

Circuit-breakers for equipment (CBE)

ICS 29.120.40

National foreword

This British Standard is the UK implementation of EN 60934:2001+A2:2013. It is identical to IEC 60934:2000, incorporating amendments 1:2007 and 2:2013. It supersedes BS EN 60934:2001 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

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A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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Circuit-breakers for equipment (CBE)
(IEC 60934:2000)

Disjoncteurs pour équipement (DPE)
(CEI 60934:2000)

Geräteschutzschalter (GS)
(IEC 60934:2000)

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CENELEC

European Committee for Electrotechnical Standardization
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Europäisches Komitee für Elektrotechnische Normung

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Foreword

The text of document 23E/430/FDIS, future edition 3 of IEC 60934, prepared by SC 23E, Circuit-breakers and similar equipment for household use, of IEC TC 23, Electrical accessories, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60934 on 2000-11-01.

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Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A, B, C, D, E, G, H, J, K and ZA are normative and annex F is informative.

Annex ZA has been added by CENELEC.

In this standard the following print types are used:

- requirements: in roman type;
- *test specifications: in italic type;*
- notes: in smaller roman type.

Endorsement notice

The text of the International Standard IEC 60934:2000 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 23E/624/FDIS, future amendment 1 to IEC 60934:2000, prepared by SC 23E, Circuit-breakers and similar equipment for household use, of IEC TC 23, Electrical accessories, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 60934:2001 on 2007-02-01.

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Foreword to amendment A2

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Endorsement notice

The text of the International Standard IEC 60934:2000/A2:2013 was approved by CENELEC as a European Standard without any modification.

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CIRCUIT-BREAKERS FOR EQUIPMENT (CBE)

1 Scope

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

- a rated voltage not exceeding 440 V a.c. (between phases) and/or d.c. not exceeding 250 V;
- a rated current not exceeding 125 A;
- a short-circuit capacity (I_{cn}) of at least $6xI_n$ (a.c types) and $4xI_n$ (d.c.-types) but not exceeding 3 000 A.

CBEs may have a conditional short-circuit current 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 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 standard 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 J). 

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60068-2-20:1979, *Environmental testing – Part 2: Tests – Test T: Soldering*

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 60417-1:1998, *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, *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*

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

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

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

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: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test – Basic EMC Publication* ²⁾

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

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

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

3 Definitions

For the purposes of this International standard, the following definitions apply.

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 and breaking currents under specified abnormal conditions such as those of short circuit [IEV 441-14-20]

3.1.2

circuit-breaker for equipment (CBE)

circuit-breaker specifically designed for the protection of equipment

 NOTE 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 [IEV 441-18-01]

3.1.5

switching device

device designed to make or break the current in one or more electric circuits [IEV 441-14-01]

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

3.1.6

mechanical switching device

switching device designed to close and open one or more electric circuits by means of separable contacts [IEV 441-14-02]

3.1.7

switch (mechanical)

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 [IEV 441-14-10]

3.1.8

disconnecter

mechanical switching device which in the open position complies with the requirements specified for the isolating function [IEV 441-14-05, modified]

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 (for example, for an enclosed CBE, it is the air outside the enclosure) [IEV 441-11-13, modified]

3.2.2

applied voltage

voltage which exists across the terminals of a pole of a CBE just before the making of the current. In the case of a.c., it is the r.m.s. value [IEV 441-17-24, modified]

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 [IEV 441-15-02, modified]

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 [IEV 441-15-03, modified]

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 [IEV 441-15-04, modified]

3.2.6

pole (of a CBE)

that 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 [IEV 441-15-01, modified]

3.2.7

protected pole

pole provided with an overcurrent release (see 3.6.2)

3.2.8

unprotected pole

pole without overcurrent release (see 3.6.2) but otherwise generally capable of the same performance as a protected pole of the same CBE

3.2.9

neutral conductor (symbol N)

conductor connected to the neutral point of a system and capable of contributing to the transmission of electrical energy [IEV 826-01-03]

3.2.10

closed position

position in which the predetermined continuity of the main circuit of a CBE is secured [IEV 441-16-22, modified]

3.2.11

open position

position in which the predetermined clearance between open contacts in the main circuit of a CBE is provided [IEV 441-16-23, modified]

3.2.12

incorporated mounting

method of mounting where the user provides in his 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 [IEV 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 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 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 a.c. or d.c. voltage across any particular insulation which can occur when a CBE is supplied at rated voltage

NOTE 1 Transients are disregarded.

NOTE 2 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 of a few milliseconds or less, oscillatory or non-oscillatory, usually highly damped [IEV 604-03-13]

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 [IEV 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 [IEV 441-11-10]

NOTE Typical exposed conductive parts are walls of metal enclosures, metal operating handles, etc.

