ± 0,2	0,7 ± 0,2
	hole	5 max.	7,5 max.	2,5			2,9 max.	1,5 ± 0,1	1,4 ± 0,2	

[a] If Figures E.10 and E.11 are combined, the dimension *T* shall be greater than the actual value of the dimension *G* plus the thickness *C* of the material.

If not otherwise specified in Table 7, the dimensions *E*1 and *F*1 shall comply with the equivalent dimensions according to Tables 5 and 6 for the larger size of the male tab, and the dimensions *B*2, *E*2 and *F*2 with the smaller size of the male tab.

Examples of designs and dimensions of flat quick-connect terminations are shown in Figures E.6 to E.13.

8.1.7.2 Male tabs may have an optional detent for latching. Round dimple detents, rectangular dimple detents and hole detents shall be located in the hatched area along the centre-line of the male tab as indicated in Figure E.10.

NOTE Male tabs can have a larger hole to allow soldering.

Table 7 – Dimensions in millimetres of combined male tabs for two different sizes of female connectors

Nominal size mm	Types according to figures				
	*E*1	*F*1	*B*2	*E*2	*F*2
2,8 × 0,8			6 min.	2,0 to 2,4	1,3 to 1,5
6,3 × 0,8	4,0 to 4,5	1,6 to 1,9			

8.1.7.3 Provisions for non-reversible restrictions may be located in the area "LG" of Figure E.11 and "KR" of Figure E.12 along the centre-line of the male tab.

If Figures E.10 and E.11 are combined, *T* shall be greater than the actual value of *G* plus the thickness *C* of the material. For the value of *T*, *G* and *C*, see Tables 5 and 6.

NOTE Male tabs according to Figure E.12 are not designed to have a hole or a dimple according to the values of *E* and *F* of Table 5.

8.1.7.4 Male tabs shall be so designed as to allow the correct insertion and withdrawal of one of the female connectors shown in Figure E.14 without damage which could impair the further use of the CBE.

Compliance is checked by the test of 9.4.3.1.

8.1.7.5 Male tabs shall be securely retained.

Compliance is checked by the mechanical overload force test of 9.4.3.2.

8.1.7.6 Male tabs as indicated in Figure E.13 may have a design which allows the connection of two different sizes of female connectors.

8.1.7.7 Male tabs of similar size and design and dimensionally similar to those shown in Tables 5 and 6 shall be allowed if they are able to pass the compliance test with the female connector shown in Figure E.14.

An example of a female connector and possible dimensions are given in Figure E.14.

Compliance is checked by the test of 9.4.3.

8.1.7.8 Male tabs which do not have the dimension criteria shown in 8.1.7.1 and 8.1.7.7 are allowed only if the dimensions and shapes are so different as to prevent any mating with the female connector shown in Figure E.14.

8.1.7.9 Male tabs shall be adequately spaced to allow the connection of the appropriate uninsulated female connectors.

Compliance is checked by applying to each different male tab design/configuration an appropriate female connector according to the manufacturer's instructions in the most severe orientation; during this operation, no strain or distortion shall occur to any of the male tabs or to their adjacent parts, nor shall the creepage distances or clearances be reduced to values less than those specified in 8.1.3.

NOTE A non-reversible stop can be included so that a female connector can only be applied in one direction, so that the female connector cannot be inserted in the reversed position.

For male tabs complying with Figure E.11 or Figure E.12, an appropriate female connector is that shown in Figure E.14.

8.2 Protection against electric shock

Parts of the CBE accessible after installation in equipment shall provide protection against electric shock.

Compliance is verified by the tests of 9.6.

Completion of the protection against electric shock after installation of the CBE is the responsibility of the equipment manufacturer.

8.3 Temperature-rise

8.3.1 Temperature-rise limits

The temperature-rises of the parts of a CBE, measured under the conditions specified in 9.8.2, shall not exceed the values specified in Table 8.

Table 8 – Temperature-rise values for CBEs for different reference ambient air temperatures (*T*)

Parts [a] [b]	Temperature rise (*K*) according to *T* [e]		
	T = 23 °C [f] (standard value)	*T* = 40 °C [f]	*T* = 55 °C [f]
Terminals [c]	60 [d]	50 [d]	35 [d]
External parts liable to be touched during manual operation, including operating means of insulating material	55	40	25
External metallic parts of operating means	35	25	10
Other external parts, including that face of the CBE in direct contact with the mounting surface	70	60	45

[a] No value is specified for the contacts, since the design of most CBEs is such that a direct measurement of the temperature of those parts cannot be made without the risk of causing alterations or displacements of parts likely to affect the reproducibility of the tests.
The 28-day test (see 9.9) is considered to be sufficient for checking indirectly the behaviour of the contacts with respect to undue overheating in service.

[b] No value is specified for parts other than those listed, but no damage shall be caused to adjacent parts of insulating materials, and the operation of the CBE shall not be impaired.

[c] For plug-in type CBEs, the terminals of the base on which the CBE is installed.

[d] Higher values are permitted for terminals for conductors inside the equipment where the CBE is intended to be installed. Relevant information on those values shall be made available to the equipment manufacturer.

[e] For other values of *T*, the admissible temperature-rise can be determined by interpolation between the values (*T* + *K*) obtained by the sum of the values shown in the table.

[f] Tolerance ±2 °C.

Compliance is checked by tests of 9.8.

8.3.2 Ambient air temperature

The temperature-rise limits given in Table 8 are applicable only if the ambient air temperature remains between the limits given in 7.2.2.

8.4 Dielectric properties

8.4.1 Dielectric strength at power frequency

CBEs shall have adequate dielectric properties at power frequency.

Compliance is checked by the tests of 9.7.1, 9.7.2 and 9.7.3, with samples in new condition.

After the verification of electrical operational capability of 9.11, the CBEs shall withstand the test of 9.7.3 but at a test voltage 0,75 times the voltage indicated in 9.7.5 and without the previous humidity treatment of 9.7.1.

8.4.2 Clearances for insulation coordination

The clearances of CBEs shall satisfy the requirements of insulation coordination.

Compliance shall be checked by measurement of the clearances as specified in 8.1.3, or by the impulse withstand voltage test specified in 9.7.6.

Requirements for isolating capability of CBEs suitable for isolation are given in K.8.4.2.

8.5 Conditions for automatic operation

8.5.1 Standard time-current zone

The tripping zone (see 3.9.4) is defined by the information given by the manufacturer in his catalogue (see Annex A). It refers to the reference conditions as specified in 9.2.

NOTE 1 The tripping characteristic of a CBE is intended to ensure adequate protection of the equipment, without premature operation.

The operating zone of a CBE shall be stated for one CBE without enclosure, mounted in still air.

NOTE 2 Conditions of temperature and mounting different from the ones stated (type of enclosure, grouping of more CBEs in the same enclosure, etc.) can affect the operating zone of a CBE.

The manufacturer shall be prepared to make available the characteristics related to specified ambient temperatures different from the standard reference ambient temperature of (23 ± 2) °C, and to give information on the variation of the tripping characteristic due to deviations from other reference conditions, for example, for mounting in planes other than vertical.

A representation of the operating zone is given by Figure A.1. For a CBE with thermal, thermal magnetic, magnetic, or hydraulic-magnetic mode of tripping, the manufacturer shall state the following values:

– the test currents indicated in Table 9, as multiples of the rated current;
– the times (t_1, t_2, t_3, t_4) indicated in Table 9, where applicable.

Table 9 – Time-current operating characteristics

Test current	Initial conditions	Time, t	Required result
I_{nt}	Cold [a]	1 h	No tripping
I_t	Immediately following the non-tripping test	≤ 1 h	Tripping
$2I_n$	Cold [a]	$t_1 \leq t \leq t_2$	Tripping
$6I_n$	Cold [a]	$t_3 \leq t \leq t_4$	Tripping
I_{ni}	Cold [a]	0,1 s	No tripping
I_i	Cold [a]	< 0,1 s	Tripping

[a] The term "cold" means without previous loading (see Annex A).

NOTE 3 Values for mode of tripping of electronic hybrid CBEs are under consideration.

8.5.2 Tripping characteristic

8.5.2.1 General

The tripping characteristic of a CBE shall be contained within the zone defined in 8.5.1.

NOTE Conditions of temperature and mounting different from those specified in 9.2 may affect the tripping characteristic of a CBE.

8.5.2.2 Effect of single-pole loading of a multi-pole CBE on the tripping characteristic

When a CBE with more than one protected pole is loaded on only one of the protected poles, starting from cold, it shall trip within the conventional time with a current equal to:

– 1,1 times the conventional tripping current (see 3.3.6), for two-pole CBEs with two protected poles;

– 1,2 times the conventional tripping current, for three-pole and four-pole CBEs.

The conventional time is 1 h.

Compliance is checked by the test of 9.10.4.

8.5.2.3 Effect of the ambient air temperature on the tripping characteristic

If applicable, the manufacturer shall state the factor by which the rated current has to be increased or reduced if the device is operated at ambient temperatures deviating from the reference value (see 5.2.3).

8.5.3 Operating limits of overvoltage releases

Overvoltage releases are tested at the operating limits indicated by the manufacturer.

Compliance is checked by the test of 9.11.5.

8.5.4 Operating limits of undervoltage and zero-voltage releases

Undervoltage and zero-voltage releases are tested at the operating limits according to Table 10. Other values may be agreed upon between manufacturer and user.

Table 10 – Operating limits of undervoltage and zero-voltage releases (for AC and DC)

Type of release	Hold level	Trip level	Reset level [a]	Withstand level
Undervoltage release	$U \geq 0{,}7\ U_n$	$U \leq 0{,}35\ U_n$	$U \geq 0{,}85\ U_n$	$U = 1{,}1\ U_n$
Zero-voltage release	$U \geq 0{,}7\ U_n$	$U \leq 0{,}1\ U_n$	$U \geq 0{,}85\ U_n$	$U = 1{,}1\ U_n$
[a] For electrically resetting devices, the threshold operating value.				

The headings of the columns of Table 10 have the following meaning.

- Hold level: the voltage at which or above which a release shall not open automatically.
- Trip level: the voltage at which or below which a release shall open automatically.
- Reset level: the voltage at which or above which a release shall reset when actuated.
- Withstand level: the voltage which a release is capable of withstanding in continuous service.

Compliance is checked by the tests of 9.11.6.1 and 9.11.6.3.

8.5.5 Electrical endurance of undervoltage releases

The manufacturer shall provide information concerning electrical endurance of undervoltage releases in his literature.

Compliance is checked by the test of 9.11.6.2.

8.6 Electrical performance and behaviour at rated short-circuit capacity

A CBE shall be capable of performing an adequate number of operating cycles.

Compliance is checked by the tests of 9.11.

It is required that a CBE be able to make and to break any value of current up to and including the value corresponding to the rated switching capacity at rated frequency, at a voltage equal to 105 % (± 5 %) of the rated operational voltage and at any power factor not less than the appropriate lower limit of the range stated in Tables 11 or 12 according to the performance.

8.7 Performance under conditional short-circuit current conditions

A CBE shall withstand the stresses due to short-circuit currents when associated with a specified SCPD without manifestations such as emission of flames, sparks or hot ionized gases, which may constitute a risk for the operator or the equipment.

Compliance is checked by the tests of 9.12.

8.8 Resistance to mechanical shock and impact

A CBE shall have adequate mechanical behaviour so as to withstand the stresses imposed during installation and use.

Compliance is checked by the test of 9.13 (under consideration).

8.9 Resistance to heat

A CBE shall be sufficiently resistant to heat.

Compliance is checked by the test of 9.14.

8.10 Resistance to abnormal heat and to fire

External parts of a CBE made of insulating material shall not be likely to ignite and to spread fire if current-carrying parts in its vicinity under fault or overload conditions attain a high temperature.

Compliance is checked by inspection and by the test of 9.15.

8.11 Resistance to tracking

Parts of insulating material retaining in position live parts of CBEs shall be of material resistant to tracking.

Compliance is checked by inspection and by the test of 9.16.

8.12 Resistance to rusting

Ferrous parts shall be adequately protected against rusting.

Compliance is checked by the test of 9.17.

Table 11 – Test conditions for electrical performance for CBEs intended for general use, including inductive circuits

Section	Test concerning behaviour at	Type according to method of operation (see 4.5)	Test conditions: Number of opera-ting cycles	Test conditions: Time of open position s	Test conditions: Test voltage	Requirements AC: Test current	Requirements AC: Power factor	Requirements DC: Test current	Requirements DC: Time constant ms
1	Rated current	M	500	15	U_e	I_n	0,55	I_n	2
		S	[a]	20		I_n	to	I_n	to
	Low overloads	R, J	50	[b]		2 I_n	0,65	2 I_n	3
2	Rated switching capacity	M	40	60 to 80 [b]	1,05 U_e	6 I_n	0,55 to 0,65	4 I_n	2 to 3
		S							
		R, J							
3.1	Rated short-circuit capacity I_{cn}	M, S, R, J	3	300 to 360	1,05 U_e	6 I_n [c]		4 I_n [c]	
						6 I_n < I_{cn} ≤ 1 500 A	0,93 to 0,98	4 I_n < I_{cn} ≤ 1 000 A	2 to 3
						1 500 A < I_{cn} ≤ 3 000 A	0,85 to 0,9	1 000 A < I_{cn} ≤ 3 000 A	4 to 6
3.2 [d]	Test verifying the suitability for use in IT systems	M, S, R, J	2	300 to 360	*105 % of the rated voltage upper value*	6 I_n	0,93 to 0,98	–	–
						I_{cn} > 6 I_n: 1,2 × I_i	0,93 to 0,98	–	–

[a] The manufacturer shall state the number, in accordance with the classification of the appliance, taken from the preferred values 3 000, 10 000, 30 000, 50 000, and 100 000.

[b] Determined by the time required to reset the device.

[c] Test is covered by section 2.

[d] Only relevant for CBEs marked with 230/400, 120/240, etc.

Table 12 – Test conditions for electrical performance of CBEs used in essentially resistive circuits only (see Clause 6, item d)

<table>
<tr><th rowspan="3">Section</th><th rowspan="3">Test concerning behaviour at</th><th rowspan="3">Type according to method of operation
(see 4.5)</th><th colspan="3">Test conditions</th><th colspan="4">Requirements</th></tr>
<tr><th rowspan="2">Number of opera-ting cycles</th><th rowspan="2">Time of open position
s</th><th rowspan="2">Test voltage</th><th colspan="2">AC</th><th colspan="2">DC</th></tr>
<tr><th>Test current</th><th>Power factor</th><th>Test current</th><th>Time constant
ms</th></tr>
<tr><td rowspan="3">1</td><td>Rated current</td><td>M</td><td>500</td><td>15</td><td rowspan="3">U_e</td><td>I_n</td><td rowspan="3">0,95
to
1</td><td>I_n</td><td rowspan="3">0
to
0,5</td></tr>
<tr><td></td><td>S</td><td>a</td><td>20</td><td>I_n</td><td>I_n</td></tr>
<tr><td>Low overloads</td><td>R, J</td><td>50</td><td>b</td><td>$2\ I_n$</td><td>$2\ I_n$</td></tr>
<tr><td>2</td><td>Rated switching capacity</td><td>M, S, R, J</td><td>40</td><td>60 to 80
b</td><td>$1{,}05\ U_e$</td><td>$6\ I_n$</td><td>0,95
to
1</td><td>$4\ I_n$</td><td>0
to
0,5</td></tr>
<tr><td rowspan="3">3.1</td><td rowspan="3">Rated short-circuit capacity I_{cn}</td><td rowspan="3">M, S, R, J</td><td rowspan="3">3</td><td rowspan="3">300
to 360</td><td rowspan="3">$1{,}05\ U_e$</td><td>$6\ I_n$ [c]</td><td rowspan="3">0,93
to 0,98</td><td>$4\ I_n$ [c]</td><td></td></tr>
<tr><td rowspan="2">$6\ I_n$
$< I_{cn} \leq$
3 000 A</td><td>$4\ I_n$
$< I_{cn} \leq$
1 000 A</td><td>1 to 2</td></tr>
<tr><td>1 000 A
$< I_{cn}$
$\leq$ 3 000 A</td><td>2 to 3</td></tr>
<tr><td rowspan="2">3.2 [d]</td><td rowspan="2">Test verifying the suitability for use in IT systems</td><td rowspan="2">M, S, R, J</td><td rowspan="2">2</td><td rowspan="2">300
to 360</td><td rowspan="2">105 % of the rated voltage upper value</td><td>$6\ I_n$</td><td>0,95 to 1</td><td>–</td><td>–</td></tr>
<tr><td>$I_{cn} > 6\ I_n$
$1{,}2 \times I_i$</td><td>0,95 to 1</td><td>–</td><td>–</td></tr>
<tr><td colspan="10">a The manufacturer shall state the number, in accordance with the classification of the appliance, taken from the preferred values 3 000, 10 000, 30 000, 50 000 and 100 000.
b Determined by the time required to reset the device.
c Test is covered by section 2.
d Only relevant for CBEs marked with 230/400, 120/240, etc.</td></tr>
</table>

9 Tests

9.1 Type tests and sequences

9.1.1 *The characteristics of a CBE are verified by means of type tests.*

The type tests required by this document are listed in Table 13.

Table 13 – List of type tests

Tests	Subclause
Indelibility of marking	9.3
Reliability of terminals, current-carrying parts and connections	9.4
Reliability of terminals for external conductors	9.5
Protection against electric shock	9.6
Dielectric properties	9.7
Temperature-rise	9.8
28-day test	9.9
Tripping characteristics	9.10
Electrical operational capability	9.11
Conditional short-circuit current	9.12
Resistance to mechanical shock and impact	9.13
Resistance to heat	9.14
Resistance to abnormal heat and fire	9.15
Resistance to tracking	9.16
Resistance to rusting	9.17

Additional tests for CBEs suitable for isolation are given in K.9.7.7.

9.1.2 For certification purposes type tests are carried out in test sequences.

The test sequences and the number of samples to be submitted are stated in Annex C.

Unless otherwise specified, each type test (or sequence of type tests) shall be made on CBEs in a clean and new condition.

9.2 Test conditions

The CBE is mounted individually, vertically and in free air at an ambient temperature of (23 ± 2) °C, unless otherwise specified, and is protected against undue external heating or cooling.

Unless otherwise specified, the CBE is wired with the appropriate cable specified in Table 14 and is mounted complete on a metal support unless the device is intended to be used in a non-metallic enclosure only. In this case, the CBE is mounted in a way corresponding as closely as possible to that in actual use.

Unless otherwise specified tests are carried out at the rated frequency ± 5 Hz.

During the tests no maintenance or dismantling of the samples is allowed.

For the tests of 9.8, 9.9 and 9.10 the CBE is connected as follows:

a) *the connections are single-core, PVC-insulated copper conductors according to IEC 60227;*
b) *the test is carried out with single-phase current, with all poles connected in series, except for the test according to 9.10.3;*
c) *the connections are in free air and spaced at not less than the distance between the terminals;*

d) the minimum length of each connection is

- *1 m for cross-sections up to and including 10 mm²;*
- *2 m for cross-sections larger than 10 mm².*

The tightening torques to be applied to the terminal screws are two-thirds of those specified in Table 15.

Table 14 – Standard cross-sections of copper conductors corresponding to the rated currents

Standard cross-section mm²	1	1,5	2,5	4	6	10	16	25	35	50
Values of the rated current A	6	> 6 to 13	> 13 to 20	> 20 to 25	> 25 to 32	> 32 to 50	> 50 to 63	> 63 to 80	> 80 to 100	> 100 to 125

9.3 Test of indelibility of marking

The test is made by rubbing the markings by hand for 15 s with a piece of cotton soaked with water and again for 15 s with a piece of cotton soaked with petroleum spirit.

NOTE 1 The petroleum spirit used is defined as a solvent hexane with a content of aromatics of maximum 0,1 % volume percentage, a kauri-butanol value of 29, an initial boiling-point of approximately 65 °C, a dry-point of approximately 69 °C and a density of approximately 0,65 g/cm³.

Marking made by impressing, moulding or engraving is not subjected to this test.

After this test the marking shall be easily legible. The marking shall also remain easily legible after all the tests of this document. It shall not be possible to remove labels easily, and these shall show no curling.

NOTE 2 A revision of this test is under consideration.

9.4 Test of reliability of terminals, current-carrying parts and connections

9.4.1 Screw type and screwless terminals

9.4.1.1 General

Compliance with the requirements of 8.1.5.3 is checked by the insertion of the largest conductor, after the insulation has been removed and the end of the rigid stranded and of the flexible conductors have been reshaped. The stripped end of the conductor shall be able to enter completely within the terminal without use of undue force.

9.4.1.2 Screw-type terminals

Compliance with the requirements of 8.1.4 is checked by inspection and, for screws and nuts which are operated when connecting the CBE, by the following test.

The screws and nuts are tightened and loosened

- *ten times for screws in engagement with a thread of insulating material (see 8.1.4.2);*
- *five times in all other cases.*

Screws or nuts in engagement with a thread of insulating material are completely removed and inserted each time.

The test is made by means of a suitable test screwdriver or spanner applying a torque as shown in Table 15.

The screws and nuts shall not be tightened in jerks.

The conductor is moved each time the screw or nut is loosened.

Table 15 – Screw-thread diameter and applied torques

Nominal diameter of the thread mm	Torque N.m		
	I	II	III
Up to and including 2,8	0,2	0,4	0,4
Above 2,8 up to and including 3,0	0,25	0,5	0,5
Above 3,0 up to and including 3,2	0,4	0,6	0,6
Above 3,2 up to and including 3,6	0,6	0,8	0,8
Above 3,6 up to and including 4,1	0,7	1,2	1,2
Above 4,1 up to and including 4,7	0,8	1,8	1,8
Above 4,7 up to and including 5,3	0,8	2,0	2,0
Above 5,3 up to and including 6,0	1,2	2,5	3,0
Above 6,0 up to and including 8,0	2,25	3,5	6,0
Above 8,0 up to and including 10,0	–	4,0	10,0

Column I applies to screws without heads if the screw, when tightened, does not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the diameter of the screw.

Column II applies to other screws which are tightened by means of a screwdriver.

Column III applies to screws and nuts which are tightened by means other than a screwdriver.

Where a screw has a hexagonal head with a slot for tightening with a screwdriver and the values in column II and III are different, the test is made twice, first applying to the hexagonal head the torque specified in column III and then, on another sample, applying the torque specified in column II by means of a screwdriver. If the values in column II and III are the same, only the test with the screwdriver is made.

During the test, the screwed connections shall not work loose and there shall be no damage, such as breakage of screws or damage to the head slot, threads, washers or stirrups, that will impair the further use of the CBE.

Moreover, enclosures and covers shall not be damaged.

9.4.1.3 Screwless terminals

Compliance with the requirements of 8.1.5.3 is checked by inspection and, for screwless terminals which are operated when connecting the CBE, by the following test.

The terminals are fitted with each type of conductor according to their design that is:

- *solid only;*
- *solid and rigid-stranded;*
- *solid, rigid-stranded and flexible.*

Each conductor of the largest cross-section for which the terminal is intended to be used is inserted and subsequently disconnected.

This test is performed five times.

New conductors are used each time, except for the fifth time, when the conductor used for the fourth insertion is clamped at the same place. For each insertion, the conductors are either pushed as far as possible into the terminal or are inserted so that adequate connection is obvious. After each insertion the conductor is twisted through 90° and subsequently disconnected. After these tests, the terminals shall not be damaged in such a way as to impair their further use.

9.4.2 Solder terminations

9.4.2.1 Solderability test

Compliance with the requirements of 8.1.6.1 is checked by the test according to IEC 60068-2-20, test Ta. If not otherwise specified by the manufacturer, method 1 (solder bath at 235 °C) is applicable.

9.4.2.2 Resistance to soldering heat

Compliance with the requirements of 8.1.6.2 is checked by applying the test according to IEC 60068-2-20, test Tb. If not otherwise specified by the manufacturer, method 1B (solder bath at 350 °C) is applicable.

The solder terminations shall be immersed in the solder bath down to a depth of 2,0 mm to 2,5 mm from the housing of the CBE and shall remain immersed for 5 s ± 1 s.

After the test the solder terminations shall not have worked loose or have been displaced in a manner impairing their further use.

Compliance is checked by inspection.

9.4.3 Flat quick-connect male tabs

9.4.3.1 Insertion and withdrawal test

Table 16 – Insertion and withdrawal forces

Nominal size mm	Insertion force maximum N	Withdrawal force minimum N
2,8	53	5
4,8	67	9
6,3	80	18
9,5	100	20

Compliance with the requirement of 8.1.7 is checked by using the female connector as shown in Figure E.14. The male tab shall be slowly and steadily inserted and withdrawn six times at a rate of travel of approximately 1 mm/s.

The insertion and withdrawal forces shall be within the limits as specified in Table 16.

Insertion and withdrawal force measurements shall be made with any suitable testing device providing accurate alignment and being capable of holding the reading.

9.4.3.2 Mechanical push/pull test

An axial force, equal to that shown in Table 17, is applied smoothly once only with a suitable test apparatus. No damage which could impair further use shall occur to the tab or to the CBE.

Compliance is checked by inspection.

Table 17 – Push/pull force

Nominal size mm	**Push/pull forces** N
2,8	58
4,8	73
6,3	88
9,5	110

9.5 Test of reliability of terminals for external conductors (see 3.12.15)

9.5.1 *Compliance with the requirements of 8.1.5 is checked by inspection, by the test of 9.4, where a rigid copper conductor having the largest cross-sectional area specified in Table 3 is placed in the terminal (for nominal cross-sectional areas exceeding 6 mm^2, a rigid stranded conductor is used; for other nominal cross-sectional areas, a solid conductor is used) and by the tests of 9.5.2, 9.5.3 and 9.5.4.*

These last tests are made by means of a suitable test screwdriver or spanner applying a torque as shown in Table 15.

9.5.2 *The terminals are fitted with copper conductors of the smallest and largest cross-sectional areas specified in Table 3, solid or stranded, whichever is the more unfavourable.*

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, and in the position most likely to assist the wire to escape.

Screws, if any, are then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 15. Each conductor is then subjected to a pull of the value shown in Table 18. The pull is applied without jerks, for 1 min, in the direction of the axis of the conductor space.

Table 18 – Pulling forces

Cross-section of conductor accepted by the terminal mm^2	**Up to 1,5**	**Up to 4**	**Up to 6**	**Up to 10**	**Up to 16**	**Up to 50**
Pull N	40	50	60	80	90	100

During the test, the conductor shall not move noticeably in the terminal.

9.5.3 *The terminals are fitted with copper conductors of the smallest and largest cross-sectional areas specified in Table 3, solid or stranded, whichever is the more unfavourable. If it is a screw-type terminal, the screws are tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 15. The terminal screws are then loosened and that part of the conductors which may have been affected by the terminal is inspected.*

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 or stirrups, which will impair the further use of the terminal.

After the test the conductors shall show no undue damage or severed wires.

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

9.5.4 *The terminals are fitted with a rigid stranded copper conductor having the make-up shown in Table 19.*

Table 19 – Make-up of conductors for the test of 9.5.4

Range of nominal cross-sections to be clamped mm²	Rigid stranded conductor	
	Number of wires	Diameter of wires mm
0,5 to 1,5 [a]	7	0,50
0,75 to 2,5 [a]	7	0,67
1 to 4 [a]	7	0,85
1,5 to 6 [a]	7	1,04
2,5 to 10	7	1,35
4 to 16	7	1,70
10 to 25	7	2,14
16 to 35	19	1,53
25 to 50	Under consideration	

[a] If the terminal is intended to clamp solid conductors only (see note of Table 3), the test is not made.

Before insertion in the terminal, the wires of the conductors are suitably reshaped.

The conductor is inserted into the terminal until the conductor reaches the bottom of the terminal or just projects from the far side of the terminal and in the position most likely to assist a wire to escape. The clamping screw or nut, if any, is then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 15.

After the test, no wire of the conductor shall have escaped outside the clamping unit in such a way as to reduce the required creepage distances and clearances.

9.6 Test of protection against electric shock

A CBE is intended to be used integrated into equipment (for example an appliance). Therefore this test cannot be carried out on an individual CBE, unless restricted to areas which can be touched when installed in accordance with the manufacturer's instructions.

The test is made with the standard test finger, Figure 4, on such parts of a CBE which may be touched when installed. CBEs with screw-type or screwless terminals are fitted with the conductors of the smallest and largest cross-sectional areas specified in Table 3. 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. The test finger is applied in every possible bending position of a real finger, an electrical contact indicator being used to show contact with live parts.

It is recommended that a lamp be used for the indication of contact and that the voltage be not less than 40 V.

9.7 Test of dielectric properties

9.7.1 Resistance to humidity

9.7.1.1 Preparation of the CBE for test

The test shall be made on the CBE itself without any enclosure.

If, in special cases, an integral enclosure is used, the inlet openings, if any, are left open; if knock-outs are provided, one of them is opened.

NOTE The term "integral enclosure" means that the CBE cannot function normally without it.

Parts which can be removed without the aid of a tool are removed and subjected to the humidity treatment with the main part; spring lids are kept open during this treatment.

9.7.1.2 Test conditions

The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %.

The temperature of the air in which the sample is placed is maintained within ±1 °C of any convenient value T between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the sample is brought to a temperature between T and T + 4 °C.

9.7.1.3 Test procedure

The sample is kept in the cabinet for 48 h.

NOTE A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water having a sufficiently large contact surface with the air.

In order to achieve the specified conditions within the cabinet, it is recommended to ensure constant circulation of the air inside and, in general, to use a cabinet which is thermally insulated.

9.7.1.4 Condition of the CBE after test

After this treatment, the sample shall show no damage within the meaning of this document and shall withstand the tests of 9.7.2 and 9.7.3.

9.7.2 Insulation resistance of the main circuit

The CBE having been treated as specified in 9.7.1, the insulation resistance is measured 5 s after application of a DC voltage of approximately 500 V, consecutively as follows:

a) *with the CBE in the open position, between each pair of the terminals or terminations which are electrically connected together when the CBE is in the closed position, on each pole in turn;*

   NOTE 1 This test is not applicable to J-type CBEs without means for manual operation.

b) *with the CBE in the closed position, between each pole in turn and the others connected together; for the test between phases, electronic components connected to the main circuit may be disconnected during the test;*

c) *with the CBE in the closed position, between all poles connected together and the frame, including a metal foil in contact with the outer surface of the internal enclosure of insulating material, if any;*

d) *between metal parts of the mechanism and the frame;*

e) *for a CBE with a metal enclosure having an internal lining of insulating material, between the frame and a metal foil in contact with the inner surface of the lining of insulating material, including bushings and similar devices.*

The tests a), b) and c) are carried out after having connected all auxiliary circuits to the frame.

NOTE 2 The term "frame" includes

– all accessible metal parts and a metal foil in contact with the surfaces of insulating material which are accessible after installation as for normal use;

– the surface on which the base of the CBE is mounted, covered if necessary, with metal foil;

– screws and other devices for fixing the base to its support;

– screws for fixing covers which have to be removed when mounting the CBE, metal parts of operating means referred to in 8.1.2.

If the CBE is provided with a terminal intended for the interconnection of protective conductors, this is connected to the frame.

For the measurement according to items a) to e) the metal foil is applied in such a way that the sealing compound, if any, is effectively tested.

The insulation resistance shall be not less than

– *2 MΩ for the measurements according to items a) and b);*

– *5 MΩ for the other measurements.*

9.7.3 Dielectric strength of the main circuit

After a CBE has passed the tests of 9.7.2, the test voltage specified in 9.7.5 is applied for 1 min between the parts indicated in 9.7.2.

Initially, no more than half the prescribed voltage is applied, then it is raised to the full value within 5 s.

No flashover or breakdown shall occur during the test.

Glow discharges without drop in the voltage are neglected.

9.7.4 Dielectric strength of the auxiliary circuits

For these tests, the main circuit shall be connected to the frame. The test voltage specified in 9.7.5 shall be applied for 1 min as follows:

a) *between all the auxiliary circuits which are not normally connected to the main circuit, connected together, and the frame of the CBE;*

b) *where appropriate, between each part of the auxiliary circuits which may be isolated from the other parts of the auxiliary circuits, and these other parts connected together.*

No flashover or breakdown shall occur during the test.

