



IEC 60934

Edition 4.0 2019-01
REDLINE VERSION

INTERNATIONAL STANDARD



Circuit-breakers for equipment (CBE)





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Circuit-breakers for equipment (CBE)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CIRCUIT-BREAKERS FOR EQUIPMENT (CBE)

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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.

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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 $6 \times I_n$ (AC types) and $4 \times I_n$ (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. systems¹⁾~~

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 Publication²⁾*

¹⁾ There is a consolidated edition 3.1 (1999) that includes IEC 60099-1 (1991) and its amendment 1 (1995).

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 disconnecter

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 it 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)

<i>Mode of tripping</i>	<i>Designation</i>
– 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

<i>Mode of tripping</i>	<i>Designation</i>
– 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 $(23 \pm 2) ^\circ\text{C}$.

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 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 380 V /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 CBEs 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  (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 $(23 \pm 2) ^\circ\text{C}$.

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 V ^a	Minimum clearance ^d mm					
	For basic insulation pollution degree			For reinforced insulation pollution degree		
	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	$600 \leq \text{PTI}$
Material group II	$400 \leq \text{PTI} < 600$
Material group III a	$175 \leq \text{PTI} < 400$
Material group III b	$100 \leq \text{PTI} < 175$

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		Minimum creepage distance for basic insulation						
	Pollution degree		Pollution degree ^e						
	1 ^b	2 ^c	1 ^b	2 (see 8.1.3)			3		
				Material group			Material group		
V	mm	mm	mm	I mm	II mm	III ^d mm	I mm	II mm	III ^d 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
~~200~~ 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	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	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	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	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	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	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	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	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	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.											