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 [IEV 826-03-01]

NOTE This term does not necessarily imply a risk of electric shock.

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 [IEV 441-15-07, modified]

3.5.7

auxiliary contact

contact included in an auxiliary circuit of a CBE and mechanically operated by the CBE [IEV 441-15-10, modified]

3.5.8

control contact

contact included in a control circuit of a CBE and mechanically operated by the CBE [IEV 441-15-09, modified]

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 [IEV 441-15-12, modified]

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 [IEV 441-15-13, modified]

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 force is applied [IEV 441-15-22]

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 [IEV 441-16-17]

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 [IEV 441-15-17, modified]

3.6.2

overcurrent release

release which causes a CBE to open, with or without delay, when the current in the release exceeds a predetermined value. In some cases this value can depend upon the rate of rise of current [IEV 441-16-33, modified]

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. 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 [IEV 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 [IEV 441-16-41]

NOTE 1 The source of voltage may be independent of the voltage of the main circuit.

NOTE 2 For CBEs, shunt releases independent of the main circuit may be called "relay releases".

3.6.9

undervoltage release

release which causes a CBE to open, with or without delay, when the voltage across the terminals of the release falls below a predetermined value [IEV 441-16-42, modified]

3.6.10

zero-voltage release

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

release which causes a CBE to open, with or without 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 [IEV 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 [IEV 441-16-40]

NOTE Such a release usually has an inverse time-delay/current characteristic.

3.7 Definitions related to insulation 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 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 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 [IEV 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 in the open position [IEV 441-17-34]

3.7.9

isolating distance (of a pole of a CBE)

clearance between contacts meeting the safety requirements specified for disconnectors [IEV 441-17-35, modified]

3.7.10

creepage distance

shortest distance along the surface of the insulating material between two conductive parts [IEV 151-03-37]

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

r.m.s. 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 Pollution degrees 1, 2, 3 and 4 are used (see 2.5.1 of IEC 60664-1).

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 not 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. 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 [IEV 441-16-01, modified]

3.8.2

operating cycle

succession of operations from one position to another and back to the first position [IEV 441-16-02, modified]

3.8.3

operating sequence

succession of specified operations with specified time intervals [IEV 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 [IEV 441-16-08, modified]

3.8.8

opening operation

operation by which a CBE is brought from the closed position to the open position [IEV 441-16-09, modified]

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. CBEs of this design may be referred to as positively trip-free [IEV 441-16-31, modified]

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 For conditions of use of non trip-free CBEs, see 4.7.3.

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

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]

3.10.3

rating

set of rated values and operating conditions [IEV 151-04-04]

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 [IEV 441-17-01, modified]

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 r.m.s. 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 a 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 [IEV 441-17-15, modified]

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);
- 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)

3.11.5

conditional short-circuit current

value of short-circuit current which a CBE protected by a 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 [IEV 441-17-16, modified]

NOTE For operating times less than 0,05 s, the two overcurrent devices in series are considered as an association (see annex F).

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 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 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). 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 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. 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 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. 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 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 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 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 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

that portion of a quick-connect termination which receives the female connector

NOTE Examples of male tabs are shown in figure E.6.

3.12.12

female connector

that portion of a quick-connect termination which is pushed onto the male tab

NOTE 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. 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; it is not a function of this thread to remove material from the hole

NOTE An example of a thread-forming screw is shown in figure 1.

3.12.20

thread-cutting screw

tapping screw having an interrupted thread; the thread is intended to remove material from the hole

NOTE 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

CBEs are classified according to the following criteria.

4.1 Quantity of poles

- the number of poles;
- the number of protected poles.

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

4.2 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.

4.3 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 be of the plug-in type or bolt-on type on the line side only, the load terminals being usually suitable for wiring connection.

4.4 Method of operation

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

4.4.2 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).

4.4.3 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 5.2.2).

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

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

4.5 Mode of tripping

4.5.1 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.

4.5.2 CBEs tripping by overcurrent and voltage

<i>Mode of tripping</i>	<i>Designation</i>
– overvoltage	OV
– undervoltage	UV

 Text deleted 

4.6 Influence of the ambient temperature

4.6.1 CBEs, the operation of which is temperature dependent.

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

4.7 Trip-free behaviour

4.7.1 Trip-free (positively trip-free).

4.7.2 Cycling trip-free.

4.7.3 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.