9.7.5 Value of test voltage

The test voltage shall have practically sinusoidal waveform and a frequency between 45 Hz and 65 Hz.

The values of the test voltage, applied as indicated in items a), b), c), d) and e) of 9.7.2, shall be in accordance with Table 20.

The source of the test voltage shall be capable of supplying a short-circuit current of at least 0,2 A.

No overcurrent tripping device of the transformer shall operate when the current in the output circuit is lower than 100 mA.

Table 20 – Test voltages

Rated voltage or working voltage V	≤ 50	> 50 ≤ 125	> 125 ≤ 250	> 250 ≤ 440
Test voltage for dielectric strength tests according to 9.7.3 and 9.7.4 a) V	500	1 000	1 500	2 000
Test voltage for dielectric strength tests according to 9.7.4 b) V	250	500	1 000	1 500

NOTE Test voltages for supplementary or reinforced insulation are under consideration.

9.7.6 Test for the verification of insulation coordination by impulse withstand voltage test

This test is used to prove the adequacy of clearances for insulation coordination, if smaller than those specified in Table 1 (see 8.1.3.2.7).

The test is carried out on a CBE installed and wired as in normal use, with the impulse voltage according to Figure 6 of IEC 60060-1:2010.

The impulses are given by a generator producing positive and negative impulses having a front time of 1,2 µs and a time to half-value of 50 µs, the tolerance being

- *±5 % for the peak value;*
- *±30 % for the front time;*
- *±5 % for the time to half-value.*

The shape of the impulses is adjusted with the CBE under test connected to the impulse generator. For this purpose, appropriate voltage dividers and voltage sensors shall be used.

Small oscillations in the impulse are allowed, provided that their amplitude near the peak of the impulse is less than 5 % of the peak value.

For oscillations on the first half of the front, amplitudes up to 10 % of the peak value are allowed.

After the CBE has passed the tests of 9.7.2, the impulse withstand test voltages specified in Table 21 are applied between the parts indicated in 9.7.2.

A first series of tests is made by applying the impulse withstand test voltage to the phase pole(s), connected together, and the neutral pole (or path) of the CBE, as applicable.

A second series of tests is made by applying the impulse withstand test voltage between the metal support, connected to the terminal(s) intended for the protective conductors(s), if any, and the phase pole(s) and the neutral pole (or path) connected together.

The impulse voltage shall be applied three times for each polarity at intervals of 1 s minimum.

There shall be no unintentional disruptive discharges during the test.

If, however, only one such disruptive discharge occurs, six additional impulses having the same polarity as that which caused the disruptive discharge are applied, the connections being the same as those with which the failure occurred.

No further disruptive discharge shall occur.

NOTE 1 The surge impedance of the test apparatus can be 500 Ω; a substantial reduction of this value is under consideration.

NOTE 2 The expression "unintentional disruptive discharge" is used to cover the phenomena associated with the failure of insulation under electric stress, which include a drop in the voltage and the flowing of current.

NOTE 3 Intentional discharges cover discharges of any incorporated surge arresters.

Table 21 – Impulse withstand test voltages for verification of insulation coordination

Rated impulse withstand voltage V	Applicable impulse voltages (1,2/50 µs pulse) according to the altitude at which the test is made [a] V				
	Sea level [b]	200 m	500 m	1 000 m	2 000 m
330	350	350	350	340	330
500	550	540	530	520	500
800	910	900	900	850	800
1 500	1 750	1 700	1 700	1 600	1 500
2 500	2 950	2 800	2 800	2 700	2 500
4 000	4 800	4 800	4 700	4 400	4 000
6 000	7 300	7 200	7 000	6 700	6 000

[a] The values are taken from Table 12 of IEC 60947-1:2007.

[b] For other altitudes the impulse voltage is determined by interpolation.

9.8 Test of temperature-rise

9.8.1 Ambient air temperature

The ambient air temperature shall be measured during the last quarter of the test period by means of at least two thermometers or thermocouples symmetrically positioned around the CBE at about half its height and at a distance of about 1 m from the CBE.

The thermometers or thermocouples shall be protected against draughts and radiant heat.

9.8.2 Test procedure

The test shall be made at the reference ambient air temperature as specified in 7.2.1.

A current equal to I_n is passed simultaneously through all the poles of the CBE for a period of time sufficient for the temperature-rise to reach the steady-state value or for the conventional time, whichever is the longer (but not exceeding 8 h).

In practice, this condition is reached when the variation of the temperature-rise does not exceed 1 K per hour.

For a four-pole CBE with three protected poles, the test is first made by passing the specified current through the three protected poles only.

The test is then repeated by passing the same current through the pole intended for the connection of the neutral and the nearest protected pole.

During the test the temperature-rises shall not exceed the values shown in Table 8.

If the CBE trips before reaching steady-state thermal conditions (after the conventional time), the temperatures reached before tripping are recorded.

9.8.3 Measurement of the temperature of parts

The temperature of the different parts referred to in Table 8 shall be measured by means of fine wire thermocouples or by equivalent means at the nearest accessible position to the hottest spot.

Good heat conductivity between the thermocouple and the surface of the part under test shall be ensured.

9.8.4 Temperature-rise of a part

The temperature-rise of a part is the difference between the temperature of this part measured in accordance with 9.8.3 and the ambient air temperature measured in accordance with 9.8.1.

9.9 28-day test

The CBE is subjected to 28 cycles, each cycle comprising 21 h with a current equal to the rated current at an open-circuit voltage of at least 30 V, and 3 h without current under the test conditions of 9.2.

The CBE being in the closed position, the current is established and interrupted by an auxiliary switch. During this test the CBE shall not trip.

Immediately after the last period of current flowing, the CBE is loaded with the rated current.

The CBE shall not trip within the conventional time. The temperature-rise of the terminals is measured immediately after the conventional time has elapsed.

Such temperature-rise shall not exceed the value measured in the temperature-rise test (see 9.8) by more than 15 K.

Immediately after this measurement of the temperature-rise the current is steadily increased within 5 s to the conventional tripping current.

The CBE shall trip within the conventional time.

9.10 Test of tripping characteristics

9.10.1 General

This test is made to verify that the CBE complies with the requirements of 8.5.1.

Unless otherwise agreed between manufacturer and user the test is only made with the test currents as specified in Table 9.

For CBEs calibrated at a reference ambient air temperature other than (23 ± 2) °C, the test shall be made at that other temperature ± 2 °C.

9.10.2 Test of time-current characteristic

9.10.2.1 *A current equal to the conventional non-tripping current is passed for the conventional time through all poles, starting from cold (see Table 9).*

The CBE shall not trip.

The current is then steadily increased, within 5 s, to the tripping current.

The CBE shall trip within the conventional time.

9.10.2.2 *A current equal to 2 I_n is passed through all poles, starting from cold.*

The opening time shall be within the limits t_1 and t_2 as stated by the manufacturer (see Figures A.1a, A.1c and A.1d).

9.10.3 Test of instantaneous tripping (of the magnetic release)

A current I_{ni} is passed through all poles, starting from cold.

The CBE shall not trip in a time less than or equal to 0,1 s.

Following this test, a current I_i is passed through all poles, starting from cold.

The CBE shall trip in a time less than 0,1 s.

9.10.4 Test of effect of single-pole loading on the tripping characteristic of multi-pole CBEs

Compliance is checked by testing the CBE connected in accordance with 9.2, under the conditions specified in 8.5.2.2.

The CBE shall trip within the conventional time.

9.10.5 Test of effect of ambient temperature on the tripping characteristic

The CBE is tested at the minimum and maximum values according to 7.2.2, at a current obtained by multiplying 2 I_n by the derating or uprating factor stated by the manufacturer for these temperatures.

The CBE shall trip within the limits t_1 to t_2 stated by the manufacturer in accordance with Table 9.

NOTE For hydraulic-magnetic CBEs derating factors are not applicable. The tripping time limits at temperatures other than the reference ambient air temperature will be tested according to the values given in the manufacturer's literature.

9.11 Verification of electrical operational capability

9.11.1 General requirements

9.11.1.1 General

The tests concerning the verification of the electrical performance are intended to verify that the CBE is capable of making and breaking the currents corresponding to representative conditions of use as indicated in 8.6.

9.11.1.2 Test conditions

The tests shall be made with the test voltages and test currents as indicated in Table 11 or Table 12.

The tolerances of the test quantities shall be:

Current: $^{+5}_{0}$ *%* *Voltage: ±5 %*

Frequency: ±5 %

The tests shall be made in test circuits as specified by Figure 3, with the current adjusted to the value specified in Tables 11 or 12, according to the declared performance, by means of resistors and reactors in series connected to the load terminals.

If air-core reactors are used, a resistor taking approximately 0,6 % of the current through the reactors shall be connected in parallel with each reactor.

If iron-core reactors are used, the iron power losses of these reactors shall not appreciably influence the recovery voltage.

For AC, the current shall have a substantially sine-wave form and the power factor shall be as indicated in Table 11 or Table 12, according to the declared performance.

For DC, the current shall be substantially free of ripples (< 5 % effective) and the time constant shall be as indicated in Table 11 or Table 12, according to the declared performance.

The CBE shall be connected using conductors of the sizes indicated in Table 14.

For devices the terminals of which are not identified as supply and load, one of the samples shall be tested with reversed connections.

9.11.1.3 Test procedure

The CBE is submitted to the number of operating cycles with a value of current as indicated in Table 11 or Table 12 according to the declared performance.

The CBE shall be operated as under intended conditions of use.

NOTE 1 Intended conditions cover the use at a reference ambient air temperature T different from the standard value.

NOTE 2 In order to reduce the number of tests, the test at the reference ambient air temperature T can be carried out, with agreement of the manufacturer, at the rated current (corresponding to the standard reference ambient air temperature).

Each operating cycle shall consist of a making operation followed by a breaking operation.

During each operating cycle, the CBE shall remain open for the time specified in Table 11 or Table 12. For M-type and S-type CBEs, the time in the ON position shall not exceed 1 s, unless otherwise agreed upon between manufacturer and user.

For R-type and J-type CBEs, the ON-time shall be that required to trip the CBE.

At the end of each operating cycle the fuse F shown in Figure 3 shall not have blown.

9.11.1.4 Condition of the CBEs after test

Following the tests of 9.11.2, 9.11.3 and 9.11.4.1, the samples shall not show:

- *undue wear;*
- *discrepancy between the positions of the moving contacts and the corresponding position of the indicating device;*
- *damage of the integral enclosure, if any, permitting access to live parts by the test finger (see 9.6);*
- *loosening of electrical or mechanical connections;*
- *seepage of sealing compound, if any.*

Moreover, the CBE shall withstand the dielectric strength test according to 9.7.3 at a voltage of 0,75 times the value prescribed in 9.7.5, without the previous humidity treatment of 9.7.1.

9.11.1.5 Verification of the tripping characteristic after test

9.11.1.5.1 *For a CBE with thermal, thermal-magnetic or hydraulic-magnetic mode of tripping, following the tests of 9.11.1.3, 9.11.1.4 and 9.11.4.1:*

- *the CBE shall not trip when a current of 1,8* I_n *is passed through all poles for a time* t_1*, starting from cold;*
- *the CBE shall trip within the time* t_2*, when a current of 2,2* I_n *is passed through all poles, starting from cold.*

9.11.1.5.2 *For a CBE with magnetic mode of tripping only, following the tests of 9.11.1.3, 9.11.1.4 and 9.11.4.1:*

- *the CBE shall not trip when a current of 0,9* I_{ni} *is passed; it shall trip when a current of 1,1* I_i *is passed.*

9.11.1.5.3 *For CBEs with electronic-hybrid mode of tripping:*

Under consideration.

9.11.2 Behaviour at rated current (or under low overloads for R-type and J-type CBEs)

Since R-type and J-type CBEs cannot be tripped manually, the tests of these CBEs to carry out the breaking operation shall be performed at a low overload.

The test conditions shall be as specified in section 1 of Table 11 or Table 12 according to the declared performance.

9.11.3 Behaviour at rated switching capacity

The test conditions shall be as specified in section 2 of Table 11 or Table 12, according to the declared performance.

9.11.4 Behaviour at rated short-circuit capacity

9.11.4.1 Short circuit test for CBEs suitable for isolation or CBEs having a rated short-circuit capacity I_{cn} **greater than 6** I_n **for AC or 4** I_n **for DC**

The distance of the grid described in Annex H of IEC 60898-1:2015 shall be in accordance with the information given in the manufacturer's literature.

The test conditions shall be as specified in section 3 of Table 11 or Table 12 according to the declared performance, but with the sequence of operations as stated below, at the rated short-circuit current assigned to the CBE by the manufacturer.

The CBE is submitted to the following sequence of operations, at a current specified by the manufacturer:

a) for trip-free, cycling trip-free CBEs and J-type CBEs

$$O - t - CO - t - CO$$

Cycling trip-free CBEs are tested, the closing command being maintained until the three breaking operations are performed;

b) for non trip-free CBEs (see note)

$$O - t - O - t - O$$

where

O represents an opening operation;

CO represents a closing operation followed by an opening operation;

t represents the time interval between two subsequent short-circuit operations and is specified as follows:

- *for trip-free CBEs: the time as specified in section 3 of Tables 11 or Table 12;*
- *for cycling trip-free and J-type CBEs: the self-resetting time of the CBE;*
- *for non-trip-free CBEs: the time sufficient for enabling the re-closing of the CBE.*

NOTE The testing of non-trip-free CBEs is based on the reasoning that these CBEs are not intended to be closed under short-circuit conditions (see 4.8.3).

After each operation, the indicating means shall show the open position of the contacts.

9.11.4.2 Short-circuit test on CBEs for verifying their suitability for use in IT systems

This subclause applies only to CBEs according to section 3.2 of Table 11 or Table 12, as applicable.

Single-pole CBEs and each protected pole of multipole CBEs are subjected individually to a test in a circuit the connections of which are shown in Figure 3a.

The impedance Z1 (see Figure 3a) is adjusted so as to obtain a current as given in Table 11 or Table 12, section 3.2.

The sequence of operations shall be

$$O - t - CO$$

For the O operation on the first protected pole the auxiliary switch A is synchronized with respect to the voltage wave so that the circuit is closed on the point 0° on the wave for this operation. For the following O operations on the other protected poles to be tested (see Clause C.2) this point is shifted each time by 30° with respect to the point on wave of the previous test, with a tolerance of ±5°.

Following the test at $I_{cn} > 6\ I_n$ the samples shall not show:

- *undue wear;*
- *discrepancy between the positions of the moving contacts and the corresponding position of the indicating device;*
- *damage of the integral enclosure, permitting access to live parts by the test finger (see 9.6);*
- *loosening of electrical or mechanical connections;*
- *seepage of sealing compound, if any.*

Moreover, the CBE shall withstand the dielectric strength test according to 9.7.3 at a voltage of 0,75 times the value prescribed in 9.7.5, without the previous humidity treatment of 9.7.1 *and the CBE shall trip within the time t_2, when a current of 2,2 I_n is passed through all poles, starting from cold.*

Following the test at I_{cn} = 6 I_n the samples shall not show damage of the integral enclosure, if any, permitting access to live parts by the test finger (see 9.6); the CBE may be inoperable after the first or second operation. If the result of the first operation is such that the CBE is rendered inoperable the remaining operation need not be performed.

Moreover, the CBE shall withstand the dielectric strength test according to 9.7.3 at a voltage of 0,75 times the value prescribed in 9.7.5, without the previous humidity treatment of 9.7.1.

9.11.5 Test of overvoltage releases at operating limits

Under consideration.

9.11.6 Behaviour of undervoltage and zero-voltage releases

9.11.6.1 Verification of the operating limits of undervoltage and zero-voltage releases

The test shall be carried out on a new sample. The test condition shall be as specified in Table 10.

9.11.6.2 Electrical endurance test of undervoltage and zero-voltage release

A CBE with an undervoltage or zero-voltage release shall be tested with the number of operating cycles given in the manufacturer's literature. Each operating cycle consists of a making operation with the undervoltage or zero-voltage release energized with rated voltage, followed by an automatically breaking operation by switching off the voltage of the undervoltage or zero-voltage release by an external auxiliary switch.

9.11.6.3 Test of withstand level of undervoltage and zero-voltage releases

Under consideration.

9.12 Conditional short-circuit current tests

9.12.1 General

The test for the verification of the performance under conditional short-circuit current conditions shall be made with an SCPD of the type, rating and characteristics as specified by the manufacturer of the CBE.

For performance category PC1 the rating of the SCPD shall be at least 15 A.

The mounting of the CBE shall be as specified in 9.2.

A grid (or grids) as described in Annex H of IEC 60898-1:2015 shall be placed at a distance from each arc vent of the CBE, in accordance with the manufacturer's instructions.

The test circuit shall be set up in accordance with Figure 7, as appropriate.

For calibration the CBE and the SCPD including the connection wires according to Figure 7 shall be replaced by links of negligible impedance.

The test circuit shall be calibrated for the value of the rated conditional short-circuit current assigned to the CBE by the manufacturer at a current and power factor or time constant in accordance with Table 22.

Table 22 – Power factor and time constant of test circuit

	Test current I_{cc} A	Power factor (range)	Time constant ms
AC	$300 < I_{cc} \leq 1\,500$	0,93 to 0,98	
	$1\,500 < I_{cc} \leq 3\,000$	0,85 to 0,90	
DC	$I_{cc} \leq 1\,000$		2,5 ± 0,5
	$I_{cc} > 1\,000$		5,0 ± 1
For testing at currents higher than 3 000 A, reference should be made to 9.12.5 of IEC 60898-1:2015.			

After calibration of the test circuit the links of negligible impedance shall be replaced by the SCPD and the CBE including the connecting wires according to Figure 7, the CBE being connected as shown in Figure 7 by means of copper conductors of length as shown in the above figures and of maximum cross-sectional area corresponding to the rated current of the CBE in accordance with Table 3.

9.12.2 Values of test quantities

All the tests concerning the verification of the rated conditional short-circuit current shall be performed with the values of current, voltage and power factor stated by the manufacturer and in accordance with the relevant tables of this document.

The value of the applied voltage is that which is necessary to produce the specified power-frequency recovery voltage. The value of the power-frequency recovery voltage in each phase shall be equal to a value corresponding to 105 % of the rated operational voltage of the CBE under test.

9.12.3 Tolerances on test quantities

The tests will be taken as valid if the RMS values recorded in the test report differ from the values specified within the following tolerances:

Current: $^{+5}_{0}$ %

Voltage: ±5 % *(including power-frequency recovery voltage)*

Frequency: ±5 %.

9.12.4 Test procedure

9.12.4.1 General

The test procedure consists of a sequence of operations.

The following symbols are used for defining the sequence of operations:

O represents an opening operation;

CO represents a closing operation followed by an opening operation;

t represents the time interval between two successive short-circuit operations and is defined as follows:

- *if the SCPD operates: 3 min or the longer time necessary to reclose the CBE;*
- *if the SCPD does not operate:*
  - *for trip-free and non-trip-free CBEs: 3 min;*
  - *for J-type and cycling trip-free CBE's: the self-resetting time of the device.*

The actual value of t *shall be stated in the test report.*

The CBE is submitted to the following sequence of operations:

– *for trip-free, cycling trip-free and J-type CBEs*

$$O – t – CO – t – CO$$

– *for non-trip-free CBEs*

$$O – t – O – t – O$$

In the case of single-phase tests the instant of initiation of the short-circuit current for the first O operation shall be such that a maximum of let-through energy of the SCPD will occur:

– *for fuses, reference should be made preferably to IEC 60269;*
– *for circuit-breakers with energy-limiting properties, the manufacturer should make available information regarding the relevant energy limiting properties.*

The CBE shall be considered to have passed the test if

– *the earth leakage detection fuse does not open; however the SCPD may operate;*
– *there is no damage to the integral enclosure, if any, permitting access to live parts by the test finger (see 9.6);*
– *no melting of the fuse of the grid circuit (see Figure H.3 of IEC 60898-1:2015) occurs;*
– *for CBEs of category PC2 tested according to 9.12.4.3, after each operation, the indicating means shall show the open position of the contacts.*

9.12.4.2 Verification of the rated conditional short-circuit current, for performance category PC1 (I_{nc1})

The CBE is submitted to the test sequence as specified in 9.12.4.1 with a test current corresponding to the rated conditional short-circuit current.

The following conditions of the CBE after the short-circuit test are considered to be acceptable:

– *non-operability after the first or second or third operation;*
– *inability to reset;*
– *inability to trip within the specified limits;*
– *inability to indicate the position of the contacts (open or closed);*
– *welding of contacts;*
– *internal damage within the CBE.*

9.12.4.3 Verification of the rated conditional short-circuit current for performance category PC2 (I_{nc2})

Two groups of CBEs (see Tables C.2 and C.3) are submitted to the sequence of operations as specified in 9.12.4.1, with test currents as specified below:

a) *one group with a test current corresponding to the rated conditional short-circuit current;*
b) *the other group with a test current corresponding to 1,5 times the rated short-circuit capacity of the CBE (see 8.6).*

Following these tests the CBEs shall comply with the conditions specified in 9.12.4.1.

In addition the CBEs shall not show

– *discrepancy between the position of the moving contacts and the corresponding position of the indicating device;*

– *seepage of the sealing compound.*

Moreover, the CBEs shall withstand the dielectric strength test according to 9.7.3 at a voltage of 0,75 times the value prescribed in 9.7.5, without previous humidity treatment.

The CBEs shall be considered to have passed the test if, after the test, they comply with 9.11.1.4 and 9.11.1.5.

9.13 Test of resistance to mechanical shock and impact

Under consideration.

9.14 Tests of resistance to heat

9.14.1 *CBEs are kept for 1 h in a heating cabinet at a temperature of (100 ± 2) °C.*

During the test they shall not undergo any change impairing their further use, and sealing compound, if any, shall not flow to such an extent that live parts are exposed.

After the test and after the samples have been allowed to cool down to approximately room temperature, there shall be no access to live parts which are normally not accessible when the samples are mounted as in normal use, even if the standard test finger is applied with a force not exceeding 5 N.

After the test, markings shall still be legible.

Discoloration, blisters or a slight displacement of the sealing compound is disregarded, provided that safety is not impaired within the meaning of this document.

9.14.2 *External parts of a CBE made of insulating material, necessary to retain current-carrying parts and parts of the protective circuit in position, are subjected to a ball-pressure test by means of the apparatus shown in Figure 5, except that the insulating parts necessary to retain the terminals for protective conductors in a box shall be tested as specified in 9.14.3.*

The surface of the part to be tested is placed in the horizontal position on a steel plate, and a steel ball of 5 mm diameter is pressed against this part with a force of 20 N.

The test is made in a heating cabinet at a temperature of (125 ± 2) °C.

After 1 h, the ball is removed from the sample, which is then cooled down within 10 s to approximately room temperature by immersion in cold water.

The diameter of the impression caused by the ball is measured and shall not exceed 2 mm.

9.14.3 *External parts of a CBE that are made of insulating material and that are not necessary to retain current-carrying parts and parts of the protective circuit in position, even though they are in contact with them, are subjected to a ball-pressure test in accordance with 9.14.2. This test is made, however, at a temperature of (75 ± 2) °C, or at a temperature of (40 ± 2) °C plus the highest temperature-rise that was determined for the relevant part during the test of 9.8, whichever is the higher.*

For CBEs calibrated at a reference ambient air temperature other than (23 ± 2) °C, the test shall be made at the upper limit of the ambient air temperature according to 7.2.2 plus the highest temperature-rise that was determined for the relevant part during the test of 9.8, or at a temperature of (75 ± 2) °C, whichever is the higher.

NOTE 1 For the purpose of the tests of 9.14.2 and 9.14.3, the bases of surface-type CBEs are considered as external parts.

NOTE 2 The tests of 9.14.2 and 9.14.3 are not made on parts of ceramic material.

NOTE 3 If two or more of the insulating parts referred to in 9.14.2 or 9.14.3 are made of the same material, the test is carried out only on one of these parts, according to 9.14.2 or 9.14.3 respectively.

NOTE 4 The revision of this test is under consideration.

9.15 Test of resistance to abnormal heat and to fire

Compliance with the requirements of 8.10 shall be checked by means of a glow-wire test, which is performed in accordance with IEC 60695-2-10 under the following conditions:

– *for external parts of a CBE made of insulating material necessary to retain current-carrying parts and parts of the protective circuit in position, by the test made at a temperature of (960 ± 10) °C;*

– *for all other external parts made of insulating material, by the test made at a temperature of (650 ± 10) °C.*

NOTE 1 For the purpose of this test, the bases of surface-type CBEs are considered as external parts.

NOTE 2 The test is not made on parts made of ceramic material.

NOTE 3 If the insulating parts are made of the same material, the test is carried out only on one of these parts, according to the appropriate glow-wire test temperature.

The glow-wire test is applied to ensure that an electrically heated test wire under defined test conditions does not cause ignition of insulating parts or to ensure that a part of insulating material which might be ignited by the heated test wire under defined conditions has a limited time to burn without spreading fire by flame, burning parts or droplets falling down from the tested part.

The test is made on one sample.

In case of doubt, the test shall be repeated on two further samples.

The test is made by applying the glow-wire once.

The sample shall be positioned during the test in the most unfavourable position of its intended use (with the surface tested in a vertical position).

The tip of the glow-wire shall be applied to the specified surface of the test sample taking into account the conditions of the intended use under which a heated or glowing element may come into contact with the sample.

The sample is regarded as having passed the glow-wire test if

– *there is no visible flame and no sustained glowing, or*

– *flames and/or glowing at the sample extinguish within 30 s after the removal of the glow-wire.*

There shall be no ignition of the tissue paper or scorching of the pinewood board.

NOTE 4 The revision of this test is under consideration.

9.16 Test of resistance to tracking

Compliance with the requirement of 8.11 is checked, for materials other than ceramic, by the following test.

A flat surface of the part to be tested, if possible at least 15 mm × 15 mm, is placed in the horizontal position.

Two electrodes of platinum with the dimensions shown in Figure 6 are placed on the surface of the sample in the manner shown in this figure, so that the rounded edges are in contact with the sample over their whole length. The force exerted on the surface by each electrode is approximately 1 N.

The electrodes are connected to a supply source of substantially sine-wave form of a frequency between 45 Hz and 65 Hz, at a voltage corresponding to the CTI of the material (see Table 1), that is 100 V, 400 V or 600 V.

The total impedance of the circuit when the electrodes are short-circuited is adjusted by means of a variable resistor, so that the current is (1,0 ± 0,1) A, at a power factor between 0,9 and 1. An overcurrent relay, with a tripping time of at least 0,5 s, is included in the circuit.

The surface of the sample is wetted by allowing drops of solution of ammonium chloride in distilled water to fall centrally between the electrodes.

The solution has a resistivity of 400 Ω.cm at 25 °C, corresponding to a concentration of approximately 0,1 %.

The drops have a volume of 20^{+5}_{0} *mm*^{3} *and fall from a height of 30 mm to 40 mm.*

The time interval between one drop and the next is (30 ± 5) s.

No flashover or breakdown between electrodes shall occur before a total of 50 drops has fallen.

Care should be taken that the electrodes are clean, correctly shaped and correctly positioned before each test is started. In case of doubt, the test may be repeated, if necessary on a new set of samples.

9.17 Test of resistance to rusting

Any grease is removed from the parts to be tested, by immersion in a cold chemical degreaser such as refined petrol, for 10 min; the parts are then immersed for 10 min in a 10 % solution of ammonium chloride in water at a temperature of (20 ± 5) °C.

Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture, at a temperature of (20 ± 5) °C.

After the parts have been dried for 10 min in a heating cabinet at a temperature of (100 ± 5) °C, their surface shall show no signs of rust.

Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.

For small springs and the like and for inaccessible parts exposed to abrasion a layer of grease may provide sufficient protection against rusting.

Such parts are only subjected to the test if there is a doubt as to the effectiveness of the grease film, and the test is then made without previous removal of the grease.

When using the liquid specified for the test, adequate precautions should be taken to prevent inhalation of the vapour.