4.8 Influence of the mounting position

4.8.1 Independent of the mounting position.

4.8.2 Dependent on the mounting position.

4.9 Electrical performance

4.9.1 For general use, including inductive circuits.

4.9.2 For use in substantially resistive circuits only.

4.10 Suitability for isolation

- not suitable for isolation
- suitable for isolation (see Annex L) 

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 4.1) and neutral path if any;
- method of mounting (see 4.2);
- method of connection (see 4.3);
- method of operation (see 4.4);
- rated quantities (see 5.2);
- operating characteristics (see 3.9).

5.2 Rated quantities

Unless otherwise specified, all values of current and voltage are r.m.s values.

5.2.1 Rated voltages

A CBE is defined by the following rated voltages:

5.2.1.1 Rated operational voltage of a CBE (U_o)

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 be assigned a number of rated voltages and associated rated switching capacities (see 5.2.4).

5.2.1.2 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.

5.2.1.3 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 correlation 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.

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

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

5.2.2 Rated current (I_n)

A current assigned by the manufacturer (in accordance with tables 11 or 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 be applied (see 7.1).

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

5.2.3 Rated frequency

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

5.2.4 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 (r.m.s. if a.c.)

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

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

 Note deleted 

 NOTE 1 For the purpose of this standard, two categories of performance are specified (see 5.2.5.1 and 5.2.5.2).

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

5.2.5.1 Rated conditional short-circuit current performance category PC1 (I_{nc1}) (see 9.12.4.2)

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.

5.2.5.2 Rated conditional short-circuit current, performance category PC2 (I_{nc2}) (see 9.12.4.3)

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. 

5.2.6 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 a.c.;
- 4 I_n for d.c.

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage

Preferred values of rated voltage are:

- a.c.:
60, 120, 240/120, 220, 230, 240, 380/220, 400/230, 415/240, 380, 400, 415, 440 V;

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

- d.c.:
12, 24, 48, 60, 120, 240, 250 V.

5.3.2 Standard rated frequencies

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

5.3.3 Standard values of rated conditional short-circuit current

Standard values of rated conditional short-circuit current are:

300, 600, 1 000, 1 500, 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 5.2.2), for example, T40 for a reference ambient air temperature of 40 °C;
- g) operating voltage limit(s) (of a voltage-sensitive CBE);
- h) CBEs 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 4.4);
- k) mode of tripping (see 4.5);
- l) degree of trip-free behaviour (see 4.7);
- 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 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 1 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 should inform the OEM to mark his equipment accordingly. 

For CBEs other than those operated by means of push-buttons, the open position shall be indicated by the symbol "O" and the closed position by the symbol "I" (a short vertical straight line).

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 "O".

 NOTE 2 National symbols additional to "O" and "I" are allowed. 

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.

[A1] NOTE 3 Other national or international indications, for example 1, 3, 5 for the supply terminals and 2, 4, 6 for the load terminals, are allowed. **[A1]**

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).

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 .

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

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

7.1 Ambient air temperature

7.1.1 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 $T ^\circ\text{C}$. In this case they have to be marked in accordance with 6 f).

7.1.2 Limits of ambient air temperature for operation in service

For standard conditions (reference ambient air temperature $T = 23 ^\circ\text{C}$), the ambient air temperature does not exceed $+40 ^\circ\text{C}$ and its average over a period of 24 h does not exceed $+35 ^\circ\text{C}$. The lower limit of the ambient air temperature is $-5 ^\circ\text{C}$.

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

7.2 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.

7.3 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.

[A₁] Additional requirements for the mechanism of CBEs suitable for isolation are given in L.8.1.2. **[A₁]**

8.1.3 Clearances and creepage distances (see annex B)

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 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.

A1 Additional requirements for clearance and creepage distances for CBEs suitable for isolation are given in L.8.1.3. **A1**

8.1.3.1 Clearances

The clearances of the CBE shall be dimensioned to withstand the rated impulse withstand voltage declared by the manufacturer according to 5.2.1.3, taking into account the rated voltage and the overvoltage category as shown by table H.1 of annex H.

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

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

8.1.3.1.1 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.

8.1.3.1.2 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.

8.1.3.1.3 Clearances for supplementary insulation

The clearances for supplementary insulation shall not be less than those specified for basic insulation in 8.1.3.1.1 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.

8.1.3.1.4 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		
	1	2 (see 8.1.3)	3	1	2 (see 8.1.3)	3
V ^{a)}						
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 .

8.1.3.1.5 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.

8.1.3.1.6 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.

8.1.3.2 Creepage distances

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.

8.1.3.2.1 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.

8.1.3.2.2 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				I	II	III ^d	I	II	III ^d
	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	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	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 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.									

8.1.3.2.3 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.

8.1.3.2.4 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.