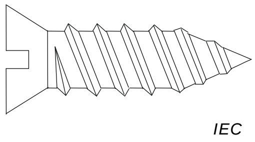


Figure 1 – Thread-forming screw

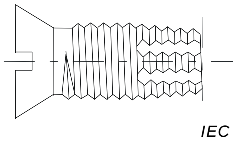


Figure 2 – Thread-cutting screw

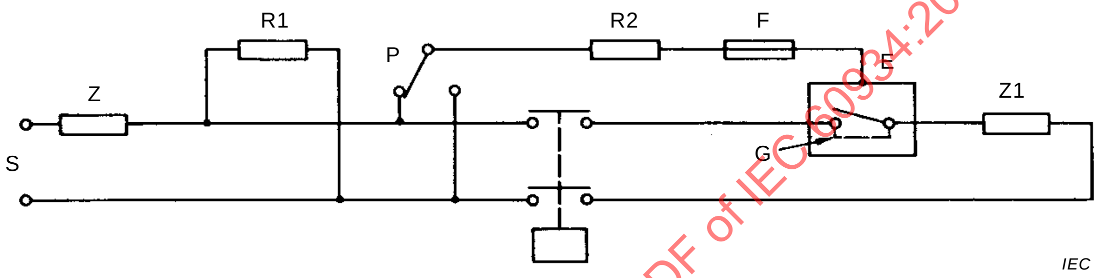


Figure 3a – Single pole CBE

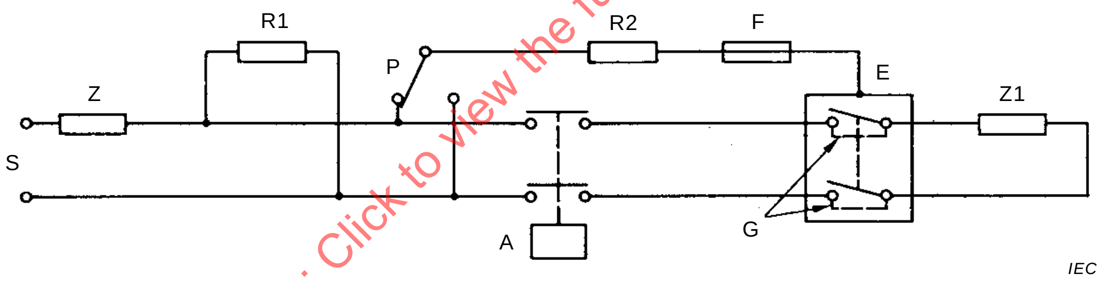


Figure 3b – Two-pole CBE

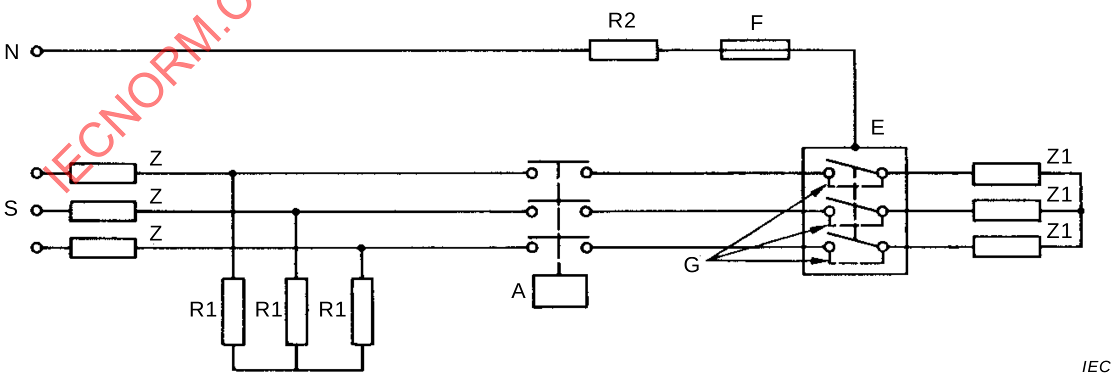


Figure 3c – Three-pole CBE or three single-pole (non-linked) CBEs

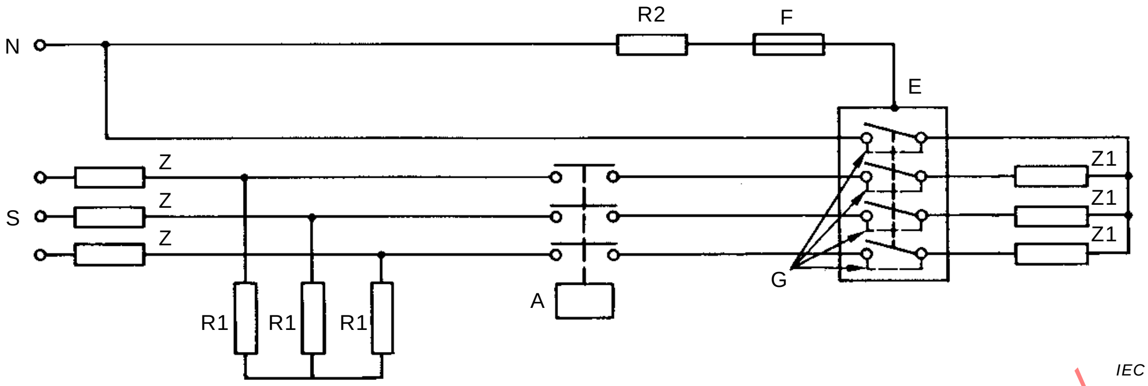


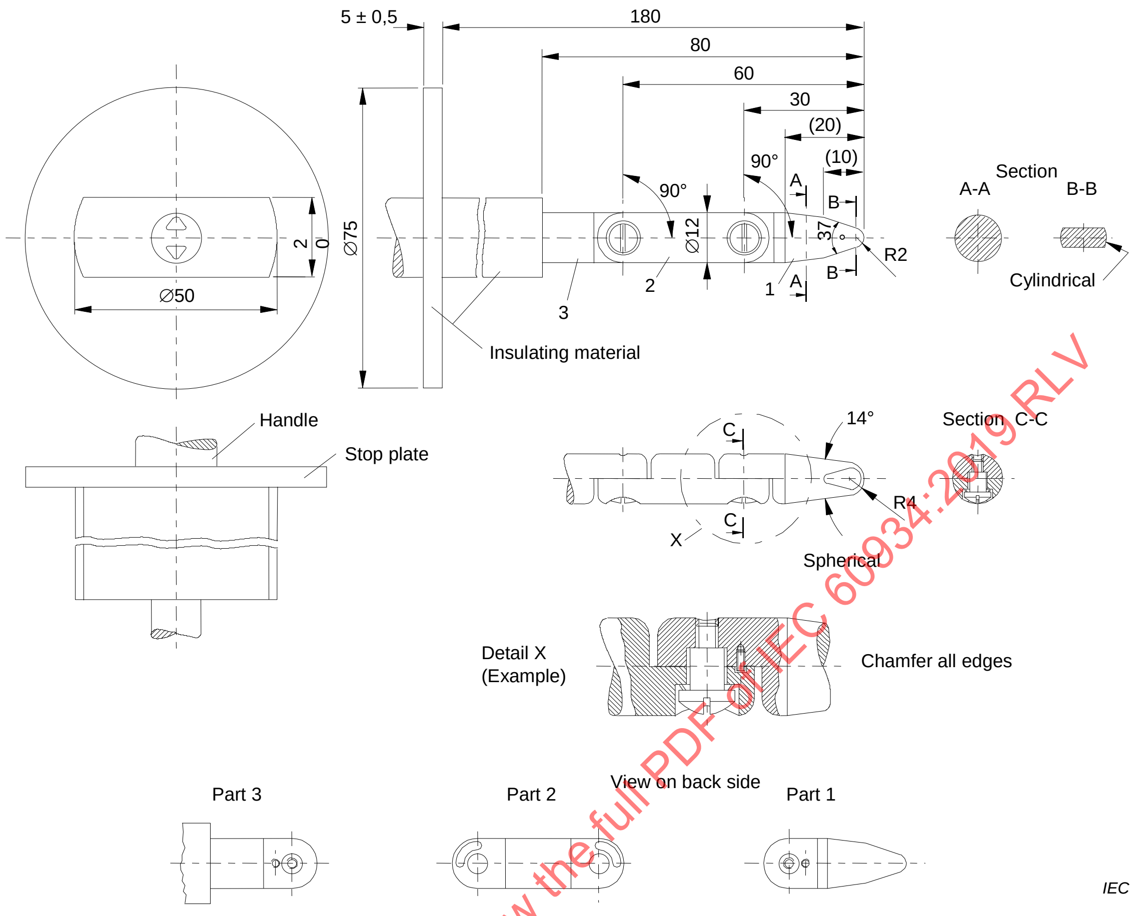
Figure 3d – Four-pole CBE

Key

S	supply source
N	neutral
Z	impedance for adjusting the prospective current to the rated short-circuit capacity
Z1	impedance for adjusting the test currents to values lower than the rated short-circuit capacity
R1	resistors, drawing a current of 10 A per phase
E	enclosure or support
A	auxiliary switch synchronized with respect to the voltage wave
G	negligible impedance connection for test-circuit calibration
R2	resistor 0,5 Ω
F	copper wire (diameter 0,1 mm, length 50 mm)
P	selector switch

Figure 3 – Test circuits for overcurrent tests of CBEs

Dimensions in millimetres



Tolerances on dimensions without specific tolerance:

– on angles: $^{0}_{-10'}$

– on linear dimensions:

up to 25 mm: $^{0}_{-0,05}$

over 25 mm: ±0,2

Material of finger: for example, heat-treated steel

NOTE 1 Both joints of this finger may be bent through an angle of 90° $^{+10°}_{0}$, but in one and the same direction.

NOTE 2 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 ensures a 90° bending angle with a 0° to +10° tolerance.

Figure 4 – Standard test finger (see IEC 60529)

Dimensions in millimetres

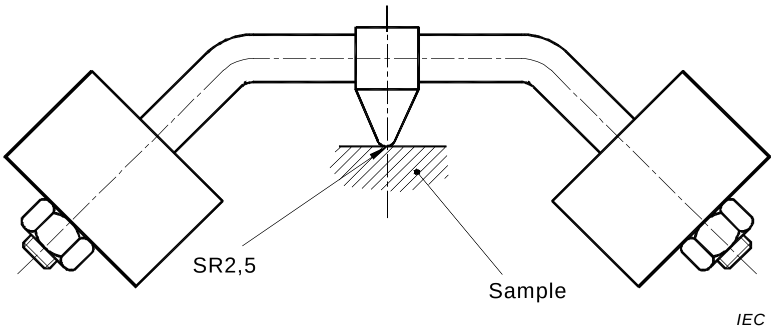


Figure 5 – Ball pressure apparatus

Dimensions in millimetres

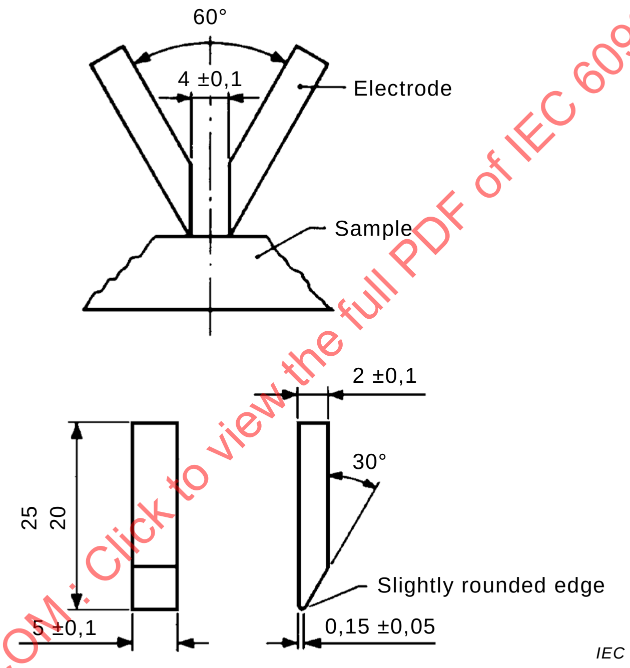


Figure 6 – Arrangements and dimensions of the electrodes for the tracking test

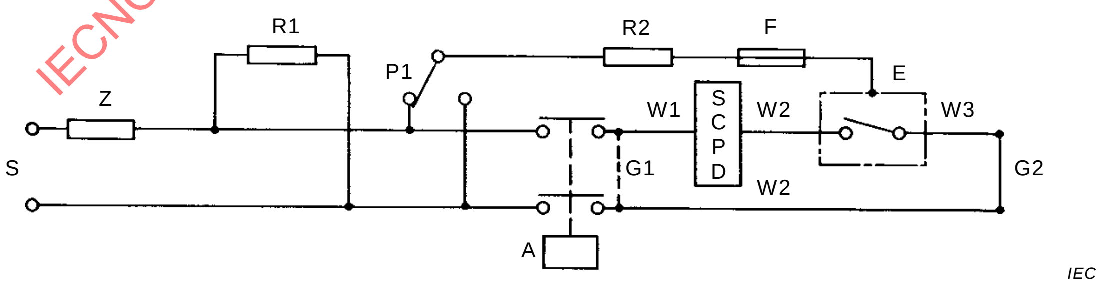


Figure 7a – Single pole CBE

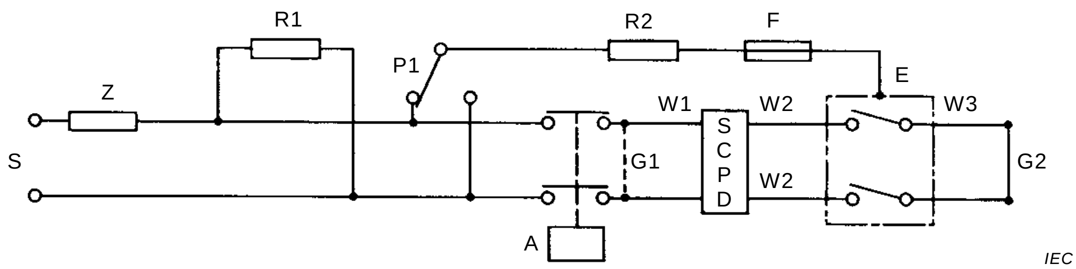


Figure 7b – Two-pole CBE

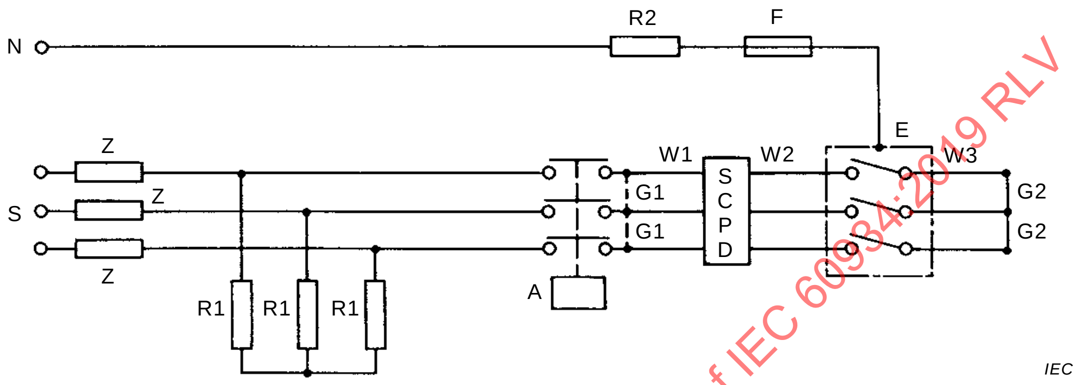


Figure 7c – Three-pole CBE or three single-pole (non-linked) CBEs

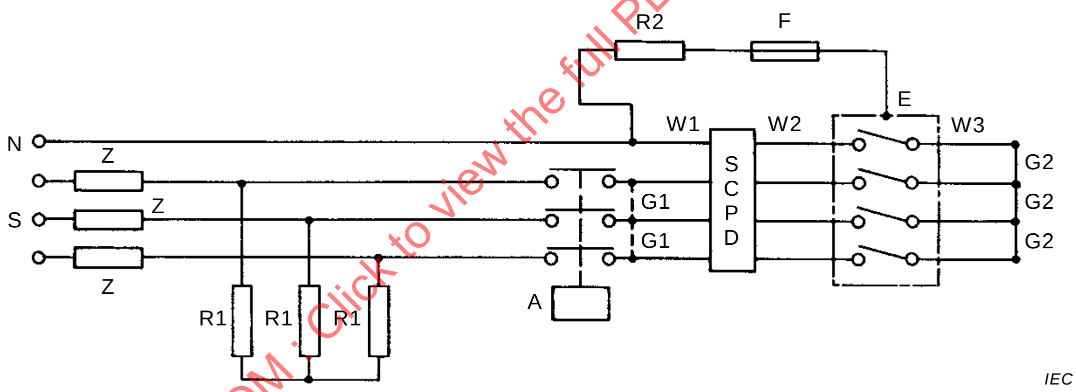


Figure 7d – Four-pole CBE

Key

S	supply source
Z	impedance for adjusting the prospective current to the rated conditional short-circuit current
R1	resistor, drawing a current of 10 A per phase
R2	resistor, 0,5 Ω
E	support of enclosure
A	auxiliary switch synchronized with respect to the voltage wave
G1	connection of negligible impedance for calibration of the test circuit
F	copper wire (diameter 0,1 mm, length 50 mm)
W1, W2	wires of length of 0,75 m each and of a cross-sectional area based on rating of SCPD
W3	wires of length of 0,75 m each and of a cross-sectional area based on rating of CBE
P1	selector switch
G2	connection of negligible impedance

Figure 7 – Test circuits for verification of the conditional short-circuit current

Annex A
(normative)

Time-current zone (see 9.10 and Table 9)

See Figure A.1.

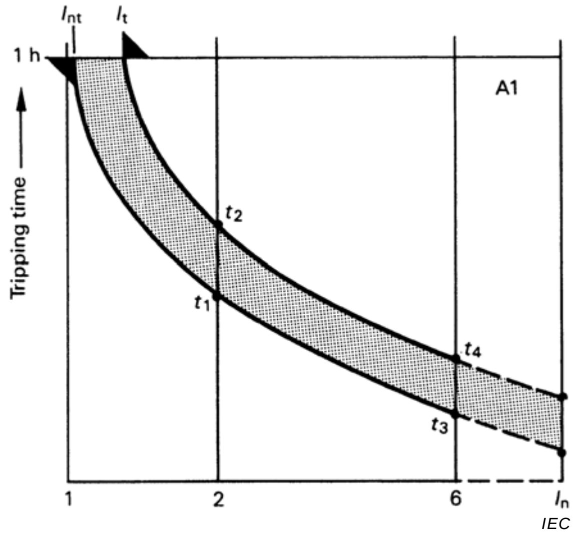


Figure A.1a – Thermal mode only

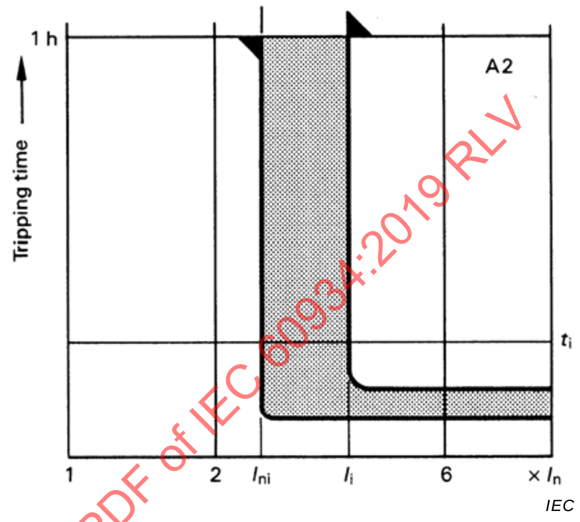


Figure A.1b – Magnetic mode only

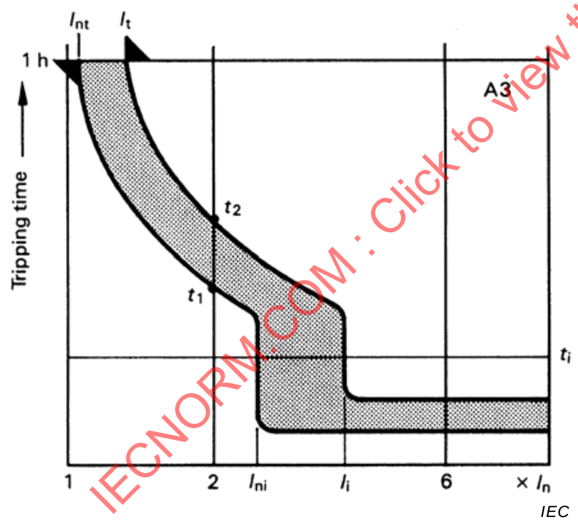


Figure A.1c – Thermal magnetic mode

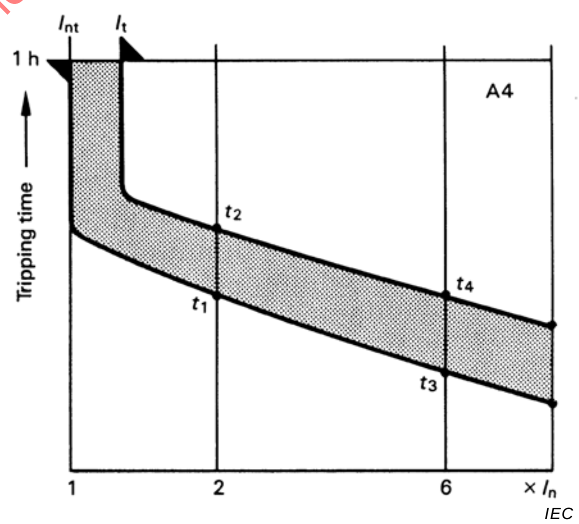


Figure A.1d – Hydraulic-magnetic mode

Key

$t_1 \ldots t_4$	times, to be stated by the manufacturer
t_i	instantaneous tripping time
I_n	rated current
I_i	instantaneous tripping current
I_{ni}	instantaneous non-tripping current
I_{nt}	conventional non-tripping current
I_t	conventional tripping current

Figure A.1 – Time-current zone

Annex B
(normative)

Determination of clearances and creepage distances

In determining clearances and creepage distances, it is recommended that the following points be considered.

If a clearance or creepage distance is influenced by one or more metal parts, the sum of the sections should have at least the prescribed minimum value.

Individual sections less than

– 0,2 mm in length for pollution degree 2, or
– 0,8 mm in length for pollution degree 3

should not be taken into consideration in the calculation of the total length of clearances.

In determining a creepage distance:

– grooves at least 1 mm wide and 1 mm deep should be measured along their contour;
– grooves having any dimension less than these dimensions should be neglected and direct distance only measured;
– ridges less than 1 mm high should be neglected;
– ridges at least 1 mm high
  - should be measured along their contour, if they are integral parts of a component of insulating material (for instance by moulding, welding or cementing);
  - should be measured along the shorter of the two following paths: along the joint or along the profile of ridge, if the ridges are not integral parts of a component of insulating material.

The application of the foregoing recommendations is illustrated by Figures B.1a to B.1j:

– Figures B.1a, B.1b and B.1c indicate the inclusion or exclusion of a groove in a creepage distance;
– Figures B.1d and B.1e indicate the inclusion or exclusion of a ridge in a creepage distance;
– Figure B.1f indicates the consideration of the joint when the ridge is formed by an inserted insulating barrier, the outside profile of which is longer than the length of the joint;
– Figures B.1g, B.1h, B.1i and B.1j illustrate how to determine the creepage distance to fixing means situated in recesses in the surface of insulating parts.

Dimensions in millimetres

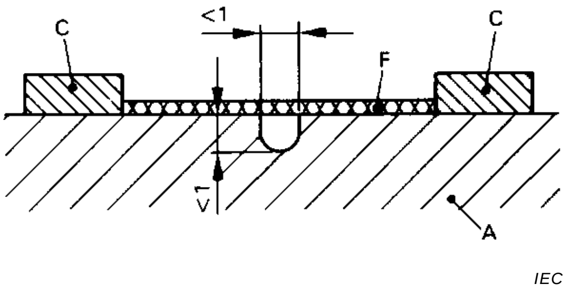


Figure B.1a

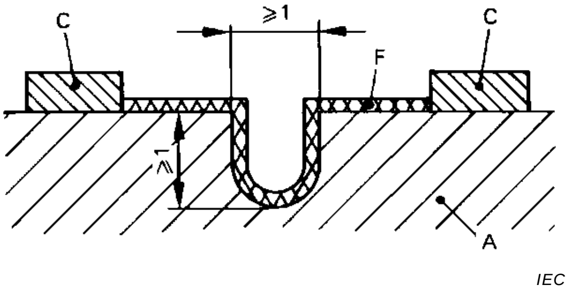


Figure B.1b

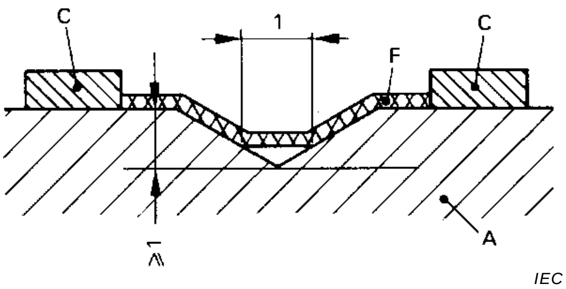


Figure B.1c

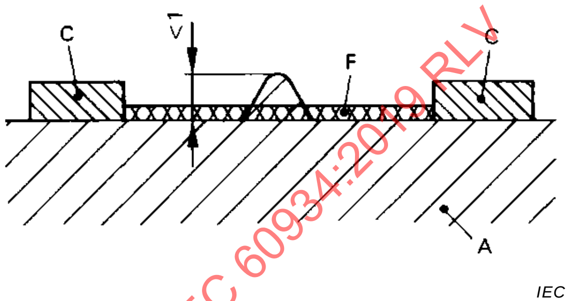


Figure B.1d

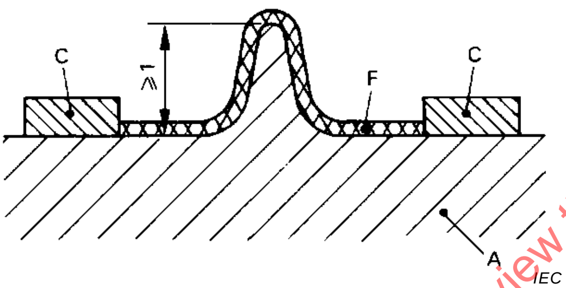


Figure B.1e

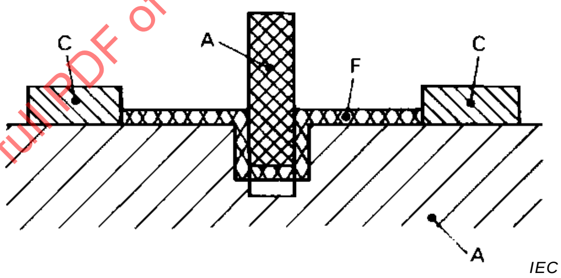


Figure B.1f

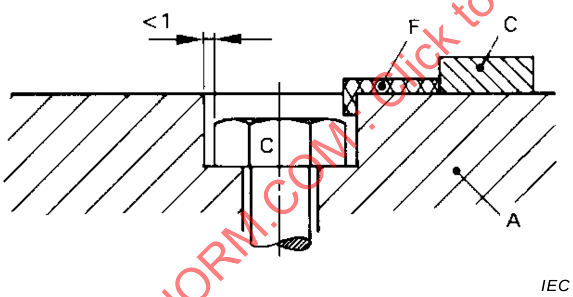


Figure B.1g

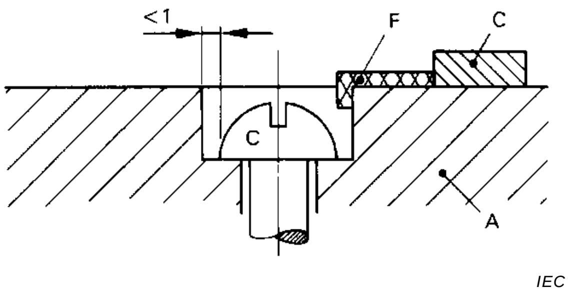


Figure B.1h

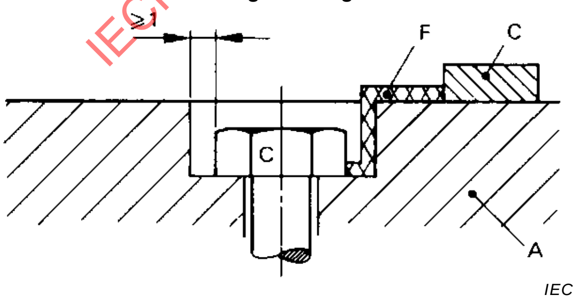


Figure B.1i

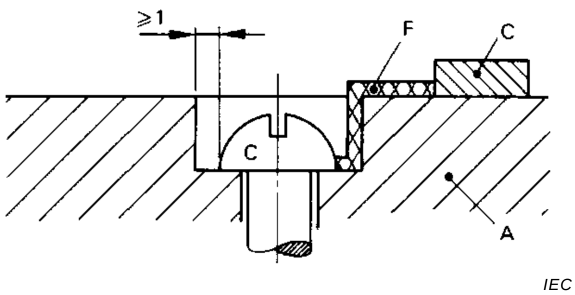


Figure B.1j

A insulating material

C conducting part

F creepage distance

Figure B.1 – Illustrations of the application of the recommendations for creepage distances

Annex C
(normative)

Test sequences and number of samples to be submitted for certification purposes

C.1 Test sequences

The tests are made according to Table C.1 of this annex, where the tests in each sequence, A to E, are carried out in the order indicated. If values for I_{nc1} and/or I_{nc2} are assigned by the manufacturer the test sequences F and/or G are carried out in addition.

Table C.1 – Test sequences

Test sequence	Clause or subclause	Test (or inspection)
A	6	Marking
	8.1	Mechanical design
	8.1.1	General
	8.1.2	Mechanism
	8.1.3	Clearances and creepage distances
	9.3	Indelibility of marking
	9.4	Reliability of terminals, current-carrying parts and connections
	9.5	Reliability of terminals for external conductors
	9.6	Protection against electric shock
	9.14	Resistance to heat
	9.15	Resistance to abnormal heat and to fire
	9.17	Resistance to rusting
B	9.7	Dielectric properties
	9.7.1	Resistance to humidity
	9.7.2	Insulation resistance of main circuit
	9.7.3	Dielectric strength of main circuit
	9.7.4	Dielectric strength of auxiliary circuits
	9.7.6	Impulse withstand voltage, if necessary
	K.9.7.7	Test of suitability for isolation, if applicable
	9.8	Temperature-rise
	9.9	28-day test
	9.16	Resistance to tracking
C	9.10	Tripping characteristics
	9.11.2	Behaviour at rated current
	9.11.1.4	Condition of the CBE after test
	9.11.1.5	Verification of tripping characteristic after test
D	9.10.2.2	Time-current characteristic
	9.11.3	Behaviour at rated switching capacity
	9.11.1.4	Condition of the CBE after test
	9.11.1.5	Verification of tripping characteristic after test
E	9.10.2.2	Time-current characteristic
	9.11.4.1	Short circuit test for CBEs suitable for isolation or CBEs having a rated short-circuit capacity I_{cn} greater than 6 I_n for AC or 4 I_n for DC
	9.11.1.4	Condition of the CBE after test
	K.9.7.7.2	Verification of leakage currents, if applicable
	9.11.1.5	Verification of tripping characteristic after test
F	9.10.2.2	Time-current characteristic
	9.12.4.2	Rated conditional short-circuit current for performance category PC 1 (I_{nc1})
G	9.10.2.2	Time-current characteristics
	9.12.4.3	Rated conditional short-circuit current for performance category PC 2 (I_{nc2})
	9.11.1.4	Condition of the CBE after test
	K.9.7.7.2	Verification of leakage currents, if applicable
	9.11.1.5	Verification of tripping characteristic after test

C.2 Number of samples to be submitted for full test procedure

If a single type of CBE is submitted for test, the number of samples to be submitted to the different test series shall be as indicated in Table C.2, where the minimum performance criteria are also indicated.

If all samples submitted according to the second column of Table C.2 pass the tests, compliance with the standard is proved. If only the minimum number given in the third column passes the test, additional samples, as shown in the fourth column, shall be tested and all shall then satisfactorily complete the test sequence.

For a CBE having more than one rated current, two separate sets of the same CBE shall be submitted to each series: one set at the maximum rated current, and the other at the minimum rated current.

Table C.2 – Number of samples for full test procedure

Test sequence	Number of samples	Minimum number of samples which shall pass the test	Number of samples for repeated tests [a]
A	1	1	–
B	3	2	3
C	3	2	3
D	3	2	3
E [b]	3	2	3
F	3	2	3
G	2 × 3	2 × 2	2 × 3

[a] In case of repeated tests, all test results shall be acceptable.

[b] Additional set of samples for verification of suitability of CBE for use in IT systems.

C.3 Number of samples to be submitted for simplified test procedure in case of submitting simultaneously a series of CBEs of the same basic design

If a series of CBEs of the same basic design is submitted for test, the number of samples to be tested may be reduced according to Table C.3. CBEs are considered to be of the same basic design if

a) all parts are the same, except those that have to be different because of a different current rating. For many designs, such differing parts are, for instance bimetals, coils and connections between these parts;

b) only the shape of the housing differs;

c) multi-pole CBEs are either composed of single-pole CBEs or are built up from the same components as the single-pole CBEs, having the same overall dimensions per pole;

d) the omission of parts belonging for instance to auxiliary or control circuits obviously does not influence the performance;

e) only the terminations differ. If appropriate, CBEs may be subjected to the temperature-rise test (see 9.8).

Table C.3 – Reduction of samples for simplified test procedure

Sequence of tests	Number of samples as the function of the number of poles [a]			
	1 pole [b]	2 pole [c]	3 pole	4 pole [d]
A [h]	1 max. rating 1 min. rating	1 max. rating	1 max. rating	1 max. rating
B	3 max. rating	3 max. rating [e]	3 max. rating [f]	3 max. rating
C	3 max. rating	3 max. rating [e]	3 max. rating [f]	3 max. rating
D	3 max. rating	3 max. rating	3 max. rating	3 max. rating
E [g,i]	3 max. rating 3 min. rating	3 max. rating 3 min. rating	3 max. rating 3 min. rating	3 max. rating 3 min. rating
F [g]	3 max. rating 3 min. rating	3 max. rating 3 min. rating	3 max. rating 3 min. rating	3 max. rating 3 min. rating
G [g]	2 × 3 max. rating 2 × 3 min. rating	2 × 3 max. rating 2 × 3 min. rating	2 × 3 max. rating 2 × 3 min. rating	2 × 3 max. rating 2 × 3 min. rating

[a] If a test is to be repeated according to the minimum performance criteria of Clause C.2, a new set of samples is used for the relevant test sequence. The results of the repeated tests shall be acceptable.

[b] If only the multi-pole CBEs are submitted, this column shall also apply to the set of samples with the smallest number of poles.

[c] Also applicable to CBEs with 1 protected pole and a neutral pole.

[d] Also applicable to CBEs with 3 protected poles and a neutral pole.

[e] This test shall be omitted in cases where 3-pole or 4-pole CBEs are tested.

[f] This test shall be omitted in cases where 4-pole CBEs are tested.

[g] If considered appropriate, taking into account the limitation of the short-circuit current due to the internal CBE impedance, an intermediate rating may be tested instead of the minimum rating.

[h] When multi-pole CBEs are submitted, a maximum of four screw-type terminals for external conductors are subjected to the tests of 9.5.

[i] Additional set of samples with maximum rating for verification of suitability of CBE for use in IT systems.

Annex D
(normative)

Correspondence between ISO and AWG copper conductors

See Table D.1.

Table D.1 – Correspondence between ISO and AWG conductor cross-sections

ISO size [a] mm²	**AWG** [b]	
	Size	**Cross-section** mm²
1	18	0,82
1,5	16	1,3
2,5	14	2,1
4	12	3,3
6	10	5,3
10	8	8,4
16	6	13,3
25	3	26,7
35	2	33,6
50	0	53,5

[a] In general, ISO sizes apply.

[b] On request of the manufacturer, AWG sizes may be used.

Annex E
(normative)

Examples of terminals

Some examples of designs of terminals are given in Figures E.1 to E.14. The conductor location shall have a diameter suitable for accepting solid rigid conductors and a cross-sectional area suitable for accepting rigid stranded conductors (see 8.1.5).

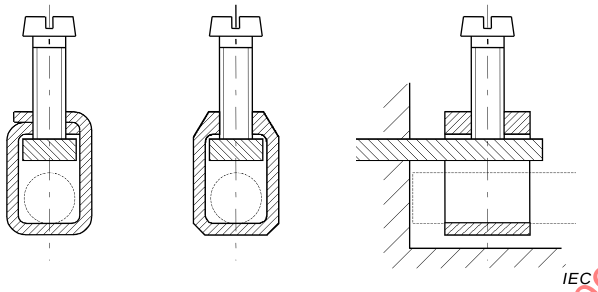


Figure E.1a – Terminals with stirrup

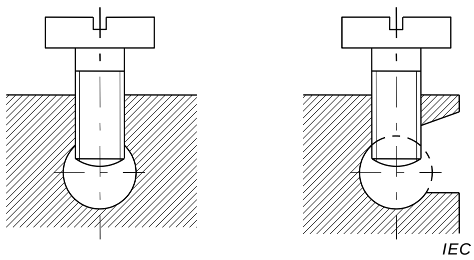


Figure E.1b – Terminals without pressure plate

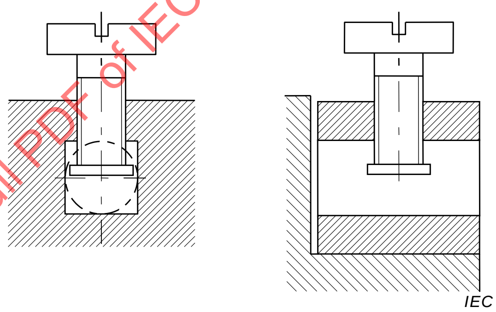


Figure E.1c – Terminals with pressure plate

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 a terminal provided with a stirrup.

Figure E.1 – Examples of pillar terminals

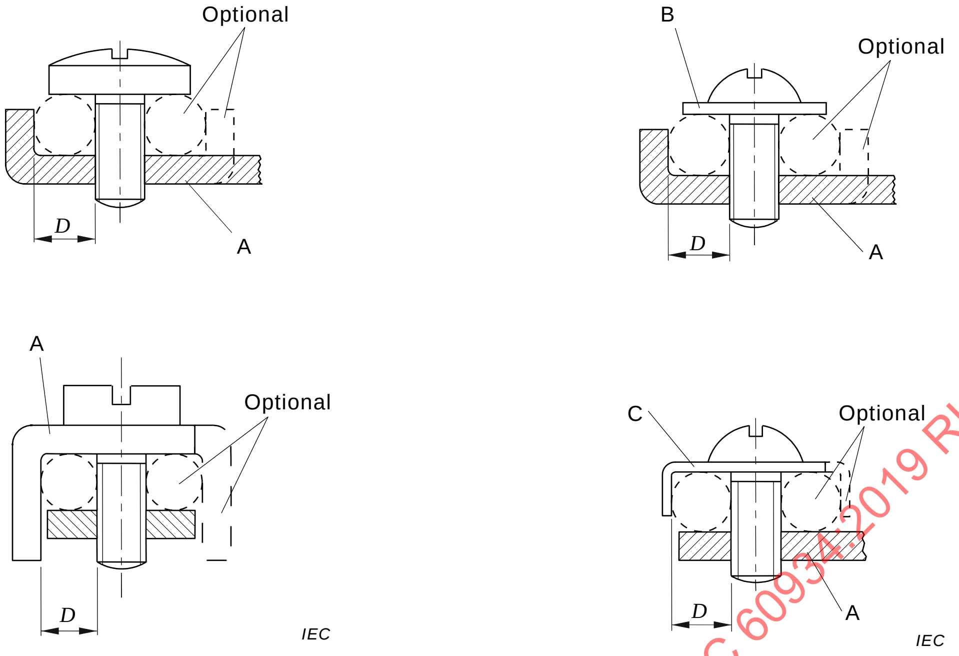


Figure E.2a – Screw terminals

Screw not requiring washer or clamping plate

Screw requiring washer, clamping plate or anti-spread device

FigureE.2b – Stud terminals

A fixed part

B washer or clamping plate

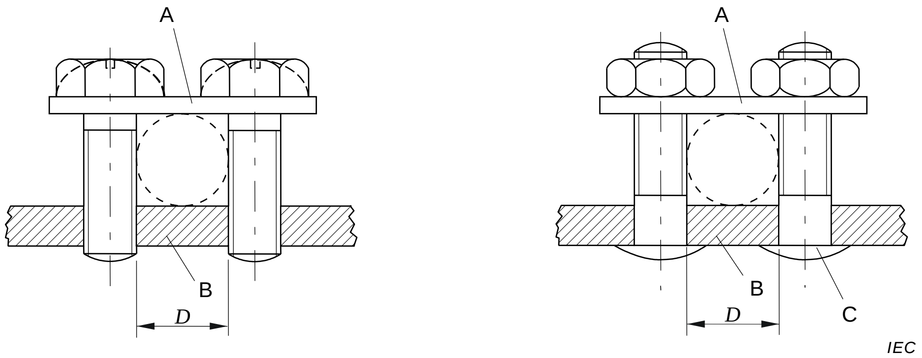
C anti-spread device

D conductor space

E stud

The part which retains the conductor in position may be of insulating material, provided the pressure necessary to clamp the conductor is not transmitted through the insulating material.

Figure E.2 – Examples of screw terminals and stud terminals



A saddle

B fixed part

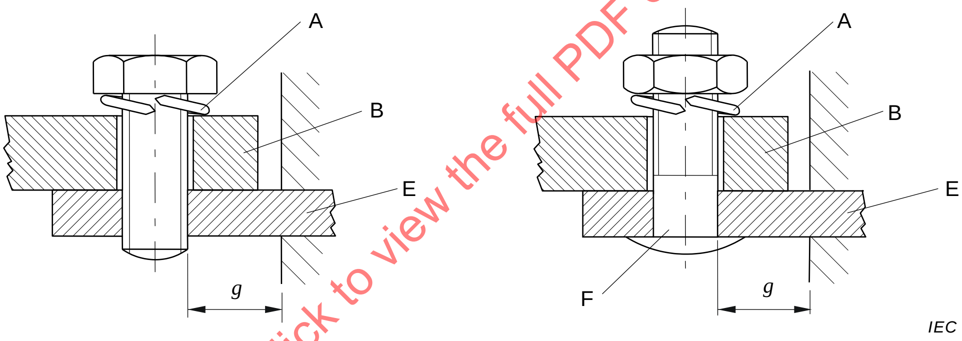
C stud

D conductor space

The two faces of the saddle may be of different shapes to accommodate conductors of either small or large cross-sectional area, by inverting the saddle.

The terminals may have more than two clamping screws or studs.

Figure E.3 – Examples of saddle terminals



A locking means

B cable lug or bar

E fixed part

F stud

g distance

For this type of terminal, a spring washer or equally effective locking means shall be provided and the surface within the clamping area shall be smooth.

For certain types of equipment, the use of lug terminals of sizes smaller than that required is allowed.

Figure E.4 – Examples of lug terminals

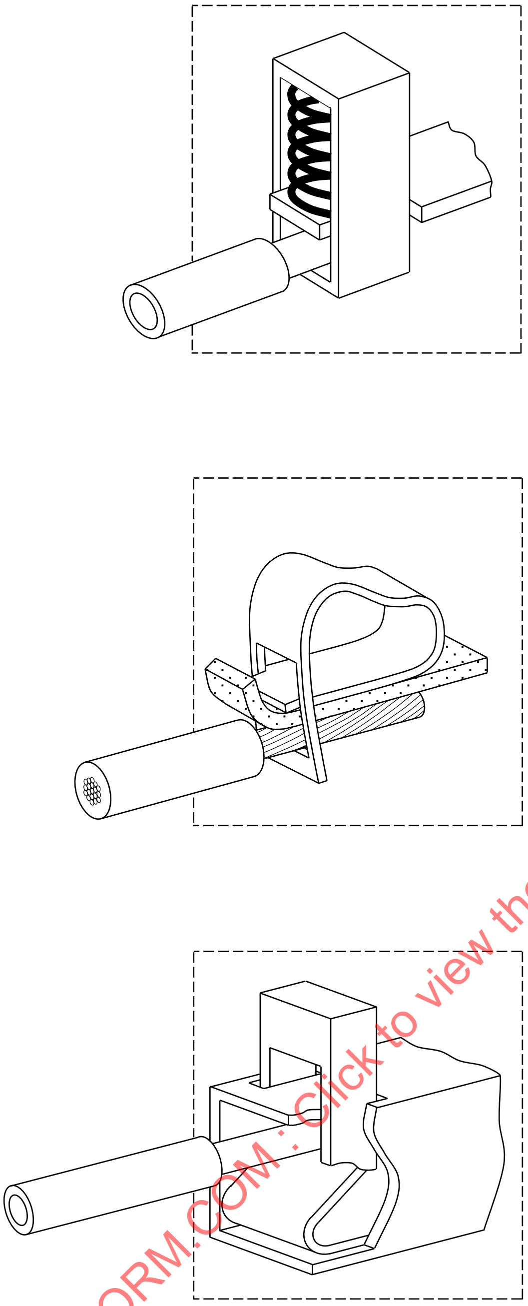
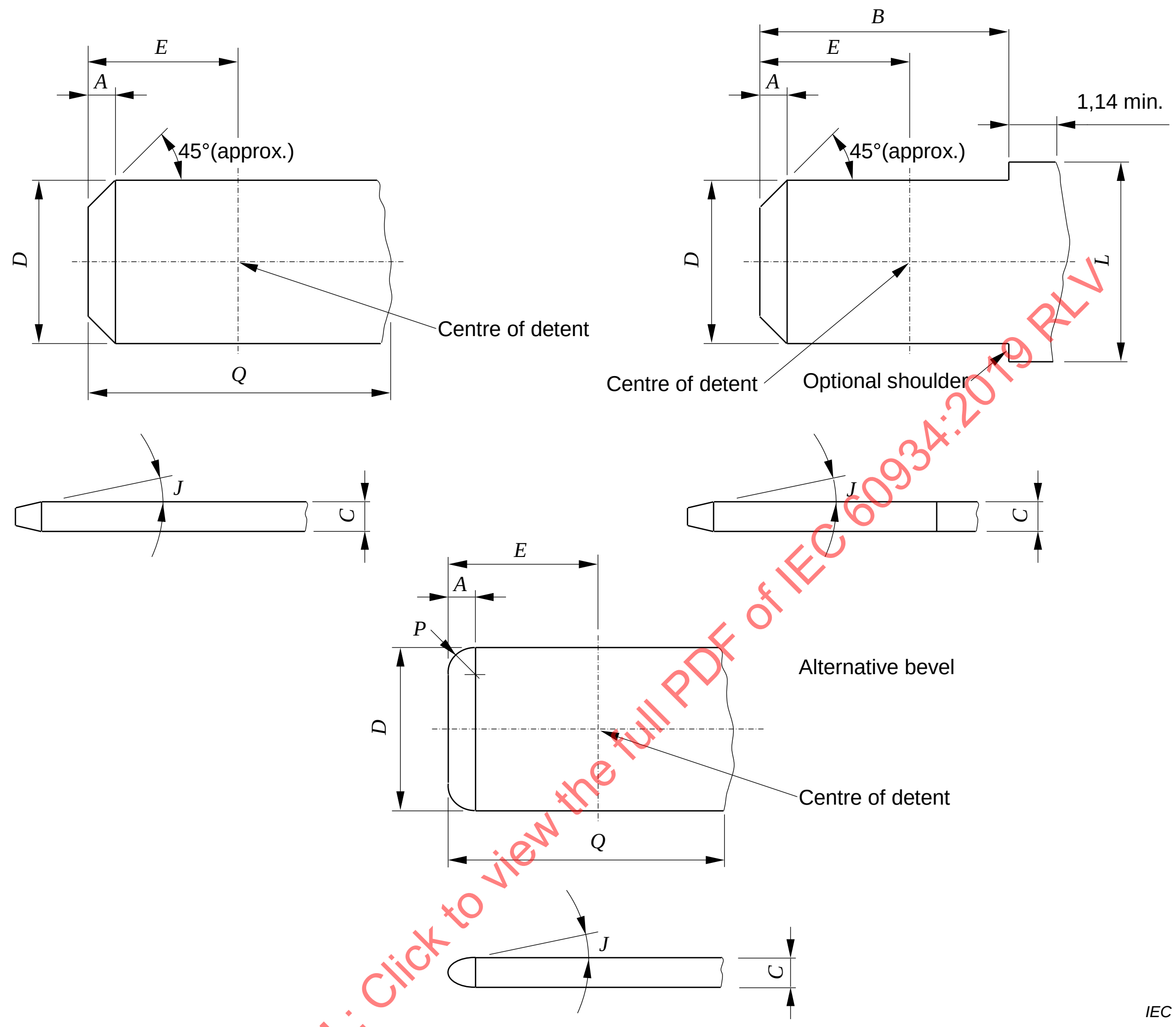


Figure E.5 – Examples of screwless terminals

The dimensions for the flat quick-connect male tabs in Figures E.6 to E.13 are given in 8.1.7.

Dimensions in millimetres



Bevel *A* of 45° need not be a straight line if it is within the confines shown.

Dimension *L* is not specified and may vary according to the application (for example fixing).

Dimension *C* of tabs may be produced from more than one layer of material provided that the resulting tab complies in all respects with the requirements of this document.

A radius on the longitudinal edge of the tab is permissible.

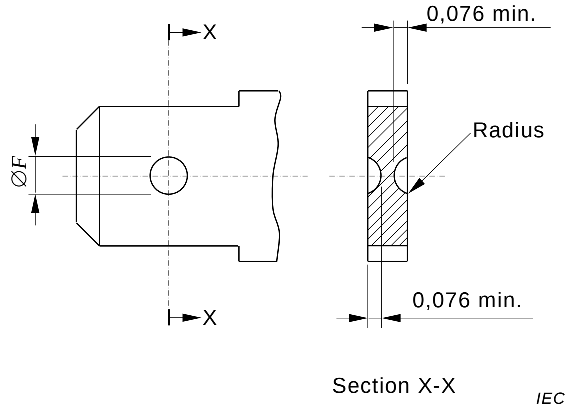
The sketches are not intended to govern the design except with regard to the dimensions shown.

The thickness *C* of the male tab may vary beyond *Q* or beyond *B* + 1,14 mm.

All portions of the tabs shall be flat and free of burrs or raised plateaux, except that there may be a raised plateau over the thickness of 0,025 mm per side, in the area defined by a line surrounding the detent and distant from it by 1,3 mm.

Figure E.6 – Dimensions of male tabs

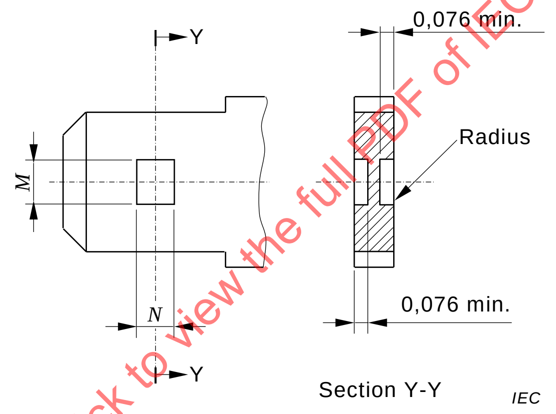
Dimensions in millimetres



The detent shall be located within 0,076 mm of the centre-line of the tab.

Figure E.7 – Dimensions of round dimple detents of male tabs (see Figure E.6)

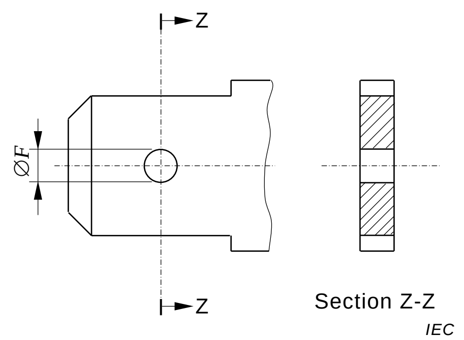
Dimensions in millimetres



The detent shall be located within 0,13 mm of the centre-line of the tab.

Figure E.8 – Dimensions of rectangular dimple detents of male tabs (see Figure E.6)

Dimensions in millimetres



The detent shall be located within 0,076 mm of the centre-line of the tab.

Figure E.9 – Dimensions of hole detents of male tabs (see Figure E.6)

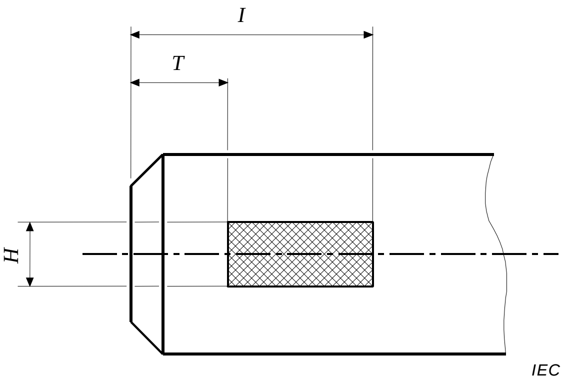


Figure E.10 – Dimensions of male tabs

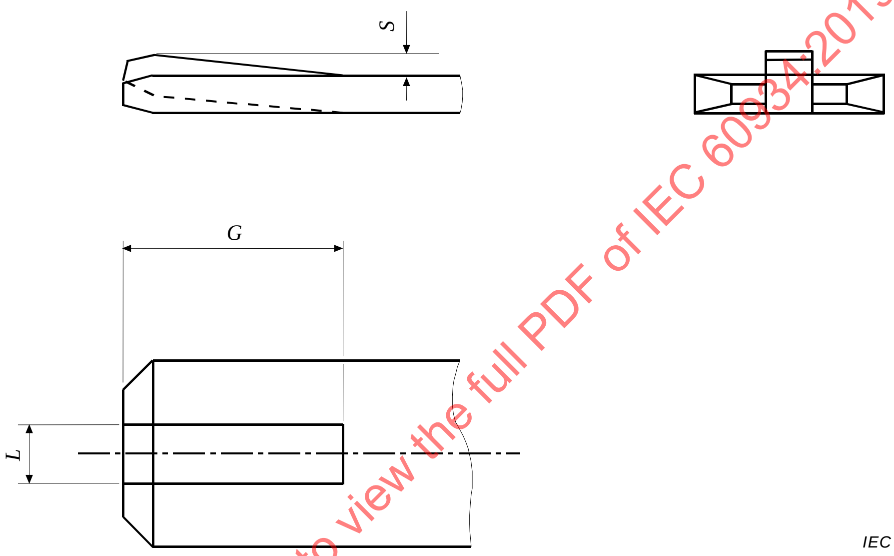


Figure E.11 – Dimensions of male tabs

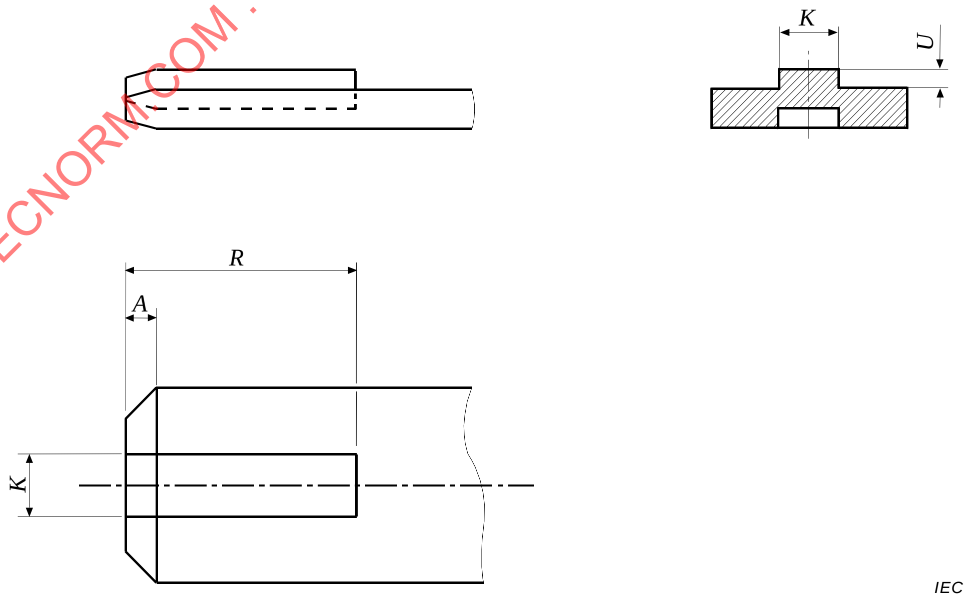


Figure E.12 – Dimensions of male tabs

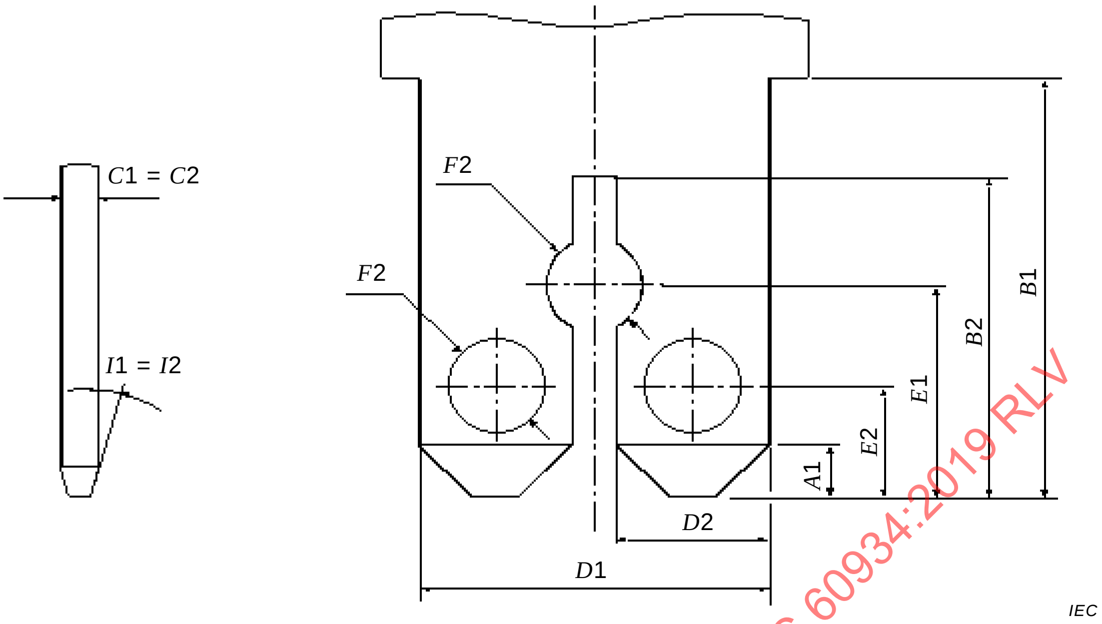
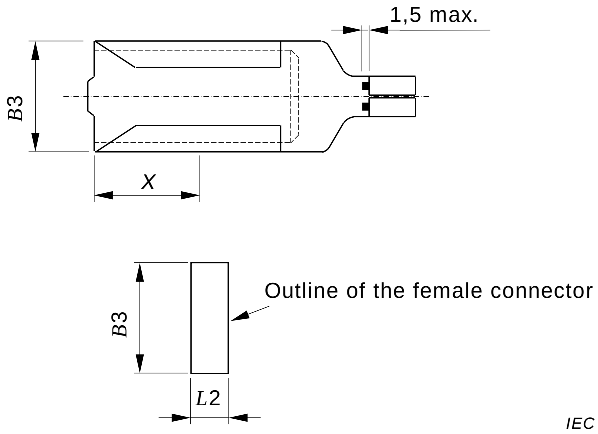


Figure E.13 – Dimensions of male tabs for two different sizes of female connectors
(see 8.1.7.1)

Dimensions in millimetres



For determining female connector dimensions varying from *B*3 and *L*2, it is necessary to refer to the tab dimensions in order to ensure that in the most onerous conditions the engagement (and detent if fitted) between tab and female connector is correct.

If a detent is provided, dimension *X* is at the manufacturer's discretion in order to meet the requirements of the performance clauses.

Female connectors should be so designed that undue insertion of the conductor into the crimping area is visible or prevented by a stop in order to avoid any interference between the conductor and a fully inserted tab.

The sketches are not intended to govern the design except as regards the dimensions shown.

Tab size	**Dimensions of female connector**			
	mm		in	
	***B*3 max**	***L*2 max**	***B*3 max**	***L*2 max**
2,8 x 0,5	3,8	2,3	0,150	0,091
2,8 x 0,8	3,8	2,3	0,150	0,091
4,8 x 0,8	6,2	2,9	0,244	0,114
6,3 x 0,8	7,8	3,5	0,307	0,138
9,5 x 1,2	11,1	4,0	0,437	0,157

Figure E.14 – Dimensions of female connectors for male tabs

Annex F
(informative)

Coordination between a CBE and a short-circuit protective device (SCPD) associated in the same circuit

F.1 General

In most applications, CBEs are part of an electrical system in which two or more overcurrent protective devices are associated in the same circuit.

It is therefore necessary to consider the aspects of system coordination, such as:

a) back-up protection;

b) discrimination.

Annex F deals mainly with back-up protection, but also gives guidance concerning discrimination.

Back-up protection becomes necessary whenever the prospective short-circuit current at the location of the CBE exceeds the rated short-circuit capacity of the CBE.

If a rated short-circuit capacity (see 5.2.7) is not assigned by the manufacturer, the rated switching capacity (see 5.2.5) shall be used instead of the rated short-circuit capacity.

In many locations the prospective short-circuit current is likely to exceed the rated short-circuit capacity (or the rated switching capacity, where applicable), of the CBE.

It is therefore required that, unless CBEs are capable of reliably breaking the prospective fault current, appropriate back-up protection shall be provided as an integral part of the equipment or shall be specified in the manufacturer's instructions.

If the maximum fault current exceeds the rated short-circuit capacity of the CBE, the requirements can only be satisfied if proper coordination between the CBE and the SCPD is verified.

Annex F gives guidance indicating how, on the basis of desk studies and/or tests, co-ordination may be achieved.

It also provides guidance on the type of information which should be made available to the prospective user.

F.2 Overview

Annex F gives guidance on the coordination between a CBE and a SCPD which may be either a fuse or a circuit-breaker.

It states

– the general requirements for the coordination of a CBE with its associated SCPD;
– the requirements for the back-up protection of a CBE by a fuse or a circuit-breaker;
– the association of a CBE and an SCPD for which, under certain conditions, discrimination and/or back-up protection may be verified by desk study;
– the methods to be used for the verification of coordination by desk study;

– the tests intended to verify that the conditions for coordination have been met.

F.3 General requirements for co-ordination of a CBE with an associated SCPD

F.3.1 General considerations

A CBE connected in series with a SCPD will interrupt a short-circuit current up to the selectivity limit current I_S without the aid of the SCPD.

For currents higher than I_S, the CBE with its associated SCPD shall safely operate at all values of overcurrent up to the conditional short-circuit current I_{nc}.

For back-up protection, the following considerations apply.

a) If the value of the prospective fault current at the point of installation is less than the rated short-circuit capacity of the CBE, it may be assumed that the SCPD is only in the circuit for considerations other than those of back-up protection.

b) If the value of the prospective fault current at the point of installation exceeds the rated short-circuit capacity of the CBE, the SCPD shall be so selected as to ensure compliance with the requirements of F.3.2 and F.3.3.

F.3.2 Requirements concerning back-up protection

F.3.2.1 General behaviour

For all values of overcurrent exceeding I_S, up to and including the rated conditional short-circuit current assigned to the CBE with its associated SCPD, the making operation of the CBE as well as the breaking operation of the association shall not give rise to external manifestations which would endanger the operator or constitute a risk of fire. For CBEs of performance category 2, the association shall be such that the CBE remains fit for further use. Compliance is checked by the relevant tests of 9.12.

F.3.2.2 Take-over current

The take-over current I_B shall be not greater than the rated short-circuit capacity of the CBE alone ($I_B \leq I_{cn}$).

F.3.3 Requirements concerning discrimination

For all values of overcurrent up to the selectivity limit current I_S, the CBE shall break the current without causing a back-up circuit-breaker to open or impairing a back-up fuse for further use.

F.3.4 Required information

The verification of coordinated short-circuit protection requires information on the performance of the CBE as well as the SCPD. This information comprises the following.

For the CBE:

– type and rating;
– the operating characteristic;
– the I^2t withstand capacity;
– the rated short-circuit capacity I_{cn};
– the rated conditional short-circuit current I_{nc} (see 5.2.6);
– the current at which electrodynamic contact separation can occur;
– the current at which welding of contacts can occur.

Where the SCPD is a circuit-breaker:

– type and rating of the circuit-breaker;
– energy-limiting class, if available and applicable;
– the operating characteristics of the circuit-breaker;

NOTE This information includes the instantaneous tripping current I_i.

– the non-tripping values of the time/current-operating characteristics of the circuit-breaker;
– the rated short-circuit capacity of the circuit-breaker.

Reference should be made to the relevant IEC standard.

Where the SCPD is a fuse:

– type and rating of the fuse;
– the operating characteristic;
– the pre-arcing characteristic;
– the rated breaking capacity of the fuse.

Reference should be made to IEC 60269.

F.4 Verification of coordination

F.4.1 General considerations including the conditions for verification by desk study

If the required information according to F.3.4 is available, coordination can, for some associations, be determined by comparison of the individual characteristics, provided the CBE incorporates only overload protection and satisfies, in addition, the following two conditions:

a) the prospective short-circuit current does not exceed 1 500 A;
b) electrodynamic contact separation and contact welding do not occur at currents up to the rated conditional short-circuit current I_{nc}.

An example of an association for which coordination can be verified by desk study is shown in Figure F.1.

For the verification of short-circuit coordination, where applicable, it is recommended to use I^2t characteristics rather than the time/current characteristic.

NOTE At present, some relevant characteristics may not be available, because the standards do not specify how they should be evaluated. An example is given in F.3.2.1.

For some associations individual characteristics may be available, but some may not allow prediction of the behaviour of the association. The series connection of two magnetic circuit-breakers of comparable instantaneous trip times may serve as an example. Such an association will allow prediction of the range of discrimination by desk study, but will not permit verification of the conditional short-circuit current without tests.

F.4.2 Verification of discrimination

F.4.2.1 Verification of discrimination by desk study

For certain associations, discrimination can be verified by superimposing the relevant characteristics, drawn to the same scale. Examples are shown in

– Figure F.1 for a thermally operated CBE backed up by a thermal-magnetic circuit-breaker;
– Figure F.2 for a thermally operated CBE, backed up by a fuse;

– Figure F.3 for a thermal-magnetic CBE, backed up by a thermal-magnetic circuit-breaker;
– Figure F.4 for a hydraulic-magnetic CBE, backed up by a thermal-magnetic circuit-breaker;
– Figure F.5 for a thermally operated CBE backed up by a hydraulic-magnetic circuit-breaker.

For some associations, discrimination can not be verified at present by desk study, because the required non-operating characteristic of the back-up circuit-breaker (= unlatching characteristic) is not available. This refers to an association of an energy-limiting CBE with a conventional thermal-magnetic back-up circuit-breaker.

The curves of the tripping characteristics made available by the manufacturers presently state the limits of actual time which may elapse until the current is interrupted. These curves are referred to the prospective short-circuit current.

The required curve should show the response of the back-up circuit-breaker to current pulses shorter than a half-wave and differing from the sinusoidal shape. Such curves are not at present standardized. The use of the curves presently provided by the manufacturer of the back-up circuit-breakers would lead to wrong conclusions. Figure F.6 gives an example.

F.4.2.2 Verification of discrimination by tests

Verification by tests is necessary when the conditions described in F.3.1 are not satisfied. This applies to some associations of CBEs with back-up circuit-breakers as mentioned in F.3.2.1. It does not apply to associations of CBEs with fuses, where the pre-arcing characteristic of the fuse is available.

F.4.2.3 Verification of I_S

Tests for the verification of I_S shall be carried out in accordance with 9.12, except that the sequence of operations at each test current shall be O-t-O and the power factor shall be 0,6 ± 0,05. The test shall be repeated with higher test currents until tripping of the back-up circuit-breaker occurs. The highest value of the test current for which tripping of the back-up circuit-breaker did not occur is the selectivity limit current I_S.

One sequence of tests shall be repeated on the association with this current.

F.4.3 Verification of coordinated back-up protection

F.4.3.1 Verification of coordinated back-up protection by desk study

a) For CBEs of performance category 1 (PC1: see 5.2.6.2)

   Compliance with the requirements of F.3.2.2 is not relevant, since the verification of I_B requires tests in accordance with F.4.3.2.

b) For CBEs of performance category 2 (PC2: see 5.2.6.3)

   Compliance with the requirements of F.3.2 can be checked by desk study, provided the conditions of F.3.1 are satisfied and the information as listed below is available:

   – operating characteristic of the CBE;
   – operating characteristic of the SCPD;
   – rated short-circuit capacity or, where relevant, rated switching capacity of the CBE;
   – maximum I^2t value which the CBE can withstand;
   – peak current, up to which contact welding will not occur;
   – peak current, up to which electrodynamic contact separation will not occur.

Illustrations are given in Clause F.5.

F.4.3.2 Verification of coordinated back-up protection by tests

Compliance with the requirements of F.2.2 can be verified by the conditional short-circuit current tests in accordance with 9.12.

NOTE Subclause 9.12 states the different criteria of acceptance for the performance categories PC1 and PC2.

The initial verification of compliance with the requirement $I_B \leq I_{cn}$ (see F.2.2.2) shall be effected by desk study.

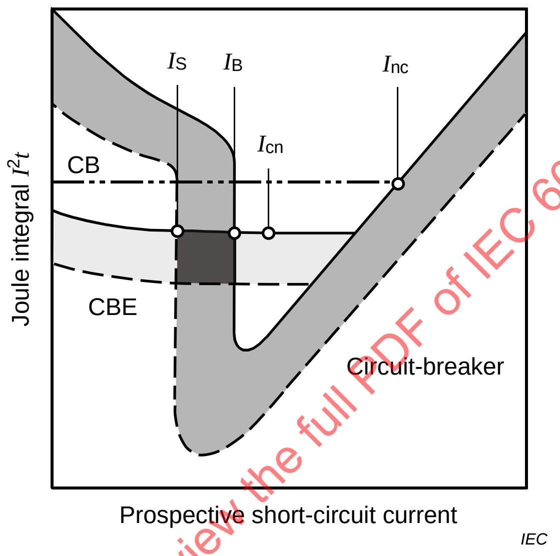
F.5 Examples of verification of coordination by desk study

In Clause F.5 illustrative examples are given to show for which associations of CBE and SCPD coordination may or may not be verified by superimposing comparable characteristics drawn to the same scale.

For some examples, time-current characteristics – suitable for showing the whole range of currents in one figure – are used; for others the I^2t versus current characteristics were taken, these being particularly suitable to cover the short-circuit range of currents.

Throughout Clause F.5, the following symbols are used:

——— (solid line)	Operating characteristic
– – – – (dashed line)	Non-tripping values of the time/current characteristic of the back-up circuit-breaker Pre-arcing characteristic of the back-up fuse
I^2t (dash-dot line)	Withstand capacity of a "thermal" CBE
(light grey box)	Operating zone of CBE
(dark grey box)	Operating zone of SCPD
I_{cn}	Rated short-circuit capacity (CBE)
I_B	Take-over current
I_{nc}	Rated conditional short-circuit current of the association
I_S	Selectivity limit current



Conclusion

For PC1

I_S and I_B can be determined by desk study.

I_{cn} can only be determined by tests.

For PC2

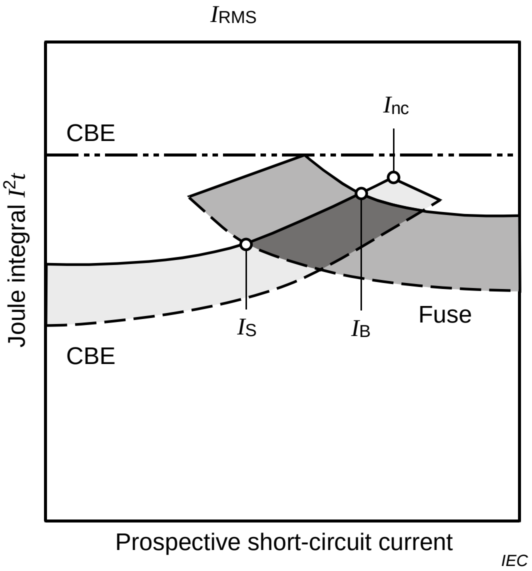
I_S and I_B can be determined by desk study.

I_{nc} can also be determined, provided contact welding does not occur below I_{nc}.

Comments

Range of test current I_T	**Behaviour of CBE and circuit-breaker**
$I_T < I_s$	CBE will interrupt, circuit-breaker will stay closed
$I_S < I_T < I_B$	CBE or circuit-breaker may interrupt. At least one device will interrupt
$I_B < I_T < I_{nc}$	CBE will not suffer thermal damage.

Figure F.1 – Thermal only CBE, backed up by thermal magnetic circuit-breaker



Conclusion

For PC1

I_S and I_B can be determined by desk study.

For PC2

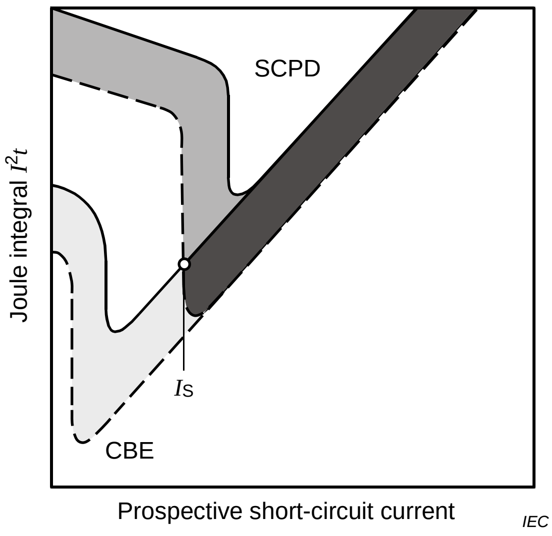
I_S and I_B can be determined by desk study.

I_{nc} is not determined by the thermal withstand capacity, but only by contact welding.

Comments

Range of test current I_T	Behaviour of CBE and fuse
$I_T < I_s$	CBE will interrupt.
$I_S < I_T < I_B$	CBE or fuse may interrupt. Fuse will be impaired.
$I_B < I_T < I_{nc}$	Only fuse will interrupt. CBE will stay closed (or may open with delay).

Figure F.2 – Thermal only CBE, backed up by a fuse



Conclusion

For PC1 and PC2

Only I_S can be determined by desk study.

Comments

Below I_S only the CBE will interrupt. Above I_S the CBE and the back-up circuit-breaker may be involved in the breaking operation.

Figure F.3 – Thermal-magnetic CBE backed up by thermal-magnetic circuit-breaker

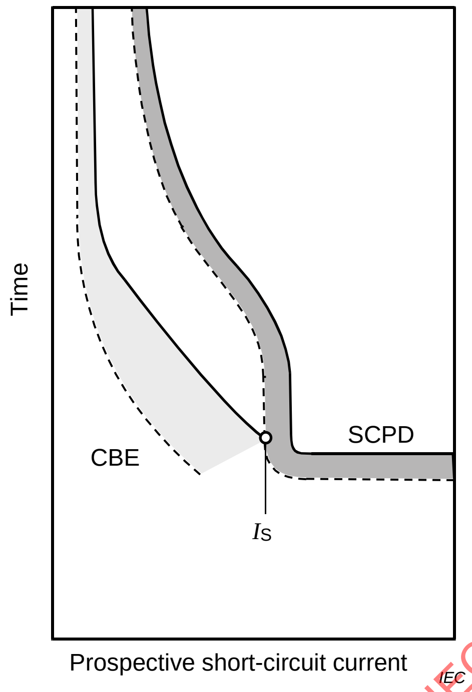
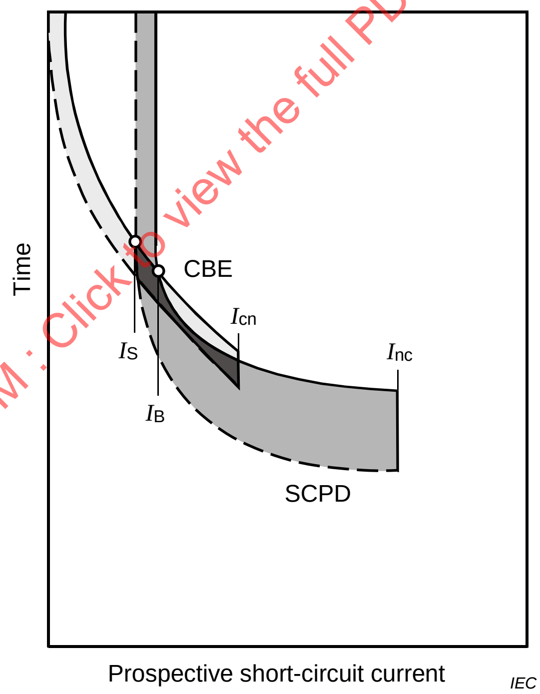


Figure F.4 – Hydraulic-magnetic CBE backed up by thermal-magnetic circuit-breaker

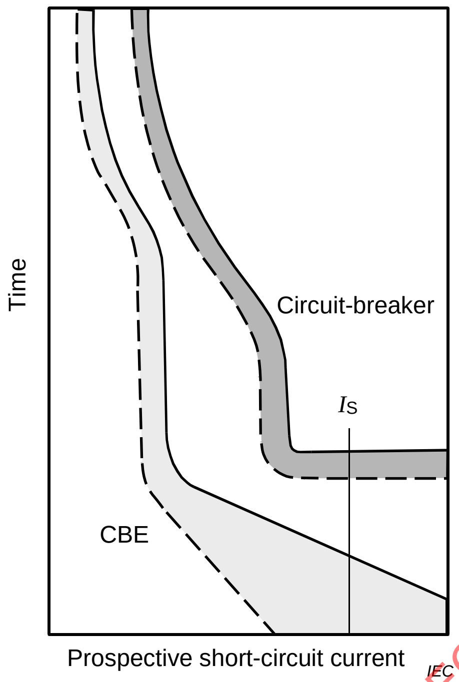


Conclusion for Figures F.4 and F.5

For PC1 and PC2

Only I_S can be determined by desk study. Back-up protection is verified by test.

Figure F.5 – Thermal CBE backed up by a hydraulic-magnetic circuit-breaker



Comments

This presentation of two characteristics as presently provided by the manufacturers implies absolute discrimination, because the curves do not intersect.

However, a test shows that the back-up circuit-breaker in this example will delatch (and open) at a current I_S, as shown in the figure.

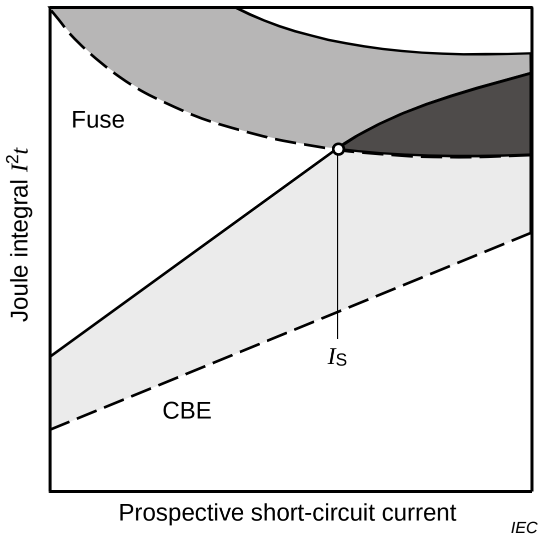
Reason:

The given characteristic of the back-up circuit-breaker does not reflect its response to pulses shorter than a half wave.

Conclusion

For an association as shown by Figure F.6 the available characteristics of the circuit-breaker do not allow the determination of I_S by desk study.

Figure F.6 – Energy-limiting CBE, backed up by thermal-magnetic circuit-breaker



Comment

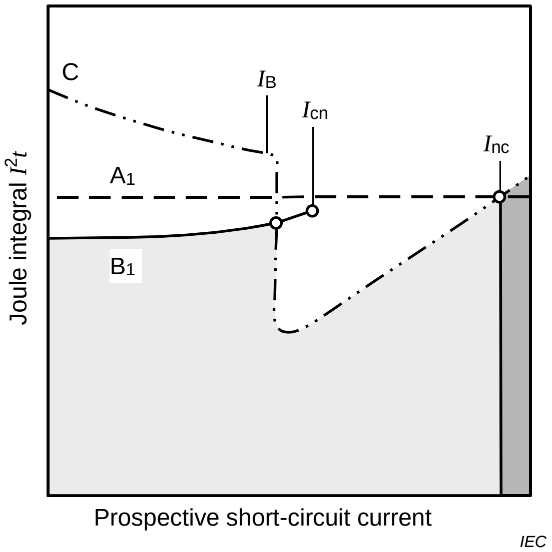
The available characteristics of this association are compatible, and this is shown by the pre-arcing characteristic of the fuse overlapping the let through I^2t characteristic of the CBE.

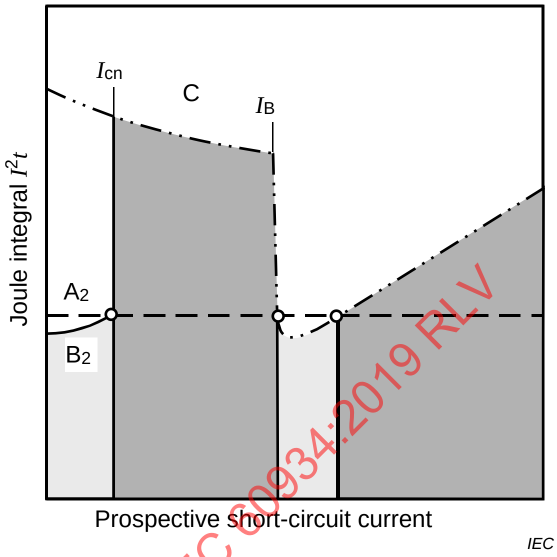
Conclusion

I_S can be determined by desk study.

Figure F.7 – Energy-limiting CBE, backed up by a fuse

The two examples in Figure F.8 show I^2t versus current characteristics of two different thermally operated CBEs of 7 A rating, backed up by the same thermal-magnetic circuit-breaker of 20 A rating.





A_1 A_2 = I^2t withstand capacities of the two CBEs

B_1 B_2 = I^2t operating characteristics of the two CBEs

C = I^2t operating characteristics of the back-up circuit-breaker

Index 1, 2 = different CBEs

Safe zone of operation S*

Unsafe zone of operation*

* According to performance category 2 (fit for further use).

Conclusion

This association provides coordinated protection up to I_{nc}.

Condition $I_B < I_{cn}$ is satisfied.

Figure F.8a – Proper coordination

Conclusion

This association does not provide coordinated protection as defined by this document.

The desk study reveals this shortcoming.

Figure F.8b – Improper coordination

Figure F.8 – Examples illustrating proper and improper coordination

Annex G
(normative)

Electromagnetic behaviour of CBEs

G.1 General

CBEs are designed specifically for being incorporated in equipment. The product standards of the various equipment specify the immunity and emission requirements the equipment has to meet, depending upon the environment where they are designed to operate. The manufacturers of equipment in designing and assembling the relevant components take into account the electromagnetic compatibility (EMC) standards (if any) for the specific equipment or the generic standards of the environment where the equipment will operate. So the EMC conditions to be fulfilled by the components (like CBEs) may differ, depending upon their incorporation in equipment. Therefore, no EMC general requirements are stated for CBEs.

Nevertheless, information shall be made available to equipment manufacturers on the electromagnetic emission and immunity characteristics of CBEs, when relevant, in order to make an appropriate choice for incorporation in the equipment to be protected.

To this purpose, Annex G gives information on EMC behaviour of CBEs depending on their design, defines the minimum EMC performances required for CBEs and states the additional information on EMC characteristics that the CBE manufacturer shall make available to the equipment manufacturer for the appropriate choice of CBEs.

G.2 Immunity

G.2.1 CBEs not incorporating electronic circuits

CBEs not incorporating electronic circuits are not sensitive to electromagnetic disturbances and, therefore, no immunity tests are required.

The behaviour of CBEs with overvoltage or undervoltage release in case of voltage dips, short interruptions and voltage variations is verified by the tests of 8.5.4.

G.2.2 CBEs incorporating electronic circuits

a) CBEs incorporating simple rectifiers alone are not sensitive to electromagnetic disturbances and, therefore, no immunity specifications are necessary.

b) For CBEs with releases incorporating electronic circuits other than those of G.2.2 a), the manufacturer shall indicate the performances under the following test conditions:
   - conducted fast transients (bursts), specified in IEC 61000-4-4;
   - surge (1,2/50 µs) immunity, specified in IEC 61000-4-5;
   - electrostatic discharges, specified in IEC 61000-4-2;
   - radiated high-frequency electromagnetic field, specified in IEC 61000-4-3.

These performances shall in any case be such as to satisfy the tests at the levels indicated in Table G.1 as a minimum.

Table G.1 – Minimum EMC immunity performances of CBEs

Type of test	Severity level to IEC 61000-4	Values
1,2/50 µs surges IEC 61000-4-5	3	2 kV (CM) [a] 1 kV (DM) [b]
Fast transients (bursts) IEC 61000-4-4	3	2 kV
Electromagnetic field IEC 61000-4-3	2	3 V/m
Electrostatic discharges IEC 61000-4-2	3	6 kV [c] air discharge

[a] Common mode.

[b] Differential mode.

[c] Applied to the front/operating mean.

The generic performance criteria as specified in IEC 61000-6-1 apply.

After the tests of Table G.1, the CBE shall meet the requirements of 8.5.1 at 2 I_n and, if applicable, of 8.5.4.

G.3 Emission

G.3.1 CBEs not incorporating electronic circuits

CBEs not incorporating electronic circuits do not generate continuous disturbances and only generate transient disturbances during switching. The frequency and the consequences of these transient disturbances are considered as part of the normal electromagnetic environment of low-voltage installations. No EMC specifications are necessary for this type of CBE.

G.3.2 CBEs incorporating electronic circuits

a) CBEs not incorporating a continuously operating oscillator do not usually generate continuous or transient disturbances except during their switching process. The frequency, the level and the consequences of such emissions are considered as part of the normal electromagnetic environment of low-voltage installations.

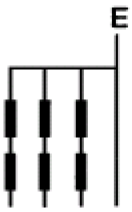
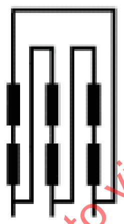
b) For CBEs incorporating a continuously operating oscillator the manufacturer shall indicate the performances under the test conditions of CISPR 32 (0,15 MHz to 30 MHz and 30 MHz to 1 000 MHz).

Annex H
(normative)

Correlation between nominal voltage of the supply systems and the line-to-neutral voltage relevant for determining the rated impulse voltage

The rated impulse voltages given in Table H.1 are based on the assumption that a protective measure is necessary and that such measure is provided by the inclusion of surge arresters having a ratio of clamping voltage to minimal voltage not smaller than that specified by IEC 60099-1.

Table H.1 – Nominal voltages and corresponding rated impulse voltages

Voltage line-to-neutral derived from nominal voltages AC or DC up to and including	Nominal voltages presently used in the world				Rated impulse voltage for equipment		
					Overvoltage category		
	Three-phase four-wire systems with earthed neutral	Three-phase three-wire systems unearthed	Single-phase two-wire systems AC or DC	Single-phase three-wire systems AC or DC	I	II	III
V	V	V	V	V			
							
50	Not applicable	Not applicable	12,5 24 25 30 42 48	30 to 60	330	500	800
100	66/115	66	60		500	800	1 500
150	120/208 [b] 127/220	115, 120, 127	100 [c] 110, 120	100 to 200 [c] 110 to 120 120 to 240	800	1 500	2 500
300	220/380, 230/400, 240/415, 260/440, 277/480	220, 230, 240 260, 277, 347 380, 400 [a], 415 440, 480	220	220 to 440	1 500	2 500	4 000
600	347/600, 380/660, 400/690, 417/720, 480/830	500, 577, 600	480	480 to 960	2 500	4 000	6 000
1 000		660 690, 720, 830, 1 000	1 000		4 000	6 000	8 000

[a] For 3-phase-3 wire systems derived from 3-phase-4 wire supply with earthed neutral point.

[b] Practice in the United States of America and in Canada.

[c] Practice in Japan.

Annex I
(normative)

Routine or statistical tests

I.1 General

The tests specified in Annex I are intended to reveal, as far as safety is concerned, unacceptable variations in material or manufacture.

Further tests may be made to ensure that every CBE conforms with the samples that withstood the tests of this document, according to the experience gained by the manufacturer.

Engineering and statistical analyses may show that routine tests on each CBE may not always be required, in which case tests may be made on a statistical basis.

I.2 Verification of the tripping characteristic

Unless otherwise agreed between manufacturer and customer, these routine tests shall be made in accordance with 9.10, but with the following test currents.

a) For CBEs with TO mode of tripping:
   – with a current of approximately 2 I_n, the CBE shall trip within the time limits defined by the time-current zone indicated by the manufacturer.

b) For CBEs with MO mode of tripping:
   – with a current of 0,95 I_{ni} applied for 0,1 s, the CBE shall not trip;
   – with a current of 1,05 I_i, the CBE shall trip within 0,15 s.

c) For CBEs with TM mode of tripping:
   – with the current of 0,95 I_{ni} applied for 0,1 s, the CBE shall not trip;
   – with the current of 1,05 I_i, the CBE shall trip within 0,1 s;
   – with the current of 2 I_n, the CBE shall trip within the time limits defined by the time-current zone indicated by the manufacturer.

d) For CBEs with HM mode of tripping:
   – with the currents of 2 I_n and of 6 I_n, the CBE shall trip within the time limits defined by the time-current zone indicated by the manufacturer.

e) For CBEs with EH mode of tripping:
   – with two currents specified by the manufacturer, the CBE shall trip within the time limits defined by the time-current zone indicated by the manufacturer.

I.3 Verification of dielectric strength

A voltage of substantially sine wave form, of values specified in Table 20 having a frequency of 50 Hz or 60 Hz is applied for 1 s

a) with the CBE in the open position, between the terminals which are electrically connected together when the CBE is in the closed position;

b) with the CBE in the closed position, between each pole of the CBE in turn and the other poles connected together with the CBE not incorporating electronic components, if applicable;

c) for the CBE incorporating electronic components, with the CBE in the open position, between each pole in turn and the adjacent poles, if applicable, either between incoming terminal of the poles or outgoing terminal of the poles, depending on the position of the electronic components and the other poles connected together.

No flashover or breakdown shall occur.

Alternatively, any convenient method of verification of the clearances between contacts (for example X-ray verification) may be used.

Annex J
(normative)

Additional requirements for electrical performance of E-type CBEs

Void.

Annex K
(normative)

Additional requirements for CBEs suitable for isolation

K.1 General

CBEs of M-type and S-type method of operation having performance category PC2 complying with the requirements and tests of the main clauses of this document and in addition with the requirements and tests of Annex K are suitable for isolation.

The requirements of Annex K supplement, modify or replace certain of the general requirements of the main clauses.

The clause numbering in Annex K follows the pattern and corresponding references of the main clauses.

The absence of reference to a clause or subclause means that the corresponding requirements of that clause or subclause are applicable.

K.6 Marking and other product information

The manufacturer shall give the following statement in his literature: "Single pole devices may not be used for isolation.".

K.8 Requirements for construction and operation

K.8.1.2 Mechanism

CBEs suitable for isolation shall provide in the open position an isolating distance in accordance with the requirements for isolation.

The indication of the position of the main contacts shall be provided by one or more of the following means:

– the position of the actuator;
– a separate mechanical indicator.

If a separate mechanical indicator is used to indicate the position of the main contacts, this shall show the colour red for the ON-position and the colour green for the OFF-position.

When means are provided or specified by the manufacturer to lock the operating means in the open position, locking in that position shall only be possible when the main contacts are in the open position.

NOTE In the USA, the colour “green” indicates the ON-position and “red” indicates a “tripped” condition.”

CBEs shall be designed so that the actuator, front plate or cover can only be fitted in a manner which ensures correct contact position indication and locking, if provided.

Compliance is checked by inspection, taking into account the instructions of the manufacturer.

K.8.1.3 Clearances and creepage distances

It is assumed that the conditions apply for devices suitable for isolation:

– degree of pollution 2 or 3;
– overvoltage category III.

NOTE CBEs may be suitable for higher overvoltage category or a higher degree of pollution. Such CBEs should be marked in accordance with the item m) of Clause 6.

For clearances and creepage distances between live parts of different polarity and live parts and accessible parts, Tables 1 and 2 apply.

For clearances and creepage distances between parts which are separated when the main contacts of the CBE are in the open position and between circuits supplied by different sources, Table K.1 and Table K.2 apply.

The clearances of Table K.1 are determined on the basis of the test voltages for verifying isolation as shown in Table K.3 for 2 000 m, but are referred to the rated impulse withstand voltage.

Table K.1 – Minimum clearances for CBEs suitable for isolation, between live parts separated when the contacts are in the open position, as a function of the rated impulse withstand voltage

U_{imp} kV	**0,8**	**1,5**	**2,5**	**3,0**	**3,5**	**4,0**	**4,5**	**5,5**
Pollution degree 2 clearance mm	0,5	1,0	2,0	3,0	3,5	4,0	5,5	7
Pollution degree 3 clearance mm	0,8	1,0	2,0	3,0	3,5	4,0	5,5	7

Table K.2 – Minimum creepage distances for CBEs suitable for isolation, between live parts separated when the contacts are in the open position

Material group	**I**					**II**					**III**				
Working voltage V	63	125	250	400	500	63	125	250	400	500	63	125	250	400	500
Creepage distance for pollution degree 2 mm	1,0	2,0	4,0	5,5	7,0	1,0	2,0	4,0	5,5	7,0	1,25	2,0	4,0	5,5	7,0
Creepage distance for pollution degree 3 mm	1,6	2,0	4,0	5,5	7,0	1,8	2,1	4,0	5,6	7,1	2,0	2,4	4,0	6,3	8,0
Creepage distances cannot be smaller than the associated clearance.															

For minimum clearances distances between circuits supplied by different sources, one of which being SELV or PELV, the clearances for reinforced insulation given in Table 1 shall be used.

For minimum creepage distances between circuits supplied by different sources, one of which being SELV or PELV, the distances for reinforced insulation given in Table 1 apply also, because creepage distances shall not be smaller than the associated clearance.

K.8.4.2 Isolating capability

The CBEs covered by Annex K shall be suitable for isolation.

Compliance is checked by:

- *the verification of the minimum applicable clearances and creepage distances of Tables K.1, K.2;*
- *the tests of K.9.7.7.*

K.9.7.7 Test of suitability for isolation

K.9.7.7.1 Verification of impulse withstand voltage across the open contacts

The test is carried out on a CBE fixed on a metal support.

The impulses are given by a generator producing positive and negative impulses having a front time of 1,2 µs, and a time to half-value of 50 µs, the tolerances being

- ±5 % for the peak value;
- ±30 % for the front time;
- ±20 % for the time to half-value.

The surge impedance of the test apparatus shall have a nominal value of 500 Ω.

The shape of the impulses is adjusted with the CBE under test connected to the impulse generator. For this purpose, appropriate voltage dividers and voltage sensors shall be used.

Small oscillations in the impulses are allowed provided that their amplitude near the peak of the impulse is less than 5 % of the peak value.

For oscillations on the first half of the front, amplitudes up to 10 % of the peak value are allowed.

The 1,2/50 µs impulse voltage according to Figure 6 of IEC 60060-1:2010 is applied between the line terminals connected together and the load terminals connected together with the contacts in the open position.

Three positive impulses and three negative impulses are applied, the interval between consecutive impulses being at least 1 s for impulses of the same polarity and being at least 10 s for impulses of the opposite polarity.

The test impulse voltage values shall be chosen in Table K.3, in accordance with the rated impulse voltage of the CBE as given in Table H.1. These values are corrected for barometric pressure and/or altitude at which the tests are carried out, according to Table K.3.

There shall be no unintentional disruptive discharges during the test.

Table K.3 – Test voltages for verifying isolation across the open contacts, as a function of the rated impulse withstand voltage and the altitude where the test is carried out

Rated impulse withstand voltage kV	**Test voltage (1,2/50 µs pulse) in kV and corresponding altitudes [a]**				
	Sea level	**200 m**	**500 m**	**1 000 m**	**2 000 m**
0,8 and less	1,8	1,7	1,7	1,6	1,5
1,5	2,3	2,3	2,2	2,2	2
2,5	3,5	3,5	3,4	3,2	3
3	4,4	4,3	4,2	4,1	4
3,5	5,3	5,2	5,0	4,8	4,5
4	6,2	6,0	5,8	5,6	5
4,5	7,1	6,9	6,6	6,5	6
5,5	8,9	8,7	8,5	8,2	7
6,0	9,8	9,6	9,3	9,0	8

[a] For other altitudes, the test voltage may be determined by interpolation.

K.9.7.7.2 Verification of leakage currents across open contacts

Each pole of the CBEs having been submitted to the tests specified in Table 11 or Table 12, section 3, is supplied at a voltage 1,1 times its rated operational voltage, the CBE being in the open position.

The leakage current flowing across the open contacts is measured and shall not exceed 2 mA.

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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La Norme internationale IEC 60934 a été établie par le sous-comité 23E: Disjoncteurs et appareillage similaire pour usage domestique, du comité d'études 23 de l'IEC: Petit appareillage.

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
23E/1084FDIS	23E/1104/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 internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Cette quatrième édition annule et remplace la troisième édition parue en 2000, l'Amendement 1:2007 et l'Amendement 2:2013. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) éclaircissements relatifs à la finalité des essais de type.

Dans le présent document, les caractères d'imprimerie suivants sont employés:

– Exigences proprement dites: caractères romains;
– *Modalités d'essais: caractères italiques*;
– Commentaires: petits caractères romains.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

DISJONCTEURS POUR ÉQUIPEMENT (DPE)

1 Domaine d'application

Le présent document est applicable aux appareils mécaniques de connexion désignés sous le nom de "disjoncteurs pour équipement" (DPE) pour applications domestiques et analogues. Selon le présent document, les DPE sont destinés à la protection des circuits internes des équipements électriques, y compris leurs composants (par exemple, les moteurs, les transformateurs, le câblage interne). Le présent document couvre aussi les DPE applicables pour la protection des équipements électriques en cas de sous-tension et/ou de surtension. Le présent document couvre aussi les DPE qui sont aptes au sectionnement.

NOTE Le terme "équipement" couvre aussi les appareils.

Les DPE ne sont pas applicables pour la protection contre les surintensités des installations câblées des immeubles.

Les DPE selon le présent document ont:

– une tension assignée n'excédant pas 440 V en courant alternatif (entre phases) et/ou n'excédant pas 250 V en courant continu;
– un courant assigné n'excédant pas 125 A;
– un pouvoir de coupure (I_{cn}) d'au moins 6 × I_n en courant alternatif et 4 × I_n en courant continu mais n'excédant pas 3 000 A.

Les DPE peuvent avoir des caractéristiques assignées de courant conditionnel de court-circuit (I_{nc}) en association avec un dispositif de protection contre les courts-circuits (DPCC) spécifié. Un guide pour la coordination d'un DPE associé dans le même circuit à un DPCC est donné à l'Annexe F.

Pour les DPE ayant un degré de protection supérieur à IP20, selon l'IEC 60529, lors d'une utilisation dans des endroits où prédominent des conditions d'environnement dangereuses (par exemple, humidité excessive, chaleur ou froid ou encore dépôt de poussière) et dans des endroits dangereux (par exemple, lieux exposés aux explosions), des constructions spéciales peuvent être exigées.

Le présent document comprend toutes les exigences nécessaires pour assurer la conformité aux caractéristiques de fonctionnement exigées pour ces appareils par les essais de type. Elle comprend également les détails relatifs aux exigences et aux modalités d'essais nécessaires pour assurer la reproductibilité des résultats.

Le présent document indique:

a) les caractéristiques des DPE;
b) les conditions auxquelles les DPE doivent satisfaire, en ce qui concerne:
   1) leur manœuvre et leur comportement en service normal;
   2) leur manœuvre et leur comportement en cas de surcharge;
   3) leur manœuvre et leur comportement en cas de court-circuit jusqu'à leur pouvoir de coupure assigné;
   4) leurs propriétés diélectriques;
c) les essais prévus pour confirmer que ces conditions sont satisfaites et les méthodes à adopter pour les essais;
d) les données devant figurer sur les appareils;

e) les séquences d'essais à effectuer et le nombre d'échantillons à soumettre pour la certification (voir Annexe C);

f) les essais individuels de série à effectuer pour déceler les changements inacceptables de matériau ou de fabrication susceptibles de compromettre la sécurité (voir Annexe I).

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60060-1:2010, *Techniques des essais à haute tension – Partie 1: Définitions et exigences générales*

IEC 60068-2-20, *Essais d'environnement – Partie 2-20: Essais – Essai T: Méthodes d'essai de la brasabilité et de la résistance à la chaleur de brasage des dispositifs à broches*

IEC 60227 (toutes les parties), *Conducteurs et câbles isolés au polychlorure de vinyle, de tension nominale au plus égale à 450/750 V*

IEC 60417, *Graphical symbols for use on equipment* (disponible en anglais seulement à l'adresse: http://www.graphical-symbols.info/equipment)

IEC 60529, *Degrés de protection procurés par les enveloppes (Code IP)*

IEC 60664-1:2007, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 1: Principes, exigences et essais*

IEC 60664-3, *Coordination de l'isolement des matériels dans les systèmes (réseaux) à basse tension – Partie 3: Utilisation de revêtement, d'empotage ou de moulage pour la protection contre la pollution*

IEC 60695-2-10, *Essais relatifs aux risques du feu – Partie 2-10: Essais au fil incandescent/chauffant – Appareillage et méthode commune d'essai*

IEC 60898-1:2015, *Petit appareillage électrique – Disjoncteurs pour la protection contre les surintensités pour installations domestiques et analogues – Partie 1: Disjoncteurs pour le fonctionnement en courant alternatif*

IEC 61000-4-2, *Compatibilité électromagnétique (CEM) – Partie 4-2: Techniques d'essai et de mesure – Essai d'immunité aux décharges électrostatiques*

IEC 61000-4-3, *Compatibilité électromagnétique (CEM) – Partie 4-3: Techniques d'essai et de mesure – Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques*

IEC 61000-4-4, *Compatibilité électromagnétique (CEM) – Partie 4-4: Techniques d'essai et de mesure – Essai d'immunité aux transitoires électriques rapides en salves*

IEC 61000-4-5, *Compatibilité électromagnétique (CEM) – Partie 4-5: Techniques d'essai et de mesure – Essai d'immunité aux ondes de choc*

IEC 61000-6-1, *Compatibilité électromagnétique (CEM) – Partie 6-1: Normes génériques – Norme d'immunité pour les environnements résidentiels, commerciaux et de l'industrie légère*

CISPR 32, *Compatibilité électromagnétique des équipements multimédia – Exigences d'émission*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1 Définitions relatives à la protection et aux appareils de connexion

3.1.1
disjoncteur
appareil mécanique de connexion capable d'établir, de supporter et d'interrompre des courants dans les conditions normales du circuit, ainsi que d'établir, de supporter pendant une durée spécifiée et d'interrompre des courants dans des conditions anormales spécifiées du circuit telles que celles du court-circuit

[SOURCE: IEC 60050-441:1984, 441-14-20]

3.1.2
disjoncteur pour équipement
DPE
disjoncteur spécialement conçu pour la protection d'un équipement

Note 1 à l'article: Ces DPE sont destinés à:

– l'interruption automatique et le réarmement non automatique ou automatique;
– l'interruption automatique, le réarmement non automatique ou automatique et les manœuvres manuelles de fermeture/ouverture.

3.1.3
DPE de type E
vide

3.1.4
fusible
coupe-circuit à fusibles
appareil dont la fonction est d'ouvrir par la fusion d'un ou de plusieurs de ses éléments conçus et calibrés à cet effet le circuit dans lequel il est inséré en coupant le courant lorsque celui-ci dépasse pendant un temps suffisant une valeur donnée. Le fusible comprend toutes les parties qui constituent l'appareil complet

[SOURCE: IEC 60050-441:1984, 441-18-01]

3.1.5
appareil de connexion
appareil destiné à établir ou à interrompre le courant dans un ou plusieurs circuits électriques

[SOURCE: IEC 60050-441:1984, 441-14-01]

3.1.6
appareil mécanique de connexion
appareil de connexion destiné à fermer et à ouvrir un ou plusieurs circuits électriques au moyen de contacts séparables

[SOURCE: IEC 60050-441:1984, 441-14-02, modifiée – La note a été supprimée.]

3.1.7
interrupteur
interrupteur mécanique
appareil mécanique de connexion capable d'établir, de supporter et d'interrompre des courants dans les conditions normales du circuit y compris éventuellement les conditions spécifiées de surcharge en service ainsi que de supporter pendant une durée spécifiée des courants dans des conditions anormales spécifiées du circuit telles que celles du court-circuit

[SOURCE: IEC 60050-441:1984, 441-14-10, modifiée – La note a été supprimée.]

3.1.8
sectionneur
appareil mécanique de connexion qui, en position d'ouverture, satisfait aux exigences spécifiées pour la fonction de sectionnement

[SOURCE: IEC 60050-441:1984, 441-14-05, modifiée – Le libellé de la définition a été changé et la note supprimée.]

3.1.9
déconnexion
interruption d'un circuit électrique dans un pôle de façon à assurer l'isolation entre l'alimentation et les parties destinées à être déconnectées de l'alimentation

3.1.10
déconnexion complète
déconnexion qui assure l'équivalent de l'isolation principale par séparation des contacts

3.1.11
microdéconnexion
déconnexion qui assure la conformité de performance par séparation des contacts

3.1.12
sectionnement
fonction de sectionnement
fonction destinée à couper l'alimentation de toutes les parties ou d'une section distincte de l'installation par séparation de l'installation de chaque source d'énergie électrique pour des raisons de sécurité

3.2 Termes généraux

3.2.1
température de l'air ambiant
température déterminée dans des conditions prescrites de l'air qui entoure le DPE complet

Note 1 à l'article: Par exemple, pour un DPE enfermé, c'est la température de l'air à l'extérieur de l'enveloppe.

[SOURCE: IEC 60050-441:1984, 441-11-13, modifiée – "la totalité de l'appareil de connexion ou du fusible" a été remplacé par "le DPE complet".]

3.2.2
tension appliquée
tension qui existe entre les bornes d'un pôle d'un DPE immédiatement avant l'établissement du courant

Note 1 à l'article: Dans le cas du courant alternatif, c'est la valeur efficace.

[SOURCE: IEC 60050-441:1984, 441-17-24, modifiée – "appareil de connexion" a été remplacé par "DPE". Note 1 à l'article a été ajoutée.]

3.2.3
circuit principal
<d'un DPE> ensemble des pièces conductrices d'un DPE insérées dans le circuit, qu'il a pour fonction de fermer ou d'ouvrir

[SOURCE: IEC 60050-441:1984, 441-15-02, modifiée – "appareil de connexion" a été remplacé par "DPE".]

3.2.4
circuit de commande
<d'un DPE> circuit (autre qu'une voie du circuit principal) destiné à la manœuvre de fermeture ou la manœuvre d'ouverture, ou les deux à la fois, d'un DPE

[SOURCE: IEC 60050-441:1984, 441-15-03, modifiée – "appareil de connexion" et "appareil" ont été remplacés par "DPE".]

3.2.5
circuit auxiliaire
<d'un DPE> ensemble des pièces conductrices d'un DPE destinées à être insérées dans un circuit autre que le circuit principal et le circuit de commande du DPE

[SOURCE: IEC 60050-441:1984, 441-15-04, modifiée – "appareil de connexion" et "appareil" ont été remplacés par "DPE" et la note a été supprimée.]

3.2.6
pôle
<d'un DPE> partie d'un DPE associé exclusivement à un chemin conducteur électriquement séparé, appartenant à son circuit principal, munie de contacts destinés à fermer et ouvrir le circuit principal lui-même, à l'exclusion des éléments assurant la fixation et le fonctionnement de tous les pôles à la fois

[SOURCE: IEC 60050-441:1984, 441-15-01, modifiée – "munie de contacts destinés à fermer et ouvrir le circuit principal lui-même," a été ajouté, "appareil de connexion" a été remplacé par "DPE" et la note a été supprimée.]

3.2.7
pôle protégé
pôle muni d'un déclencheur à maximum de courant

Note 1 à l'article: Pour la définition du déclencheur à maximum de courant, voir 3.6.2.

3.2.8
pôle non protégé
pôle sans déclencheur à maximum de courant, mais généralement capable des mêmes performances qu'un pôle protégé du même DPE

Note 1 à l'article: Pour la définition du déclencheur à maximum de courant, voir 3.6.2.

3.2.9
conducteur neutre
N
conducteur relié électriquement au point neutre et pouvant contribuer au transport de l'énergie électrique

[SOURCE: IEC 60050-826:2004, 826-14-07]

3.2.10
position de fermeture
position dans laquelle la continuité prédéterminée du circuit principal d'un DPE est assurée

[SOURCE: IEC 60050-441:1984, 441-16-22, modifiée – "appareil" a été remplacé par "DPE"]

3.2.11
position d'ouverture
position dans laquelle la distance prédéterminée d'isolement entre contacts ouverts est assurée dans le circuit principal d'un DPE

[SOURCE: IEC 60050-441:1984, 441-16-23, modifiée – "appareil" a été remplacé par "DPE"]

3.2.12
montage incorporé
méthode de montage dans laquelle l’utilisateur ménage dans son équipement une cavité pour fixer le DPE dans sa position

3.3 Définitions relatives aux courants

3.3.1
courant
écoulement des charges électriques le long d'un conducteur

3.3.2
courant assigné
courant attribué par le constructeur pour une condition de fonctionnement spécifiée du DPE

3.3.3
surintensité
courant supérieur au courant assigné

[SOURCE: IEC 60050-441:1984, 441-11-06]

3.3.4
courant de surcharge
surintensité qui survient dans un circuit électriquement non endommagé

3.3.5
courant de court-circuit
surintensité résultant d'un défaut d'impédance négligeable entre des points destinés à être à des potentiels différents en service normal

Note 1 à l'article: Un courant de court-circuit peut provenir d'un défaut ou d'une connexion incorrecte.

3.3.6
courant conventionnel de déclenchement
I_t
valeur spécifiée du courant qui provoque le déclenchement d'un DPE avant l'expiration d'un temps spécifié (temps conventionnel)

3.3.7
courant conventionnel de non-déclenchement
I_{nt}
valeur spécifiée du courant qu'un DPE peut supporter pendant un temps spécifié (temps conventionnel) sans se déclencher

3.3.8
courant de déclenchement instantané
I_i
valeur du courant pour laquelle le fonctionnement automatique d'un DPE (sans temporisation intentionnelle) a lieu dans un temps inférieur à 0,1 s

3.3.9
courant de non-déclenchement instantané
I_{ni}
valeur du courant pour laquelle le fonctionnement automatique du DPE (sans temporisation intentionnelle) n'a pas lieu dans un temps inférieur ou égal à 0,1 s

3.4 Définitions relatives aux tensions

3.4.1
tension assignée
valeur de la tension attribuée à un DPE ou à ses composants par le constructeur et à laquelle sont référencées les caractéristiques de fonctionnement et de manœuvre

Note 1 à l'article: Un DPE peut avoir plus d'une valeur de tension assignée ou peut avoir une plage de tensions assignées.

3.4.2
tension locale
valeur la plus élevée de la tension en courant alternatif ou continu qui peut apparaître à travers n'importe quelle isolation lorsqu'un DPE est alimenté sous la tension assignée

Note 1 à l'article: Les surtensions transitoires sont négligées.

Note 2 à l'article: Il est tenu compte à la fois des conditions à vide et des conditions normales de fonctionnement.

3.4.3
surtension
tension ayant une valeur de crête dépassant la valeur de crête correspondante de la tension maximale en régime permanent dans les conditions normales de fonctionnement

3.4.4
surtension temporaire
surtension à fréquence industrielle de durée relativement longue

3.4.5
surtension transitoire
surtension d'une durée ne dépassant pas quelques millisecondes, oscillatoire ou non, généralement fortement amortie

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

3.4.6
surtension de tenue temporaire
valeur la plus élevée d'une surtension temporaire qui ne provoque pas de claquage de l'isolation dans des conditions spécifiées

3.5 Définitions relatives aux éléments constructifs d'un DPE

3.5.1
partie accessible
partie qui peut être touchée en utilisation normale

3.5.2
partie conductrice
partie capable de conduire du courant, bien qu'elle ne soit pas nécessairement utilisée pour conduire du courant en service normal

[SOURCE: IEC 60050-441:1984, 441-11-09]

3.5.3
partie conductrice accessible
partie conductrice, susceptible d'être touchée directement, qui n'est pas normalement sous tension, mais peut le devenir en cas de défaut

Note 1 à l'article: Des parties conductrices accessibles caractéristiques sont les parois des enveloppes métalliques, les poignées de commande métalliques, etc.

[SOURCE: IEC 60050-441:1984, 441-11-10, modifiée – La Note 1 à l'article a été reformulée.]

3.5.4
partie active
conducteur ou partie conductrice destiné à être sous tension en service normal, y compris le conducteur neutre, mais par convention, excepté le conducteur PEN, le conducteur PEM ou le conducteur PEL

Note 1 à l'article: Ce terme n'implique pas nécessairement un risque de choc électrique.

[SOURCE: IEC 60050-826:2004, 826-12-08]

3.5.5
partie détachable
partie qui peut être retirée sans l'aide d'un outil d'usage courant

3.5.6
contact principal
contact inséré dans le circuit principal d'un DPE, prévu pour supporter, dans la position de fermeture, le courant du circuit principal

[SOURCE: IEC 60050-441:1984, 441-15-07, modifiée – "appareil mécanique de connexion" a été remplacé par "DPE".]

3.5.7
contact auxiliaire
contact inséré dans un circuit auxiliaire d'un DPE et manœuvré mécaniquement par le DPE

[SOURCE: IEC 60050-441:1984, 441-15-10, modifiée – "d'un DPE" a été ajouté et "l'appareil de connexion" a été remplacé par "le DPE".]

3.5.8
contact de commande
contact inséré dans un circuit de commande d'un DPE et manœuvré mécaniquement par le DPE

[SOURCE: IEC 60050-441:1984, 441-15-09, modifiée – "appareil mécanique de connexion" et "appareil" ont été remplacés par "DPE".]

3.5.9
contact forme "A"
contact à fermeture
contact de commande ou auxiliaire qui est fermé lorsque les contacts principaux d'un DPE sont fermés et qui est ouvert lorsque ces contacts sont ouverts

[SOURCE: IEC 60050-441:1984, 441-15-12, modifiée – Le terme "contact «a»" a été remplacé par "contact forme "A"". "appareil mécanique de connexion" a été remplacé par "DPE".]

3.5.10
contact forme "B"
contact à ouverture
contact de commande ou auxiliaire qui est ouvert lorsque les contacts principaux d'un DPE sont fermés et qui est fermé lorsque ces contacts sont ouverts

[SOURCE: IEC 60050-441:1984, 441-15-13, modifiée – Le terme "contact «b»" a été remplacé par "contact forme "B"". "appareil mécanique de connexion" a été remplacé par "DPE".]

3.5.11
contact forme "C"
contact à ouverture et à fermeture
contact de commande ou auxiliaire qui est composé d'un élément inverseur de fermeture/coupure à trois bornes

3.5.12
organe de commande
partie du mécanisme transmetteur à laquelle un effort extérieur de manœuvre est appliqué

[SOURCE: IEC 60050-441:1984, 441-15-22, modifiée – La note a été supprimée.]

3.5.13
système de commande
<d'un DPE> ensemble des organes de manœuvre d'un DPE transmettant l'effort de commande aux contacts

3.5.14
effort (moment) de commande
effort (moment) appliqué à un organe de commande nécessaire à l'accomplissement de la manœuvre prévue

[SOURCE: IEC 60050-441:1984, 441-16-17, modifiée – "(moment)" a été ajouté.]

3.6 Définitions relatives aux déclencheurs dans les DPE

3.6.1
déclencheur
appareil raccordé mécaniquement à ou intégré dans un DPE dont il libère les organes de retenue et qui permet l'ouverture automatique du DPE

[SOURCE: IEC 60050-441:1984, 441-15-17, modifiée – "ou intégré dans" a été ajouté et "appareil mécanique de connexion" a été remplacé par "DPE".]

3.6.2
déclencheur à maximum de courant
déclencheur qui provoque l'ouverture, avec ou sans retard, d'un DPE, lorsque le courant dans le déclencheur dépasse une valeur prédéterminée

Note 1 à l'article: Cette valeur peut, dans certains cas, dépendre de la vitesse d'accroissement du courant.

[SOURCE: IEC 60050-441:1984, 441-16-33, modifiée – "permet" a été remplacé par "provoque" et "appareil mécanique de connexion" a été remplacé par "DPE".]

3.6.3
déclencheur à maximum de courant à temps inverse
déclencheur à maximum de courant qui provoque l'ouverture d'un DPE après un intervalle de temps qui varie en raison inverse de la valeur de la surintensité

Note 1 à l'article: Un tel déclencheur peut être conçu pour que le retard atteigne une valeur minimale définie pour des valeurs élevées de surintensité.

3.6.4
déclencheur direct à maximum de courant
déclencheur à maximum de courant alimenté directement par le courant du circuit principal d'un DPE

3.6.5
déclencheur instantané à maximum de courant
déclencheur à maximum de courant qui fonctionne sans aucun retard intentionnel

3.6.6
déclencheur de surcharge
déclencheur à maximum de courant destiné à la protection contre les surcharges

[SOURCE: IEC 60050-441:1984, 441-16-38]

3.6.7
déclencheur de court-circuit
déclencheur à maximum de courant destiné à la protection contre les courts-circuits

3.6.8
déclencheur shunt
déclencheur alimenté par une source de tension

Note 1 à l'article: La source de tension peut être indépendante de la tension du circuit principal.

Note 2 à l'article: Pour les DPE, les déclencheurs shunt indépendants du circuit principal peuvent être appelés "relais déclencheurs".

[SOURCE: IEC 60050-441:1984, 441-16-41, modifiée – La Note 2 à l'article a été ajoutée.]

3.6.9
déclencheur à minimum de tension
déclencheur shunt qui provoque l'ouverture du DPE avec ou sans retard, lorsque la tension aux bornes du déclencheur tombe au-dessous d'une valeur prédéterminée

[SOURCE: IEC 60050-441:1984, 441-16-42, modifiée – "appareil mécanique de connexion" a été remplacé par "DPE".]

3.6.10
déclencheur à tension zéro
déclencheur shunt qui provoque l'ouverture d'un DPE lorsque la tension aux bornes du déclencheur tombe au-dessous de 10 % de la tension assignée

3.6.11
déclencheur de surtension
déclencheur shunt qui provoque l'ouverture d'un DPE, avec ou sans retard, lorsque la tension aux bornes du déclencheur dépasse une valeur prédéterminée

3.6.12
déclencheur thermique de surcharge
déclencheur de surcharge à temps inverse dont le fonctionnement, y compris la temporisation, dépend de l'action thermique du courant qui traverse le déclencheur

[SOURCE: IEC 60050-441:1984, 441-16-39]

3.6.13
déclencheur magnétique de surcharge
déclencheur de surcharge dont le fonctionnement dépend de la force produite par un courant circulant dans le circuit principal et alimentant la bobine d'un électro-aimant

Note 1 à l'article: Un tel déclencheur a généralement une caractéristique de courant à temps inverse.

[SOURCE: IEC 60050-441:1984, 441-16-40]

3.7 Définitions relatives à la coordination de l'isolement

3.7.1
isolation fonctionnelle
isolation entre parties actives qui est uniquement nécessaire au bon fonctionnement de l'équipement

3.7.2
isolation principale
isolation des parties actives, destinée à assurer la protection principale contre les chocs électriques

Note 1 à l'article: L'isolation principale ne comprend pas nécessairement l'isolation utilisée à des fins fonctionnelles.

3.7.3
isolation supplémentaire
isolation indépendante utilisée en plus de l'isolation principale afin d'assurer une protection contre les chocs électriques en cas de défaillance de l'isolation principale

3.7.4
isolation renforcée
système d'isolation unique des parties actives assurant un degré de protection contre les chocs électriques équivalent à une double isolation

Note 1 à l'article: Un système d'isolation unique ne sous-entend pas que l'isolation se compose nécessairement d'une partie homogène. Elle peut comporter plusieurs couches qui ne peuvent pas être soumises à l'essai séparément comme l'isolation principale, supplémentaire ou renforcée.

3.7.5
double isolation
isolation comprenant à la fois une isolation principale et une isolation supplémentaire

3.7.6
distance d'isolement
plus petite distance dans l'air entre deux parties conductrices

3.7.7
distance d'isolement à la terre
distance d'isolement entre n'importe quelle partie conductrice et n'importe quelle partie réunie à la terre ou prévue pour être réunie à la terre

[SOURCE: IEC 60050-441:1984, 441-17-33]

3.7.8
distance d'isolement entre contacts ouverts
distance d'isolement totale entre les contacts, ou n'importe quelles parties conductrices qui leur sont reliées, d'un pôle d'un DPE dans la position d'ouverture

[SOURCE: IEC 60050-441:1984, 441-17-34, modifiée – "appareil mécanique de connexion" a été remplacé par "DPE".]

3.7.9
distance de sectionnement
<d'un pôle de DPE> distance d'isolement entre contacts satisfaisant aux exigences de sécurité concernant les sectionneurs

[SOURCE: IEC 60050-441:1984, 441-17-35, modifiée – "appareil mécanique de connexion" a été remplacé par "DPE".]

3.7.10
ligne de fuite
distance la plus courte, le long de la surface d'un isolant solide, entre deux parties conductrices

[SOURCE: IEC 60050-151:2001, 151-15-50]

3.7.11
coordination de l'isolement
correspondance mutuelle des caractéristiques d'isolement de l'équipement électrique en tenant compte du microenvironnement prévu et des autres contraintes ayant une influence

3.7.12
tension de tenue aux chocs
valeur de crête la plus élevée d'une tension de choc, de forme et de polarité spécifiées, qui ne provoque pas de claquage dans des conditions spécifiées

3.7.13
tension de tenue à fréquence industrielle
valeur efficace d'une tension sinusoïdale à fréquence industrielle qui ne provoque pas la rupture de l'isolation dans des conditions spécifiées

3.7.14
pollution
apport de matériau étranger, solide, liquide ou gazeux (par exemple gaz ionisés), pouvant entraîner une réduction de la rigidité diélectrique ou de la résistivité de la surface de l'isolation

3.7.15
degré de pollution
nombre caractérisant la pollution prévue du microenvironnement

Note 1 à l'article: Les degrés de pollution 1, 2, 3 et 4 sont utilisés (voir 4.6.2 de l'IEC 60664-1:2007).

3.7.16
catégorie de surtension
nombre conventionnel basé sur la limitation ou le contrôle des valeurs des surtensions présumées survenant dans un circuit et dépendant des moyens utilisés pour influencer les surtensions

3.7.17
champ homogène
champ électrique dont le gradient de tension est essentiellement constant entre les électrodes (champ uniforme), tel que celui existant entre deux sphères dont le rayon de chacune est plus grand que la distance qui les sépare

3.7.18
champ hétérogène
champ électrique dont le gradient de tension entre électrodes n'est pas essentiellement constant (champ non uniforme)

3.7.19
macroenvironnement
environnement de la pièce ou de tout endroit où l’équipement est installé ou utilisé

3.7.20
microenvironnement
environnement immédiat de l'isolation qui influence en particulier le dimensionnement des lignes de fuite

3.8 Définitions relatives au fonctionnement des DPE

3.8.1
manœuvre
passage d'un ou de plusieurs contacts mobiles de la position d'ouverture à la position de fermeture ou vice versa

Note 1 à l'article: Si une distinction est nécessaire, on emploiera les termes "manœuvre électrique" s'il s'agit d'une opération au sens électrique (par exemple, établissement ou coupure) et "manœuvre mécanique" s'il s'agit d'une opération au sens mécanique (par exemple, fermeture ou ouverture).

[SOURCE: IEC 60050-441:1984, 441-16-01, modifiée – "d'une position à une position adjacente" a été remplacé par "de la position d'ouverture à la position de fermeture ou vice versa" et la Note 1 a été supprimée.]

3.8.2
cycle de manœuvres
suite de manœuvres d'une position à une autre avec retour à la première position

[SOURCE: IEC 60050-441:1984, 441-16-02, modifiée – "en passant par toutes les autres positions, s'il en existe" a été supprimé.]

3.8.3
séquence de manœuvres
suite de manœuvres spécifiées effectuées avec des intervalles de temps spécifiés

[SOURCE: IEC 60050-441:1984, 441-16-03]

3.8.4
service temporaire
service dans lequel les contacts principaux d'un équipement restent fermés pendant une période insuffisante pour atteindre l'équilibre thermique, les périodes en charge étant séparées par des périodes à vide de durée suffisante pour permettre de revenir à une température voisine de la température ambiante

3.8.5
service ininterrompu
service dans lequel les contacts principaux d'un DPE restent fermés tout en supportant un courant régulier sans interruption pendant de longues périodes (qui peuvent se compter en semaines, en mois, voire même en années)

3.8.6
service intermittent
service avec des périodes en charge, dans lequel les contacts principaux d'un équipement restent fermés, en relation définie avec des périodes à vide, les deux périodes étant trop courtes pour permettre à l'équipement d'atteindre l'équilibre thermique

3.8.7
manœuvre de fermeture
manœuvre par laquelle on fait passer un DPE de la position d'ouverture à la position de fermeture

[SOURCE: IEC 60050-441:1984, 441-16-08, modifiée – "l'appareil" a été remplacé par "un DPE".]

3.8.8
manœuvre d'ouverture
manœuvre par laquelle on fait passer un DPE de la position de fermeture à la position d'ouverture

[SOURCE: IEC 60050-441:1984, 441-16-09, modifiée – "l'appareil" a été remplacé par "un DPE".]

3.8.9
DPE à déclenchement libre
DPE dont les contacts mobiles reviennent en position d'ouverture et y demeurent quand la manœuvre d'ouverture automatique est commandée après le début de la manœuvre de fermeture, même si l'ordre de fermeture est maintenu

Note 1 à l'article: Les DPE de cette conception peuvent être désignés comme étant à déclenchement complètement libre.

[SOURCE: IEC 60050-441:1984, 441-16-31, modifiée – "appareil mécanique de connexion" a été remplacé par "DPE".]

3.8.10
DPE à déclenchement cyclique
DPE dont les contacts mobiles reviennent en position d'ouverture quand la manœuvre d'ouverture automatique est commandée après le début de la manœuvre de fermeture et qui par la suite reviennent temporairement en position de fermeture de façon cyclique tant que l'ordre de fermeture est maintenu

3.8.11
DPE à déclenchement non libre
DPE dont les contacts mobiles ne s'ouvrent pas quand la manœuvre d'ouverture automatique est commandée si l'ordre de fermeture est maintenu

Note 1 à l'article: Pour les conditions d'utilisation des DPE à déclenchement non libre, voir 4.8.3.

3.9 Définitions relatives aux caractéristiques de fonctionnement des DPE

3.9.1
temps de déclenchement
intervalle de temps entre le moment auquel le courant de déclenchement associé commence à circuler dans le circuit principal et le moment auquel le courant est interrompu (dans tous les pôles)

3.9.2
caractéristique de déclenchement
caractéristique temps-courant au-dessus de laquelle un DPE doit s'être déclenché

3.9.3
caractéristique de non-déclenchement
caractéristique temps-courant en dessous de laquelle un DPE ne se déclenche pas

3.9.4
zone de fonctionnement
zone temps-courant limitée par les caractéristiques de fonctionnement définies en 3.9.2 et 3.9.3

Note 1 à l'article: Cette zone tient compte des tolérances de fabrication et de fonctionnement du DPE.

3.9.5
temps de réarmement automatique
intervalle de temps entre le moment auquel les contacts du circuit principal s'ouvrent et le moment auquel ils se referment

3.10 Définitions relatives aux grandeurs caractéristiques

3.10.1
valeur assignée
valeur déclarée de chacune des grandeurs caractéristiques qui servent à définir les conditions de fonctionnement pour lesquelles le DPE a été conçu et réalisé

3.10.2
valeur limite
<dans une spécification> plus grande ou la plus petite valeur admissible d'une grandeur

[SOURCE: IEC 60050-151:2001, 151-16-10, modifiée – "d'un composant, dispositif, matériel ou système" a été supprimé.]

3.10.3
caractéristiques assignées
ensemble des valeurs assignées et des conditions de fonctionnement

[SOURCE: IEC 60050-151:2001, 151-16-11]

3.10.4
courant présumé
courant qui circulerait dans un circuit si chaque pôle d'un DPE était remplacé par un conducteur d'impédance négligeable

[SOURCE: IEC 60050-441:1984, 441-17-01, modifiée – "de l'appareil de connexion ou le fusible" a été remplacé par "d'un DPE".]

3.10.5
pouvoir de coupure et de fermeture
valeur du courant qu'un DPE est capable d'établir et de couper à une tension déclarée dans les conditions spécifiées d'utilisation et de manœuvre

3.10.6
pouvoir de coupure et de fermeture en court-circuit
courant présumé, exprimé en valeur efficace, qu'un DPE est conçu pour établir, transporter pendant son temps d'ouverture et interrompre dans des conditions spécifiées

3.11 Définitions concernant la coordination des DPE et des DPCC associés dans le même circuit

3.11.1
dispositif de protection contre les courts-circuits
DPCC
moyen de protection contre les surintensités destiné à protéger un circuit ou des parties d'un circuit contre les courants de court-circuit par leur interruption

3.11.2
protection d'accompagnement
coordination des surintensités de deux dispositifs de protection contre les surintensités placés en série dont un DPCC assure la protection contre les surintensités avec ou sans l'assistance du DPE et prévient toute contrainte excessive sur le DPE dans des conditions spécifiées

3.11.3
sélectivité lors d'une surintensité
coordination entre les caractéristiques correspondantes d'un DPE et de son DPCC de telle façon qu'à l'apparition de surintensités comprises dans des limites déclarées, le DPE ouvre le circuit tandis que le DPCC ne fonctionne pas

[SOURCE: IEC 60050-441:1984, 441-17-15, modifiée – "dispositif de protection à maximum de courant" a été remplacé par "DPE" et "DPCC".]

3.11.4
courant limite de sélectivité
I_s
valeur limite du courant

– au-dessous de laquelle le DPE effectue sa manœuvre d'ouverture dans un temps ne permettant pas au DPCC de commencer à fonctionner (c'est-à-dire que la sélectivité est assurée), et
– au-dessus de laquelle le DPE peut ne pas terminer sa manœuvre d'ouverture dans un temps suffisant pour empêcher le DPCC de commencer à fonctionner (c'est-à-dire que la sélectivité n'est pas assurée)

VOIR: Figure F.1.

3.11.5
courant conditionnel de court-circuit
valeur du courant de court-circuit qu'un DPE protégé par un DPCC en série peut supporter dans des conditions d'utilisation et de comportement spécifiées

3.11.6
séparation électrodynamique des contacts
valeur la plus basse du courant de crête qui provoque une séparation des contacts alors que le mécanisme reste fermé

3.11.7
courant de courte durée admissible
<d'un DPE> valeur de courant qu'un DPE peut supporter pendant un temps spécifié sans aucun dommage pour son utilisation ultérieure

3.11.8
courant d'intersection
valeur du courant correspondant à l'intersection des caractéristiques de déclenchement de deux dispositifs de protection contre les surintensités placés en série pour des durées de fonctionnement supérieures ou égales à 0,05 s

Note 1 à l'article: Pour les durées de fonctionnement inférieures à 0,05 s, les deux dispositifs de protection contre les surintensités en série sont considérés comme une association (voir Annexe F).

[SOURCE: IEC 60050-441:1984, 441-17-16, modifiée – "caractéristiques temps-courant de deux dispositifs de protection à maximum de courant" a été remplacé par "caractéristiques de déclenchement de deux dispositifs de protection contre les surintensités placés en série pour des durées de fonctionnement supérieures ou égales à 0,05 s" et la Note 1 à l'article a été ajoutée.]

3.12 Définitions relatives aux bornes et aux terminaisons

3.12.1
terminaison
connexion entre deux ou plusieurs parties conductrices qui peut seulement être effectuée en utilisant un procédé spécial

Note 1 à l'article: Le procédé spécial peut être la soudure, la brasure ou la préparation des conducteurs à l'aide d'un outil spécifique.

3.12.2
borne
partie conductrice d'un appareil prévue pour la connexion électrique et la déconnexion sans l'aide d'un procédé spécial

3.12.2.1
borne pour conducteurs non préparés
borne qui n'exige pas de préparation spéciale du conducteur autre que le dénudage et la remise en forme du conducteur avant son introduction dans la borne ou le torsadage d'un conducteur câblé pour en consolider l'extrémité

3.12.2.2
borne pour conducteurs préparés
borne qui exige une préparation spéciale du conducteur telle que l'utilisation d'embouts, de cosses ou de dispositifs similaires

3.12.2.3
borne pour conducteurs internes
borne raccordée en usine
borne pour la connexion des conducteurs internes de l'équipement

Note 1 à l'article: Les DPE sont généralement, mais pas nécessairement, équipés de bornes pour les conducteurs internes.

3.12.3
borne à vis
borne permettant le raccordement et la déconnexion ultérieure d'un conducteur ou l'interconnexion démontable de deux conducteurs ou plus, le raccordement étant réalisé directement ou indirectement au moyen de vis ou d'écrous de tout type

3.12.4
borne à trou
borne à vis dans laquelle l'âme d'un conducteur est introduite dans un trou ou dans un logement, où elle est serrée sous le corps de la ou des vis

Note 1 à l'article: La pression de serrage peut être appliquée directement par le corps de la vis ou au moyen d'un organe de serrage intermédiaire auquel la pression est appliquée par le corps de la vis.

Note 2 à l'article: Des exemples de bornes à trou sont donnés à l'Annexe E.

3.12.5
borne de serrage sous tête de vis
borne à vis dans laquelle l'âme d'un conducteur est serrée sous la tête de la vis

Note 1 à l'article: La pression de serrage peut être appliquée directement par la tête de la vis ou au moyen d'un organe intermédiaire, tel qu'une rondelle, une plaquette ou un dispositif empêchant le conducteur ou ses brins de s'échapper.

Note 2 à l'article: Des exemples de bornes à serrage sous tête de vis sont donnés à l'Annexe E.

3.12.6
borne à goujon fileté
borne à vis dans laquelle l'âme d'un conducteur est serrée sous un écrou

Note 1 à l'article: La pression de serrage peut être appliquée directement par un écrou de forme appropriée ou au moyen d'un organe intermédiaire, tel qu'une rondelle, une plaquette ou un dispositif empêchant le conducteur ou ses brins de s'échapper.

Note 2 à l'article: Des exemples de bornes à goujon fileté sont donnés à l'Annexe E.

3.12.7
borne à plaquette
borne à vis dans laquelle l'âme d'un conducteur est serrée sous une plaquette au moyen de deux vis ou écrous ou plus

Note 1 à l'article: Des exemples de bornes à plaquette sont donnés à l'Annexe E.

3.12.8
borne pour cosses et barrettes
borne de 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

Note 1 à l'article: Des exemples de bornes pour cosses et barrettes sont donnés à l'Annexe E.

3.12.9
borne sans vis
borne de connexion permettant le raccordement et la déconnexion ultérieure d'un conducteur ou l'interconnexion démontable de deux conducteurs ou plus, le raccordement étant réalisé directement ou indirectement par des moyens autres que des vis

Note 1 à l'article: Les exemples suivants ne sont pas considérés comme des bornes sans vis:

– bornes exigeant la fixation de dispositifs spéciaux sur le conducteur avant de le serrer dans la borne, par exemple les bornes plates à connexion rapide;
– bornes exigeant l'enroulement des conducteurs, par exemple celle avec joint enroulé;
– bornes permettant le contact direct avec les conducteurs au moyen de coins ou de pointes pénétrant dans l'isolation.

Des exemples de bornes sans vis sont donnés aux Figures E.5 à E.14.

3.12.9.1
borne sans vis universelle
borne sans vis destinée au raccordement de tous les types de conducteurs

3.12.9.2
borne sans vis non universelle
borne sans vis destinée au raccordement de certains types de conducteurs seulement

EXEMPLES borne pousse-fil pour conducteurs massifs seulement; borne pousse-fil pour conducteurs rigides massifs et conducteurs câblés rigides seulement

3.12.10
borne plate à connexion rapide
connexion électrique se composant d'une languette et d'un clip qui peut être inséré et retiré sans l'utilisation d'un outil

3.12.11
languette
partie d'une borne à connexion rapide qui reçoit le clip

Note 1 à l'article: Des exemples de languettes sont donnés à la Figure E.6.

3.12.12
clip
partie d'une borne à connexion rapide qui est poussée sur la languette

Note 1 à l'article: Un exemple de clip est donné à la Figure E.14.

3.12.13
verrouillage
empreinte (creux) ou trou de la languette dans laquelle ou dans lequel s'engage une partie en protubérance du clip assurant un verrouillage de l'accouplement

3.12.14
terminaison à souder
partie conductrice d'un DPE prévue pour permettre une terminaison effectuée au moyen d'une soudure

3.12.15
conducteur externe
conducteur raccordé au montage
câble, conducteur ou âme de conducteur dont une partie est externe à un équipement dans ou sur lequel le DPE est monté

3.12.16
conducteur intégré
conducteur qui est utilisé pour interconnecter de façon permanente les parties d'un DPE

3.12.17
conducteur interne
conducteur raccordé en usine
tout câble, conducteur ou âme de conducteur interne à un équipement, mais qui n'est ni un conducteur externe ni un conducteur intégré

3.12.18
vis autotaraudeuse
vis réalisée dans un matériau présentant une plus grande résistance à la déformation quand elle est insérée par rotation dans une cavité située dans un matériau présentant une moins grande résistance à la déformation

Note 1 à l'article: La vis est réalisée avec un filetage conique, la conicité étant appliquée au diamètre du noyau du filetage à la section terminale de la vis. Le filetage résultant de la mise en place de la vis n'est formé de façon sûre qu'après réalisation d'un nombre suffisant de révolutions dépassant le nombre de filets de la section conique.

3.12.19
vis autotaraudeuse par déformation
vis autotaraudeuse ayant un filetage ininterrompu

Note 1 à l'article: La fonction de ce filetage n'est pas d'enlever du matériau de la cavité.

Note 2 à l'article: Un exemple de vis autotaraudeuse sans découpe est donné à la Figure 1.

3.12.20
vis autotaraudeuse avec découpe
vis autotaraudeuse ayant un filetage non continu

Note 1 à l'article: Ce filetage est destiné à enlever du matériau de la cavité.

Note 2 à l'article: Un exemple de vis autotaraudeuse à découpe est donné à la Figure 2.

3.13 Définitions relatives aux essais

3.13.1
essai de type
essai effectué sur un ou plusieurs dispositifs réalisés selon une conception donnée pour vérifier que cette conception répond à certaines spécifications

3.13.2
essai individuel de série
essai auquel est soumis chaque dispositif en cours ou en fin de fabrication pour vérifier qu'il satisfait à des critères définis

3.13.3
essai spécial
essai, en supplément des essais de type et des essais individuels de série, effectué soit à la discrétion du constructeur soit selon un accord entre le constructeur et l'utilisateur

4 Classification

4.1 Généralités

Les DPE sont classés selon les critères donnés en 4.2 à 4.11.

4.2 Quantité de pôles

– le nombre de pôles;
– le nombre de pôles protégés.

NOTE Le pôle qui n'est pas protégé peut être soit un pôle non protégé soit un pôle neutre de sectionnement.

4.3 Méthode de montage

– type pour montage en saillie;
– type à encastrer;
– type pour montage en tableau;
– type pour montage intégré.

NOTE 1 Les modèles pour montage en tableau comprennent les types à encliquetage et les types à bride.

NOTE 2 Les modèles pour montage intégré sont des types maintenus en place par un moyen de fixation et n'exigeant aucun autre moyen de montage.

4.4 Mode de connexion

– DPE dont les connexions ne sont pas associées au dispositif de fixation mécanique;
– DPE dont une ou plusieurs connexions sont associées au dispositif de fixation mécanique, par exemple:
  - type enfichable;
  - type à fixation par boulons;
  - type à vis;
  - type à connexion soudée.

NOTE Certains DPE peuvent être de type enfichable ou à fixation par boulons du côté de l'alimentation uniquement, les bornes de sortie étant utilisées habituellement pour des connexions par fils.

4.5 Mode de manœuvre

4.5.1 DPE à interruption automatique et à réenclenchement non automatique (manuel) seulement (type R).

4.5.2 DPE à interruption automatique et à réenclenchement non automatique (manuel), équipés d'organes de manœuvre manuelle conçus pour une coupure manuelle occasionnelle, mais non pour des coupures manuelles répétées dans les conditions normales de charge (type M).

4.5.3 DPE à interruption automatique et à réenclenchement non automatique (manuel), équipés d'organes de manœuvre manuelle et conçus pour des coupures manuelles répétées dans les conditions normales de charge (type S) (voir note de 5.2.3).

4.5.4 DPE à interruption automatique et à réenclenchement automatique (type J).

Les DPE de type J peuvent être également fournis avec des organes de manœuvre manuelle. Dans ce cas les exigences correspondantes des autres types sont applicables.

4.6 Mode de déclenchement

4.6.1 DPE se déclenchant par le courant (surintensité)

Mode de déclenchement	*Désignation*
– thermique	TO
– magnétothermique	TM
– magnétique	MO
– magnétohydraulique	HM
– électronique hybride	EH

NOTE Le type électronique hybride désigne un dispositif commandé électroniquement en association avec tout autre mode de déclenchement.

4.6.2 DPE se déclenchant par la tension

Mode de déclenchement	*Désignation*
– surtension	OV
– sous-tension	UV

4.7 Influence de la température ambiante

4.7.1 DPE dont la manœuvre dépend de la température.

4.7.2 DPE dont la manœuvre ne dépend pas de la température.

4.8 Comportement en déclenchement libre

4.8.1 À déclenchement libre (déclenchement complètement libre).

4.8.2 À déclenchement libre cyclique.

4.8.3 À déclenchement non libre.

Les DPE du type à déclenchement non libre ne sont pas destinés à être utilisés pour des travaux en court-circuit.

4.9 Influence de la position de montage

4.9.1 Indépendant de la position de montage.

4.9.2 Dépendant de la position de montage.

4.10 Performances électriques

4.10.1 Pour une utilisation générale, y compris sur des circuits inductifs.

4.10.2 Pour une utilisation uniquement dans des circuits essentiellement résistifs.

4.11 Aptitude au sectionnement

– non apte au sectionnement;
– apte au sectionnement (voir Annexe K).

5 Caractéristiques des DPE

5.1 Liste des caractéristiques

Les caractéristiques d'un DPE doivent être énoncées comme suit, le cas échéant:

– nombre de pôles, de pôles protégés (voir 4.2) et, s'il y a lieu, chemin du neutre;
– méthode de montage (voir 4.3);
– mode de connexion (voir 4.4);
– mode de manœuvre (voir 4.5);
– grandeurs assignées (voir 5.2);
– caractéristiques de fonctionnement (voir 3.9).

5.2 Grandeurs assignées

5.2.1 Généralités

Les grandeurs assignées sont spécifiées en 5.2.2 à 5.2.7. Sauf spécification contraire, toutes les valeurs de courants et de tensions sont données en valeurs efficaces.

5.2.2 Tensions assignées

5.2.2.1 Généralités

Un DPE est défini par les tensions assignées définies en 5.2.2.2 à 5.2.2.5.

5.2.2.2 Tension d'emploi assignée d'un DPE (U_e)

Valeur de la tension d'emploi assignée ("tension assignée" dans la suite du texte) d'un DPE à laquelle se rapportent ses performances.

NOTE Plusieurs tensions assignées et leurs pouvoirs de coupure (et de fermeture) assignés associés peuvent être attribués à un même DPE (voir 5.2.5).

5.2.2.3 Tension d'isolement assignée (U_i)

Valeur de la tension d'isolement assignée d'un DPE à laquelle se rapportent les essais diélectriques, les distances d'isolement et les lignes de fuite.

Sauf spécification contraire, la tension d'isolement assignée est la valeur de la tension assignée maximale du DPE. En aucun cas la tension assignée maximale ne doit dépasser la tension d'isolement assignée.

5.2.2.4 Tension assignée de tenue aux chocs (U_{imp})

Valeur de crête d'une tension de choc, de forme et de polarité spécifiées, que le DPE est capable de supporter sans défaillance dans des conditions d'essai spécifiées et à laquelle correspondent les valeurs des distances d'isolement.

La tension assignée de tenue aux chocs d'un équipement doit être supérieure ou égale aux valeurs des surtensions transitoires déclarées survenant dans le circuit dans lequel l'équipement est monté.

Les corrélations entre les tensions assignées des systèmes d'alimentation et les tensions assignées de tenue aux chocs sont données à l'Annexe H.

Les tensions d'essais de tenue aux chocs pour la vérification de la coordination de l'isolement sont données dans le Tableau 21.

5.2.2.5 Tension assignée des déclencheurs à minimum de tension et des déclencheurs à tension zéro (U_n)

Valeur de la tension assignée des déclencheurs à minimum de tension et/ou des déclencheurs à tension zéro en lien avec la valeur de tension à laquelle se rapportent les performances.

5.2.3 Courant assigné (I_n)

Courant attribué par le constructeur (conformément au Tableau 11 ou au Tableau 12, suivant la performance déclarée) comme étant le courant que le DPE peut supporter en service ininterrompu (voir 3.8.5) à une température de l'air ambiant de référence spécifiée.

La température de l'air ambiant de référence normale est (23 ± 2) °C.

Si les températures de l'air ambiant de référence sont différentes de la valeur normale, le facteur de réduction indiqué dans la documentation du constructeur doit être appliqué (voir 7.2).

NOTE Pour les DPE de type S, le constructeur peut déclarer un courant assigné différent de celui attribué conformément au Tableau 11 pour les charges inductives.

5.2.4 Fréquence assignée

Fréquence industrielle pour laquelle le DPE est conçu et à laquelle correspondent les valeurs des autres caractéristiques.

5.2.5 Pouvoir de coupure et de fermeture assigné

Valeur du pouvoir de coupure et de fermeture (voir 3.10.5) attribuée au DPE par le constructeur.

NOTE Cette grandeur est exprimée par une valeur de courant (valeur de courant efficace si celui-ci est alternatif).

5.2.6 Courant conditionnel de court-circuit assigné (I_{nc})

5.2.6.1 Généralités

Valeur du courant conditionnel de court-circuit (voir 3.11.5) si attribuée au DPE par le constructeur.

NOTE 1 Pour les besoins du présent document, deux catégories de performances sont spécifiées (voir 5.2.6.2 et 5.2.6.3).

NOTE 2 Le constructeur peut décider de ne pas attribuer une valeur de I_{nc} au DPE, auquel cas les essais applicables sont omis.

5.2.6.2 Courant conditionnel de court-circuit assigné, catégorie de performance PC1 (I_{nc1})

Valeur du courant conditionnel de court-circuit assigné, si attribuée par le constructeur, pour laquelle les conditions spécifiées ne comprennent pas l'aptitude du DPE à être utilisé ultérieurement. Voir 9.12.4.2.

5.2.6.3 Courant conditionnel de court-circuit assigné, catégorie de performance PC2 (I_{nc2})

Valeur du courant conditionnel de court-circuit assigné, si attribuée par le constructeur, pour laquelle les conditions spécifiées comprennent l'aptitude du DPE à être utilisé ultérieurement. Voir 9.12.4.3.

5.2.7 Pouvoir de coupure assigné (I_{cn})

Le pouvoir de coupure assigné d'un DPE est la valeur du courant attribuée au DPE par le constructeur selon 3.10.6.

Le pouvoir de coupure assigné ne doit pas être inférieur à

– 6 I_n en courant alternatif,

– 4 I_n en courant continu.

5.3 Valeurs normales et valeurs préférentielles

5.3.1 Valeurs préférentielles de tension assignée

Les valeurs préférentielles de tension assignée sont les suivantes.

– En courant alternatif:

60 V, 120 V, 240 V/120 V, 220 V, 230 V, 240 V, 380 V/220 V, 400 V/230 V, 415 V/240 V, 380 V, 400 V, 415 V, 440 V;

NOTE Dans l'IEC 60038, la valeur de tension alternative de réseau 400 V/230 V a été normalisée. Cette valeur remplacera progressivement les valeurs 380 V/220 V et 415 V/240 V.

– En courant continu:

12 V, 24 V, 48 V, 60 V, 120 V, 240 V, 250 V.

5.3.2 Valeurs normales des fréquences assignées

Les fréquences normales assignées sont: 50 Hz, 60 Hz et 400 Hz.

5.3.3 Valeurs normales du courant conditionnel de court-circuit assigné

Les valeurs normales du courant conditionnel de court-circuit assigné sont:

300 A, 600 A, 1 000 A, 1 500 A et 3 000 A.

6 Marquage et autres informations sur le produit

Chaque DPE doit porter de façon indélébile les indications suivantes:

a) le nom du constructeur ou sa marque de fabrique;

b) la désignation du type ou le numéro de série;

c) la ou les tensions assignées;

d) le courant assigné (une référence codée est admise, par exemple, la valeur de courant sans le symbole A, suivie de la désignation de type);

Si le DPE est prévu pour des charges résistives seulement, cela doit être mentionné dans le catalogue du constructeur.

e) la fréquence assignée, si le DPE est prévu pour une fréquence autre que 50 Hz et 60 Hz;

f) pour les DPE étalonnés à une température de l'air ambiant de référence différente de la valeur normale (voir 5.2.3), la température de l'air ambiant de référence réelle – par exemple, T40 pour une température de l'air ambiant de référence de 40 °C;

g) la ou les limites de la tension de fonctionnement (d'un DPE sensible à la tension);

h) le symbole µ, pour les DPE à distance entre contacts inférieure à la distance d'isolement spécifiée;

i) le mode de manœuvre R, M, S ou J (voir 4.5);

k) le mode de déclenchement (voir 4.6);

l) le degré de comportement en déclenchement libre (voir 4.8);

m) la catégorie de surtension si elle est différente de II et le degré de pollution s'il est différent de 2 (voir 8.1.3);

n) le courant conditionnel de court-circuit assigné, catégorie de performance PC1 (I_{nc1});

o) le courant conditionnel de court-circuit assigné, catégorie de performance PC2 (I_{nc2}), le cas échéant;

p) la tension assignée de tenue aux chocs;

q) le pouvoir de coupure assigné I_{cn}, le cas échéant (voir 5.2.6);

r) le temps de réarmement automatique;

s) symbole d'aptitude au sectionnement  (IEC 60417-6169-1:2012-08, modifié) sur l'appareil, le cas échéant.

Si, pour de petits appareils, l'espace disponible est insuffisant pour tous les marquages indiqués, au moins les indications a), b) et, le cas échéant, g), h) et s) doivent être marquées sur l'appareil et, si possible, c) et d). Les autres informations doivent être données dans le catalogue du constructeur.

NOTE Bien que souhaitable, la visibilité de la partie frontale n'est pas obligatoire pour les DPE, car les DPE sont spécifiés par les constructeurs originaux de l'équipement (OEM – *original equipment manufacturer*) pour leur équipement sur la base des informations fournies par les constructeurs des DPE. En raison du manque de place sur les DPE habituellement de petite taille, il peut ne pas être possible d'apposer le marquage sur la partie frontale visible après l'installation. Si le DPE n'est pas marqué dans une position visible, le constructeur peut indiquer au constructeur OEM de marquer son équipement en conséquence.

Dans son catalogue, le constructeur doit indiquer les conditions d'installation des DPE (notamment les DPE classés en 4.8.3), le cas échéant.

Pour les DPE autres que ceux manœuvrés par boutons-poussoirs, la position d'ouverture doit être indiquée par le symbole ◯ (IEC 60417-5008:2002-10) et la position de fermeture par le symbole | (IEC 60417-5007:2002-10).

Pour les DPE manœuvrés au moyen de deux boutons poussoirs, le bouton-poussoir prévu pour la seule manœuvre d'ouverture doit être rouge et/ou être marqué du symbole ◯.

Des symboles nationaux ajoutés à ◯ et | sont acceptables.

Le rouge ne doit être employé pour aucun autre bouton-poussoir, mais peut être utilisé pour d'autres types d'organes de commande, par exemple les manettes ou les bascules, à condition que les positions FERMÉ et OUVERT soient clairement identifiées.

S'il est nécessaire de faire la distinction entre les bornes d'alimentation et les bornes de sortie, les premières doivent être marquées de flèches dirigées vers le DPE et les dernières de flèches orientées vers l'extérieur du DPE.

D'autres indications nationales ou internationales, par exemple 1, 3, 5 pour les bornes d'alimentation et 2, 4, 6 pour les bornes de sortie sont acceptables.

Les bornes destinées exclusivement au neutre doivent être marquées de la lettre "N".

Les bornes pour le conducteur de protection, le cas échéant, doivent être marquées du symbole ⏚ (IEC 60417-5019:2002-10).

La conformité est vérifiée par examen et par l'essai de 9.3.

Chaque fois que cela est possible, les DPE doivent comporter un schéma de raccordement, à moins que le mode correct de connexion ne soit évident.

Sur ce schéma, les bornes doivent être indiquées par le symbole ○ (IEC 60617-S00017:2001-07).

Le marquage doit être durable et facilement lisible; il ne doit pas être placé sur des vis, rondelles ou autres parties amovibles.

7 Conditions normales de fonctionnement en service

7.1 Généralités

Les DPE conformes au présent document doivent être capables de fonctionner dans les conditions normales suivantes.

7.2 Température de l'air ambiant

7.2.1 Température de l'air ambiant de référence T pour étalonnage

La valeur normale de la température de l'air ambiant de référence est (23 ± 2) °C.

Toutefois les DPE peuvent être étalonnés pour une température de l'air ambiant de référence T °C différente. Dans ce cas ils doivent être marqués selon l'Article 6 f).

7.2.2 Limites de la température de l'air ambiant pour fonctionnement en service

Pour les conditions normales (température de l'air ambiant de référence T = 23 °C), la température de l'air ambiant n'excède pas +40 °C et sa moyenne, mesurée sur une période de 24 h, n'excède pas +35 °C. La limite inférieure de la température de l'air ambiant est de –5 °C.

Pour les DPE prévus pour une température de l'air ambiant de référence T supérieure à 23 °C, par hypothèse la limite supérieure est de (T + 10) °C. Les limites inférieures doivent être prises dans les informations fournies par le constructeur.

7.3 Altitude

L'altitude du lieu d'installation n'excède pas 2 000 m (6 600 ft).

Pour les installations à des altitudes plus élevées, il est nécessaire de tenir compte de la diminution de la rigidité diélectrique et de l'effet réfrigérant de l'air.

Les DPE prévus pour fonctionner dans ces conditions doivent être spécialement conçus ou utilisés conformément à un accord entre constructeur et utilisateur.

Les renseignements donnés dans le catalogue du constructeur peuvent tenir lieu d'un tel accord.

7.4 Conditions atmosphériques

L'air est propre et son humidité relative ne dépasse pas 50 % à une température maximale de +40 °C. Des taux d'humidité relative supérieurs peuvent être admis à des températures plus basses, par exemple 90 % à +20 °C.

Il convient de tenir compte par des moyens appropriés (par exemple, des orifices de drainage) des condensations modérées qui peuvent se produire occasionnellement lors des variations de température.

8 Exigences de construction et de manœuvre

8.1 Conception mécanique

8.1.1 Généralités

Un DPE doit être conçu et réalisé de sorte qu'en utilisation normale, son fonctionnement soit sûr et sans danger pour l'utilisateur ou l'environnement.

En règle générale, ceci est vérifié par l'exécution de tous les essais applicables spécifiés.

8.1.2 Mécanisme

Les contacts mobiles des DPE multipolaires doivent être couplés mécaniquement de sorte que tous les pôles, protégés ou non, se ferment et s'ouvrent pratiquement ensemble, qu'ils soient manœuvrés manuellement ou automatiquement, même si une surcharge se produit sur un pôle seulement. Le constructeur doit indiquer dans sa notice si le DPE est à déclenchement libre, à déclenchement libre cyclique ou à déclenchement non libre.

Un DPE, à l'exception des DPE type J sans organe de manœuvre manuelle, doit comporter des organes indiquant sa position de fermeture et d'ouverture, qui doit être facilement visible lorsque ce dernier est équipé de son capot ou de sa plaque de recouvrement, le cas échéant. Lorsque l'organe de manœuvre est utilisé pour indiquer la position des contacts, il doit avoir deux positions de repos distinctes correspondant à la position des contacts et l'organe de manœuvre, lorsqu'il est libéré, doit prendre automatiquement la position correspondant à celle des contacts mobiles. Pour l'ouverture automatique, le DPE peut comporter une troisième position distincte de l'organe de manœuvre.

Le fonctionnement du mécanisme ne doit pas être influencé par la position des enveloppes ou des capots et doit être indépendant de toute partie amovible.

Les organes de manœuvre doivent être solidement fixés sur leurs axes et il ne doit pas être possible de les retirer sans l'aide d'un outil. Les organes de manœuvre directement fixés aux capots sont autorisés.

La conformité aux exigences ci-dessus est vérifiée par examen et par un essai manuel.

Des exigences supplémentaires pour le mécanisme des DPE aptes au sectionnement sont données en K.8.1.2.

8.1.3 Distances d'isolement et lignes de fuite (voir Annexe B)

8.1.3.1 Généralités

Les DPE doivent être construits de sorte que les distances d'isolement et les lignes de fuite soient capables de supporter les contraintes électriques, mécaniques et thermiques, en tenant compte des influences externes, qui peuvent survenir pendant la durée de vie escomptée du DPE.

NOTE 1 Les exigences et les essais sont basés sur l'IEC 60664-1.

Pour les DPE, les conditions suivantes sont par principe généralement applicables:

– catégorie de surtension II;
– degré de pollution 2.

NOTE 2 Les DPE peuvent être conçus pour d'autres catégories de surtension et degrés de pollution.

NOTE 3 Une ligne de fuite ne peut pas être inférieure à la distance d'isolement associée telle que la plus petite ligne de fuite possible soit égale à la distance d'isolement exigée.

Des exigences supplémentaires pour les distances d'isolement et les lignes de fuite pour les DPE aptes au sectionnement sont données en K.8.1.3.

8.1.3.2 Distances d'isolement

8.1.3.2.1 Généralités

Les distances d'isolement du DPE doivent être dimensionnées de façon à supporter la tension assignée de tenue aux chocs déclarée par le constructeur selon 5.2.2.4 tenant compte de la tension assignée et de la catégorie de surtension indiquée dans le Tableau H.1.

Les dimensions selon le Tableau 1 sont réputées satisfaire à l'essai de tenue aux tensions de choc.

NOTE La corrélation entre les tensions assignées des systèmes d'alimentation et la tension entre phase et neutre correspondant pour déterminer la tension assignée de choc est donnée à l'Annexe H.

8.1.3.2.2 Distances d'isolement pour l'isolation principale

Les distances d'isolement pour l'isolation principale ne doivent pas être inférieures à celles données dans le Tableau 1. Des distances d'isolement plus faibles peuvent être utilisées si le DPE satisfait à l'essai de tenue aux tensions de choc de 9.7.6, mais seulement si les parties sont rigides ou sont placées dans un moulage ou si la construction est telle qu'il n'y ait aucune possibilité de réduction de la distance par déformation, par déplacement des parties ou pendant le montage, le raccordement et l'utilisation en utilisation normale à une valeur telle que le DPE ne satisfasse plus à l'essai de tenue aux tensions de choc.

La conformité est vérifiée par mesurage ou, si nécessaire, par l'essai de 9.7.6.

8.1.3.2.3 Distances d'isolement pour l'isolation fonctionnelle

Les distances d'isolement pour l'isolation fonctionnelle ne doivent pas être inférieures à celles données dans le Tableau 1. Des distances d'isolement plus faibles peuvent être utilisées dans les conditions spécifiées pour l'isolation principale.

La conformité est vérifiée par mesurage ou, si nécessaire, par l'essai de 9.7.6.

8.1.3.2.4 Distances d'isolement pour l'isolation supplémentaire

Les distances d'isolement pour l'isolation supplémentaire ne doivent pas être inférieures à celles spécifiées pour l'isolation principale en 8.1.3.2.2, à la différence près que des distances d'isolement plus faibles que celles données dans le Tableau 1 ne sont pas autorisées.

La conformité est vérifiée par mesurage.

NOTE L'isolation supplémentaire est utilisée conjointement avec l'isolation principale.

8.1.3.2.5 Distances d'isolement pour l'isolation renforcée

Les distances d'isolement pour l'isolation renforcée ne doivent pas être inférieures à celles données dans le Tableau 1.

La conformité est vérifiée par mesurage.

Tableau 1 – Distances d'isolement minimales pour l'isolation principale et l'isolation renforcée

Tension assignée de tenue aux chocs	Distance d'isolement minimale [d] mm					
	Degré de pollution pour l'isolation principale			Degré de pollution pour l'isolation renforcée		
V [a]	1	2 (voir 8.1.3)	3	1	2 (voir 8.1.3)	3
330	0,01	0,2 [b c]	0,8 [c]	0,04	0,2 [b c]	0,8 [c]
500	0,04	0,2 [b c]	0,8 [c]	0,10	0,2 [b c]	0,8 [c]
800	0,10	0,2 [b c]	0,8 [c]	0,5	0,5	0,8 [c]
1 500	0,5	0,5	0,8 [c]	1,5	1,5	1,5
2 500	1,5	1,5	1,5	3	3	3
4 000	3	3	3	5,5	5,5	5,5
6 000	5,5	5,5	5,5	8	8	8

[a] Cette tension est

– pour l'isolation fonctionnelle: la tension de choc maximale susceptible d'apparaître à travers la distance d'isolement;

– pour l'isolation principale directement exposée ou influencée de façon significative par les surtensions transitoires venant de l'alimentation basse tension: la tension assignée de tenue aux chocs du DPE;

– pour l'isolation principale non directement exposée ou influencée de façon significative par les surtensions transitoires venant de l'alimentation basse tension: la tension de choc la plus élevée pouvant survenir dans le circuit.

[b] Pour les cartes imprimées à l'intérieur du DPE, le degré de pollution 1 s'applique, à la différence près que la valeur ne doit pas être inférieure à 0,04 mm.

[c] Valeur minimale de la distance d'isolement basée sur l'expérience plutôt que sur des données fondamentales.

[d] Des DPE avec une distance entre contacts inférieure à la distance minimale d'isolement spécifiée sont autorisés, mais ils doivent être marqués du symbole µ.

8.1.3.2.6 Distances d'isolement à travers la microdéconnexion

Les distances d'isolement à travers la microdéconnexion doivent être dimensionnées pour résister aux surtensions temporaires (voir 3.4.4).

La conformité est vérifiée par l'essai de 9.11.1.3.

8.1.3.2.7 Distances d'isolement à travers la déconnexion complète

Les distances d'isolement à travers la déconnexion complète doivent être dimensionnées pour résister aux surtensions transitoires. Elles ne doivent pas être inférieures à celles données dans le Tableau 1 pour l'isolation principale. Des distances plus petites peuvent être utilisées si le DPE est capable de supporter la tension d'essai de tenue aux chocs à travers les contacts ouverts après les essais de 9.9 et 9.11.

La conformité est vérifiée par mesurage ou par l'essai de 9.7.6.

8.1.3.3 Lignes de fuite

8.1.3.3.1 Généralités

Les lignes de fuite du DPE ne doivent pas être inférieures à celles correspondant à la tension susceptible d'apparaître en utilisation normale, en tenant compte du groupe de matériau et du degré de pollution.

8.1.3.3.2 Lignes de fuite pour l'isolation principale

Les lignes de fuite pour l'isolation principale ne doivent pas être inférieures à celles spécifiées dans le Tableau 2.

NOTE Les lignes de fuite ne peuvent pas être inférieures aux distances d'isolement associées.

La relation entre le groupe de matériau et les valeurs de l'indice de tenue au cheminement (ITC) est la suivante:

Groupe de matériau I	600	≤	ITC		
Groupe de matériau II	400	≤	ITC	<	600
Groupe de matériau III a	175	≤	ITC	<	400
Groupe de matériau III b	100	≤	ITC	<	175

Pour les matériaux des circuits imprimés, les valeurs des indices de résistance aux courants de cheminement (IRC) sont appliquées.

NOTE Les valeurs de l'IRC sont obtenues conformément à l'IEC 60112, en utilisant la solution A.

La conformité est vérifiée par mesurage.

8.1.3.3.3 Lignes de fuite pour l'isolation fonctionnelle

Les lignes de fuite pour l'isolation fonctionnelle ne doivent pas être inférieures à celles spécifiées dans le Tableau 2.

La conformité est vérifiée par mesurage.

NOTE Pour le verre, les céramiques et les autres matériaux non organiques qui ne sont pas sujets au cheminement, il n'est pas nécessaire que les lignes de fuite soient supérieures à leurs distances d'isolement associées.

Tableau 2 – Lignes de fuite minimales

Tension locale à travers les lignes de fuite	Cartes imprimées [f] Degré de pollution		Ligne de fuite minimale pour l'isolation principale Degré de pollution [e]						
	1 [b]	**2** [c]	**1** [b]	**2** (voir 8.1.3)			**3**		
				Groupe de matériau			Groupe de matériau		
				I	**II**	**III**[d]	**I**	**II**	**III** [d]
V	mm	mm	mm	mm	mm	mm	mm	mm	mm
10	0,025	0,04	0,08	0,04	0,04	0,04	1,0	1,0	1,0
12,5	0 025	0,04	0,09	0,42	0,42	0,42	1,05	1,05	1,05
16	0,025	0,04	0,10	0,45	0,45	0,45	1,1	1,1	1,1
20	0 025	0,04	0,11	0,48	0,48	0,48	1,2	1,2	1,2
25	0 025	0,04	0 125	0,50	0,50	0,50	1,25	1,25	1,25
32	0 025	0,04	0,14	0,53	0,53	0,53	1,3	1,3	1,3
40	0 025	0,04	0,16	0,56	0,8	1,1	1,4	1,6	1,8
50	0 025	0,04	0,18	0,6	0,85	1,2	1,5	1,7	1,9
63	0,04	0 063	0,20	0,63	0,9	1,25	1,6	1,8	2,0
80	0 063	0,1	0,22	0,67	0,95	1,3	1,7	1,9	2,1
100	0,1	0,16	0,25	0,71	1,0	1,4	1,8	2,0	2,2
125	0,16	0,25	0,28	0,75	1,05	1,5	1,9	2,1	2,4
160	0,25	0,4	0,32	0,8	1,1	1,6	2,0	2,2	2,5
200	0,4	0,63	0,42	1,0	1,4	2,0	2,5	2,8	3,2
250	0,56	1,0	0,56	1,25	1,8	2,5	3,2	3,6	4,0
320	0,75	1,6	0,75	1,6	2,2	3,2	4,0	4,5	5,0
400	1,0	2,0	1,0	2,0	2,8	4,0	5,0	5,6	6,3
500[a]	1,3	2,5	1,3	2,5	3,6	5,0	6,3	7,1	8,0

[a] Pour des tensions locales plus élevées, les valeurs du Tableau 4 de l'IEC 60664-1:2007 s'appliquent.

[b] Groupes de matériaux I, II, III a et III b.

[c] Groupes de matériaux I, II, III a.

[d] Groupe de matériau III inclue III a et III b.

[e] Dans le DPE, le microenvironnement est réputé s'appliquer.

[f] Pour les cartes imprimées revêtues conformes à l'IEC 60664-3, il n'est pas nécessaire d'appliquer ces valeurs.

8.1.3.3.4 Lignes de fuite pour l'isolation supplémentaire

Les lignes de fuite de l'isolation supplémentaire ne doivent pas être inférieures à celles spécifiées pour l'isolation principale.

La conformité est vérifiée par mesurage.

8.1.3.3.5 Lignes de fuite pour l'isolation renforcée

Les lignes de fuite de l'isolation renforcée ne doivent pas être inférieures au double de celles spécifiées pour l'isolation principale.

La conformité est vérifiée par mesurage.

8.1.4 Vis, parties sous tension et connexions

8.1.4.1 Les connexions, tant électriques que mécaniques, doivent être capables de résister aux contraintes mécaniques qui se produisent en service normal.

Les connexions à vis sont considérées comme vérifiées par les essais de 9.8, 9.9, 9.11, 9.13 et 9.14.

8.1.4.2 Les connexions électriques doivent être conçues de sorte que la pression de contact ne se transmette pas par l'intermédiaire de matériaux isolants autres que la céramique, le mica pur ou d'autres matériaux présentant des caractéristiques au moins équivalentes, sauf si l'élasticité des parties métalliques est suffisante pour compenser un éventuel retrait ou fléchissement du matériau isolant.

La conformité est vérifiée par examen.

NOTE Le caractère approprié du matériau est évalué par rapport à la stabilité des dimensions.

8.1.4.3 Les parties sous tension et les contacts destinés aux conducteurs de protection doivent être:

– en cuivre;
– en alliage contenant au moins 58 % de cuivre pour les pièces obtenues par laminage ou au moins 50 % de cuivre pour les autres; ou
– en un autre métal ou métal avec revêtement adapté, aussi résistant que le cuivre à la corrosion et ayant des propriétés mécaniques au moins équivalentes.

NOTE De nouvelles exigences, à vérifier par un essai pour déterminer la résistance à la corrosion, sont à l'étude. Il convient que ces exigences permettent l'utilisation d'autres matériaux à condition qu'ils soient convenablement revêtus.

Ces exigences ne s'appliquent pas aux contacts, circuits magnétiques, éléments chauffants, éléments bimétalliques, shunts et parties de dispositifs électroniques ni aux vis, écrous, rondelles, plaques de serrage et parties similaires des bornes.

8.1.5 Bornes à vis et bornes sans vis

8.1.5.1 Les bornes doivent être telles que les conducteurs puissent être connectés de façon à ce que la pression de contact nécessaire soit assurée.

La conformité est vérifiée par examen et par l'essai de 9.5.2.

8.1.5.2 Les bornes doivent être fixées de sorte que la borne ne puisse pas se desserrer lorsque le conducteur est connecté ou déconnecté.

La conformité est vérifiée par examen, par mesurage et par l'essai de 9.4.1.

8.1.5.3 Les bornes pour la connexion des conducteurs externes (voir 3.12.15) doivent permettre la connexion de conducteurs en cuivre ayant la section nominale indiquée dans le Tableau 3.

Les bornes qui doivent être utilisées pour les conducteurs internes (voir 3.12.17) et pour les conducteurs intégrés (voir 3.12.16) doivent permettre la connexion des conducteurs en cuivre des diamètres les plus grands et les plus petits spécifiés par le constructeur. À défaut, le Tableau 3 s'applique.

Des exemples de formes et de dimensions possibles des bornes sont donnés à l'Annexe E.

La conformité est vérifiée par examen et en raccordant les conducteurs des types déclarés ayant la plus petite et la plus grande des sections spécifiées.

Tableau 3 – Sections raccordables de conducteurs externes en cuivre pour les bornes à vis et sans vis

Courant assigné A	Plage des sections à serrer [a] mm^2
Jusqu'à 6 inclus	0,5 à 1,0
Au-dessus de 6 à 13 inclus	0,75 à 1,5
Au-dessus de 13 à 20 inclus	1,0 à 2,5
Au-dessus de 20 à 25 inclus	1,5 à 4
Au-dessus de 25 à 32 inclus	2,5 à 6
Au-dessus de 32 à 50 inclus	4 à 10
Au-dessus de 50 à 63 inclus	6 à 16
Au-dessus de 63 à 80 inclus	10 à 25
Au-dessus de 80 à 100 inclus	16 à 35
Au-dessus de 100 à 125 inclus	25 à 50

[a] L'acceptation de sections supérieures et inférieures est admise.

8.1.5.4 Les bornes pour conducteurs non préparés en cuivre qui conviennent au raccordement des conducteurs souples (externes) doivent être disposées ou protégées de sorte que, si un brin d'un conducteur souple s'échappe de la borne lorsque les conducteurs sont raccordés, il n'y ait pas de risque de contact entre les parties actives et les parties métalliques accessibles et, pour les DPE pour appareils de classe II, entre les parties actives et les parties métalliques séparées des parties métalliques accessibles par une isolation supplémentaire seulement.

La conformité est vérifiée par examen et par l'essai de 9.5.

8.1.5.5 Les moyens de fixation des conducteurs dans les bornes ne doivent pas servir à fixer un quelconque autre composant, bien qu'ils puissent maintenir les bornes en place ou les empêcher de tourner.

La conformité est vérifiée par examen et par l'essai de 9.5.1.

8.1.5.6 Les bornes doivent être conçues de sorte que l'insertion du conducteur soit limitée par un arrêt si une insertion plus profonde peut réduire les lignes de fuite et/ou les distances d'isolement ou influencer le mécanisme du DPE.

La conformité est vérifiée par examen.

8.1.5.7 Les bornes doivent être conçues de façon à ce qu'elles serrent le conducteur sans lui occasionner de dommage excessif.

La conformité est vérifiée par examen et par l'essai de 9.5.3.

8.1.5.8 Les bornes doivent être conçues de façon à ce qu'elles effectuent une connexion fiable entre les surfaces métalliques sans dommage excessif pour le conducteur.

La conformité est vérifiée par examen et par les essais de 9.4 et 9.5.

8.1.5.9 Les bornes doivent serrer le conducteur entre des surfaces métalliques, à l'exception des bornes destinées à être utilisées dans des circuits transportant un courant ne dépassant pas 0,2 A dont l'une des surfaces peut être non métallique.

8.1.5.10 Les bornes pour des courants assignés jusqu'à 32 A inclus, destinées au raccordement de conducteurs externes, doivent permettre la connexion de conducteurs en cuivre non préparés.

La conformité est vérifiée par examen.

8.1.5.11 Les bornes pour conducteurs préparés en cuivre doivent être adaptées à leur usage lorsque la connexion est effectuée comme spécifié par le constructeur dans sa documentation.

La conformité est vérifiée par examen et par l'essai de 9.5.4.

8.1.5.12 Les bornes à vis doivent avoir une résistance adéquate. Les vis et les écrous pour le serrage des conducteurs doivent avoir un filetage métrique ISO ou un filetage comparable en pas et en résistance mécanique.

La conformité est vérifiée par examen et par les essais de 9.4 et 9.5.2.

NOTE Provisoirement, les pas SI, BA et UN peuvent être utilisés, car ils sont considérés comme comparables, en filetage et résistance mécanique, au pas métrique ISO.

8.1.5.13 Les vis ou écrous de serrage des bornes destinées au raccordement des conducteurs de protection doivent être protégés de façon adéquate contre un desserrage accidentel.

La conformité est vérifiée par examen et par l'essai de 9.5.1.

En général, les conceptions de bornes selon les Figures E.1 à E.4 procurent une élasticité suffisante pour satisfaire à cette exigence. Pour d'autres conceptions, des dispositions spéciales (par exemple, l'utilisation d'une pièce élastique convenable qui ne peut pas être retirée par inadvertance) peuvent être nécessaires.

8.1.5.14 Les vis et les écrous des bornes destinées au raccordement des conducteurs externes doivent s'engager dans un filetage métallique et la vis ne doit pas être du type autotaraudeuse.

8.1.5.15 Pour les bornes à trous, la distance entre la vis de serrage et l'extrémité du conducteur lorsque celui-ci est introduit à fond doit être au moins conforme à celle du Tableau 4.

La distance minimale entre la vis de serrage et l'extrémité du conducteur s'applique seulement aux bornes à trous à travers lesquelles le conducteur ne peut passer directement.

Tableau 4 – Distance minimale entre la vis de serrage et l'extrémité du conducteur introduit à fond

Courant assigné A	**Valeurs minimales** mm	
	Avec une vis de serrage	**Avec deux vis de serrage**
Jusqu'à 6 inclus	1,5	1,5
Au-dessus de 6 à 13 inclus	1,5	1,5
Au-dessus de 13 à 20 inclus	1,8	1,5
Au-dessus de 20 à 25 inclus	1,8	1,5
Au-dessus de 25 à 32 inclus	2,0	1,5
Au-dessus de 32 à 50 inclus	2,5	2,0
Au-dessus de 50 à 80 inclus	3,0	2,0
Au-dessus de 80 à 100 inclus	4,0	3,0
Au-dessus de 100 à 125 inclus	À l'étude	À l'étude

La conformité est vérifiée par mesurage après qu'un conducteur massif de la section la plus grande spécifiée par le constructeur a été introduit à fond et serré au couple indiqué dans le Tableau 15.

8.1.5.16 Sauf spécification contraire par le constructeur, les bornes sans vis (voir Figure E.5) doivent accepter les conducteurs indiqués dans le Tableau 3, auquel cas aucun marquage n'est nécessaire.

Si une borne sans vis ne peut accepter que des conducteurs massifs, cela doit être soit clairement marqué sur le produit final, aux fins de connexion, par les lettres "sol", soit indiqué sur le plus petit emballage, dans une documentation technique et/ou dans les catalogues du constructeur.

Si une borne sans vis ne peut accepter que des conducteurs rigides (à âme massive ou câblée), cela doit être soit clairement marqué sur le produit final, aux fins de connexion, par la lettre "r", soit indiqué sur le plus petit emballage, dans une documentation technique et/ou dans les catalogues du constructeur.

La conformité est vérifiée par examen et par l'essai de 9.4.1.

8.1.5.17 Les bornes sans vis doivent résister aux contraintes mécaniques survenant en utilisation normale. La connexion ou la déconnexion des conducteurs doit être faite comme suit:

– pour les bornes universelles, en utilisant un outil d'usage courant ou avec un dispositif approprié intégré à la borne et conçu pour l'ouvrir lors de l'insertion ou du retrait des conducteurs;

– pour les bornes pousse-fil par simple insertion. Pour la déconnexion des conducteurs, une manœuvre autre qu'une traction sur le conducteur doit être nécessaire.

L'utilisation d'un outil d'usage courant ou d'un dispositif approprié intégré à la borne est admise dans le but de "l'ouvrir" et d'aider à l'insertion ou au retrait du conducteur.

La conformité est vérifiée par examen et par l'essai de 9.4.

8.1.5.18 Les bornes sans vis doivent permettre la connexion correcte des conducteurs.

La façon d'insérer et de déconnecter les conducteurs doit être évidente ou des instructions doivent être données par le constructeur.

NOTE Des exemples de bornes sans vis sont donnés à la Figure E.5.

La déconnexion intentionnelle du conducteur doit exiger une manœuvre autre qu'une traction sur le conducteur telle qu'elle puisse être effectuée manuellement avec ou sans l'aide d'un outil en utilisation normale.

Les ouvertures pour l'utilisation d'un outil destiné à aider l'insertion ou la déconnexion doivent être clairement distinctes des ouvertures pour le conducteur.

La conformité est vérifiée par examen, par mesurage et par l'insertion des conducteurs souples et/ou rigides appropriés de sections conformes à celles du Tableau 3.

8.1.5.19 Les bornes sans vis destinées à être utilisées pour l'interconnexion de plus d'un conducteur doivent être conçues de telle façon qu'après l'insertion, le fonctionnement de l'organe de serrage de l'un des conducteurs soit indépendant du fonctionnement de l'organe de serrage de l'autre conducteur. Pendant la déconnexion, les conducteurs peuvent être déconnectés soit simultanément soit séparément.

La conformité est vérifiée par examen et par les essais avec toutes les combinaisons spécifiées par le constructeur.

8.1.6 Terminaisons à souder

8.1.6.1 Les terminaisons à souder doivent avoir une soudabilité suffisante.

La conformité est vérifiée en appliquant l'essai de 9.4.2.1.

8.1.6.2 Les matériaux adjacents aux terminaisons à souder doivent avoir une résistance suffisante à la chaleur de soudage.

La conformité est vérifiée en appliquant l'essai de 9.4.2.2.

8.1.6.3 Les terminaisons à souder doivent comporter des moyens maintenant mécaniquement le conducteur en position de sécurité indépendamment de la soudure.

Ces moyens peuvent être, par exemple:

– un trou adapté pour accrocher le conducteur;
– une mise en forme des bords de la borne pour permettre l'enroulage du conducteur autour de la borne avant le soudage;
– un moyen de serrage adjacent à la connexion soudée.

NOTE Les terminaisons à souder pour la connexion des cartes imprimées ne sont pas prises en considération dans le présent document.

La conformité est vérifiée par examen.

8.1.7 Languettes des bornes plates à connexion rapide (Figures E.6 à E.13)

8.1.7.1 Les languettes doivent satisfaire aux dimensions des Tableaux 5, 6 et 7.

Tableau 5 – Dimensions des languettes en millimètres – Dimensions *A*, *B*, *C*, *D*, *E*, *F*, *J*, *M*, *N*, *P* et *Q*

Taille nominale		*A*	*B* min	*C*	*D*	*E*	*F*	*J* [a]	*M*	*N*	*P*	*Q* min
2,8 × 0,5	empreinte	0,6 0,3	7,0	0,54 0,47	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°	1,7 1,4	1,4 1,0	1,4 0,3	8,1
	trou	0,6 0,3	7,0	0,54 0,47	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°			1,4 0,3	8,1
2,8 × 0,8	empreinte	0,6 0,3	7,0	0,84 0,77	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°	1,7 1,4	1,4 1,0	1,4 0,3	8,1
	trou	0,6 0,3	7,0	0,84 0,77	2,90 2,70	1,8 1,3	1,3 1,1	12° 8°			1,4 0,3	8,1
4,8 × 0,8	empreinte	1,0 0,7	6,2	0,84 0,77	4,80 4,60	2,8 2,3	1,5 1,3	12° 8°	1,7 1,4	1,5 1,2	1,8 0,7	7,3
	trou	1,0 0,6	6,2	0,84 0,77	4,90 4,67	3,4 3,0	1,5 1,3	12° 8°			1,8 0,7	7,3
6,3 × 0,8	empreinte	1,0 0,7	7,8	0,84 0,77	6,40 6,20	4,1 3,6	2,0 1,6	12° 8°	2,5 2,2	2,0 1,8	1,8 0,7	8,9
	trou	1,0 0,5	7,8	0,84 0,77	6,40 6,20	4,7 4,3	2,0 1,6	12° 8°			1,8 0,7	8,9
9,5 × 1,2	trou	1,3 0,7	12,0	1,23 1,17	9,60 9,40	5,5 4,5	2,0 1,7	14° 6°			2,0 1,0	13,1

[a] La soudure des fils sur la languette et les modifications dimensionnelles correspondantes, si nécessaire, sont à l'étude.

Tableau 6 – Dimensions des languettes en millimètres – Dimensions *H*, *I*, *T*, *K*, *R*, *G*, *L*, *S* et *U*

Taille nominale		*H*	*I*	*T* [a]	*K*	*R*	*G*	*L*	*S*	*U*
2,8 × 0,5	empreinte				1,7 max.	7,0 max.				
	trou	1,7 max.	2,7 max.							
2,8 × 0,8	empreinte				1,7 max.	7,0 max.				
	trou	1,7 max.	2,7 max.	1 min.						
4,8 × 0,8	empreinte				1,7 max.	6,2 max.	1,6 max.	0,7 ± 0,1	1,0 ± 0,2	0,5 ± 0,2
	trou	2,2 max.	4,2 max.	2 min.			1,6 max.	0,7 ± 0,1	1,0 ± 0,2	
6,3 × 0,8	empreinte				2,5 max.	7,8 max.	2,9 max.	1,0 ± 0,1	1,0 ± 0,2	0,5 ± 0,2
	trou	3,5 max.	5,5 max.	2 min.			2,9 max.	1,0 ± 0,1	1,0 ± 0,2	
9,5 × 1,2	empreinte				4 max.	12,0 max.	2,9 max.	1,5 ± 0,1	1,4 ± 0,2	0,7 ± 0,2
	trou	5 max.	7,5 max.	2,5			2,9 max.	1,5 ± 0,1	1,4 ± 0,2	

[a] Si les Figures E.10 et E.11 sont combinées, la dimension *T* doit être supérieure à la valeur réelle de la dimension *G* augmentée de l'épaisseur *C* du matériau.

Sauf spécification contraire, dans le Tableau 7 les dimensions *E*1 et *F*1 doivent correspondre aux dimensions équivalentes des Tableaux 5 et 6 pour la grande taille de languette et les dimensions *B*2, *E*2 et *F*2 pour la petite taille de languette.

Des exemples de conceptions et de dimensions de bornes plates à connexion rapide sont donnés aux Figures E.6 à E.13.

8.1.7.2 Les languettes peuvent comporter un encliquetage facultatif pour le verrouillage. Les empreintes rondes ou rectangulaires d'encliquetage et les trous d'encliquetage doivent être situés dans la zone hachurée sur l'axe de la languette comme indiqué à la Figure E.10.

NOTE Les languettes peuvent avoir un trou plus large pour permettre la soudure.

Tableau 7 – Dimensions des languettes combinées acceptant deux tailles différentes de clips (millimètres)

	Types selon les figures				
Dimensions nominales mm	***E*1**	***F*1**	***B*2**	***E*2**	***F*2**
2,8 × 0,8			6 min.	2,0 à 2,4	1,3 à 1,5
6,3 × 0,8	4,0 à 4,5	1,6 à 1,9			

8.1.7.3 Des dispositions pour des limitations de non-réversibilité peuvent être placées dans la zone "LG" de la Figure E.11 et "KR" de la Figure E.12 sur l'axe de la languette.

Si les Figures E.10 et E.11 sont combinées, la dimension *T* doit être supérieure à la valeur réelle de la dimension *G* augmentée de l'épaisseur *C* du matériau. Pour les valeurs de *T*, *G* et *C,* voir les Tableaux 5 et 6.

NOTE Les languettes de la Figure E.12 ne sont pas conçues pour avoir un trou ou une empreinte selon les valeurs de E et F du Tableau 5.

8.1.7.4 Les languettes doivent être conçues pour permettre l'insertion et le retrait corrects de l'un des clips indiqués à la Figure E.14 sans dommage qui pourrait compromettre l'utilisation ultérieure du DPE.

La conformité est vérifiée par l'essai de 9.4.3.1.

8.1.7.5 Les languettes doivent être retenues de façon sûre.

La conformité est vérifiée par l'essai de force de surcharge mécanique de 9.4.3.2.

8.1.7.6 Les languettes indiquées à la Figure E.13 peuvent avoir une conception qui permet de connecter deux dimensions différentes de clips.

8.1.7.7 Les languettes de dimensions et de conception similaires à celles indiquées dans les Tableaux 5 et 6 doivent être admises si elles sont capables de satisfaire à l'essai de conformité avec le clip indiqué à la Figure E.14.

Un exemple de clip et des dimensions possibles sont donnés à la Figure E.14.

La conformité est vérifiée par l'essai de 9.4.3.

8.1.7.8 Les languettes qui n'ont pas les critères dimensionnels indiqués en 8.1.7.1 et 8.1.7.7 sont admises seulement si les dimensions et les formes sont si différentes qu'elles empêchent tout assemblage avec le clip indiqué à la Figure E.14.

8.1.7.9 Les languettes doivent être espacées de façon à permettre la connexion des clips non isolés appropriés.

La conformité est vérifiée en appliquant sur chaque conception/configuration de languette un clip approprié selon les instructions du constructeur avec l'orientation la plus défavorable. Pendant cette manœuvre aucune contrainte ou déformation ne doit apparaître sur l'une quelconque des languettes ou de leurs parties adjacentes et les lignes de fuite et les distances d'isolement ne doivent pas être réduites à des valeurs inférieures à celles spécifiées en 8.1.3.

NOTE Un blocage non réversible peut être inclus ne permettant l'introduction du clip que dans une direction de sorte que le clip ne puisse pas être inséré dans la position inverse.

Pour les languettes conformes à la Figure E.11 ou à la Figure E.12, un clip approprié est celui indiqué à la Figure E.14.

8.2 Protection contre les chocs électriques

Les parties du DPE accessibles après installation dans l'équipement doivent fournir une protection contre les chocs électriques.

La conformité est vérifiée par les essais de 9.6.

L'achèvement de la protection contre les chocs électriques après installation du DPE est de la responsabilité du constructeur de l'équipement.

8.3 Échauffement

8.3.1 Limites d'échauffement

Les échauffements des différentes parties d'un DPE mesurés dans les conditions spécifiées en 9.8.2 ne doivent pas dépasser les limites spécifiées dans le Tableau 8.

Tableau 8 – Valeurs d'échauffement des DPE pour des températures de l'air ambiant de référence différentes (T)

Parties [a] [b]	Valeurs des échauffements (K) en fonction de T [e]		
	T = 23 °C [f] (valeur normale)	T = 40 °C [f]	T = 55 °C [f]
Bornes [c]	60 [d]	50 [d]	35 [d]
Parties extérieures susceptibles d'être touchées pendant la manœuvre manuelle y compris les organes de manœuvre en matériau isolant	55	40	25
Parties métalliques externes de l'organe de manœuvre	35	25	10
Autres parties externes y compris la face du DPE en contact avec la surface de montage	70	60	45

[a] Aucune valeur n'est spécifiée pour les contacts; ceci tient au fait que la conception de la plupart des DPE est telle que le mesurage direct de la température de ces parties ne peut être effectué sans risquer de provoquer des altérations ou déplacements de parties susceptibles d'affecter la reproductibilité des essais.
L'essai de 28 jours (voir 9.9) est considéré comme suffisant pour contrôler indirectement le comportement des contacts en ce qui concerne un échauffement excessif en service.

[b] Aucune valeur n'est spécifiée pour les parties autres que celles indiquées dans le tableau, mais les parties adjacentes en matériau isolant ne doivent pas être endommagées et le fonctionnement du DPE ne doit pas être affecté.

[c] Pour les DPE du type enfichable, les bornes de la base sur laquelle le DPE est installé.

[d] Des valeurs plus élevées sont admises pour les bornes pour conducteurs internes à l'équipement dans lequel le DPE est destiné à être installé. Les informations correspondant à ces valeurs doivent être communiquées au constructeur de l'équipement.

[e] Pour d'autres valeurs de T l'échauffement admissible peut être déterminé par interpolation entre les valeurs ($T + K$) obtenues par la somme des valeurs indiquées dans le tableau.

[f] Tolérance ±2 °C.

La conformité est vérifiée par les essais de 9.8.

8.3.2 Température de l'air ambiant

Les limites d'échauffement indiquées dans le Tableau 8 sont seulement applicables si la température de l'air ambiant reste dans les limites indiquées en 7.2.2.

8.4 Propriétés diélectriques

8.4.1 Rigidité diélectrique à fréquence industrielle

Les DPE doivent avoir des propriétés diélectriques à fréquence industrielle appropriées.

La conformité est vérifiée par les essais de 9.7.1, 9.7.2 et 9.7.3, avec des échantillons à l'état neuf.

Après la vérification des performances électriques de 9.11, les DPE doivent supporter l'essai de 9.7.3, mais sous une tension d'essai égale à 0,75 fois la tension indiquée en 9.7.5 et sans avoir subi le traitement préalable à l'humidité de 9.7.1.

8.4.2 Distances d'isolement pour la coordination de l'isolement

Les distances d'isolement doivent satisfaire aux exigences de la coordination de l'isolement.

La conformité doit être vérifiée par mesurage des distances d'isolement comme spécifié en 8.1.3 ou par l'essai de tenue aux tensions de choc de 9.7.6.

Des exigences pour l'aptitude au sectionnement des DPE aptes au sectionnement sont données en K.8.4.2.

8.5 Conditions de manœuvre automatique

8.5.1 Zone temps-courant normale

La zone de fonctionnement (voir 3.9.4) est définie à partir des informations données par le constructeur dans son catalogue (voir Annexe A). Les conditions de référence sont celles spécifiées en 9.2.

NOTE 1 La caractéristique de déclenchement d'un DPE est destinée à assurer, sans déclenchement prématuré, une protection adéquate de l'équipement.

La zone de fonctionnement d'un DPE doit être indiquée pour un DPE, sans enveloppe, monté en air calme.

NOTE 2 La zone de fonctionnement d'un DPE peut être affectée par des conditions de température et de montage différentes de celles qui sont indiquées (type d'enveloppe, groupement de plusieurs DPE dans une même enveloppe, etc.).

Le constructeur doit être en mesure de donner les caractéristiques pour des températures ambiantes spécifiées différentes de la température ambiante de référence normale de (23 ± 2) °C, et de donner des informations sur la variation de la caractéristique de déclenchement du fait des écarts par rapport aux autres conditions de référence (par exemple, montage dans des plans autres que verticaux).

Une représentation de la zone de fonctionnement est donnée par la Figure A.1. Pour un DPE à déclenchement thermique, magnétothermique, magnétique ou magnétohydraulique, le constructeur doit indiquer les valeurs suivantes:

– les courants d'essai indiqués dans le Tableau 9, comme multiple du courant assigné;
– les temps (t_1, t_2, t_3, t_4) indiqués dans le Tableau 9, le cas échéant.

Tableau 9 – Caractéristiques de fonctionnement temps-courant

Courant d'essai	Conditions initiales	Temps, t	Résultat exigé
I_{nt}	État froid [a]	1 h	Non-déclenchement
I_t	Immédiatement après l'essai de non-déclenchement	≤ 1 h	Déclenchement
$2I_n$	État froid [a]	$t_1 \leq t \leq t_2$	Déclenchement
$6I_n$	État froid [a]	$t_3 \leq t \leq t_4$	Déclenchement
I_{ni}	État froid [a]	0,1 s	Non-déclenchement
I_i	État froid [a]	< 0,1 s	Déclenchement

[a] Le terme "état froid" signifie sans charge préalable (voir Annexe A).

NOTE 3 Pour les DPE de type électronique hybride, les valeurs sont à l'étude.