

This is a preview - click here to buy the full publication



IEC 60934

Edition 4.0 2019-01
REDLINE VERSION

INTERNATIONAL STANDARD



Circuit-breakers for equipment (CBE)

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.120.40; 29.120.50

ISBN 978-2-8322-6549-9

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	8
1 Scope and object	10
2 Normative references	10
3 Terms and definitions	13
3.1 Definitions related to protection and switching devices.....	13
3.2 General terms	15
3.3 Definitions related to current	16
3.4 Definitions related to voltage.....	17
3.5 Definitions related to constructional elements of a CBE	18
3.6 Definitions related to releases in CBEs	20
3.7 Definitions related to insulation coordination and clearances in a CBE	21
3.8 Definitions related to operation of CBEs.....	23
3.9 Definitions related to the operating characteristic of CBEs	25
3.10 Definitions related to characteristic quantities	25
3.11 Definitions concerning coordination of CBEs and SCPDs associated in the same circuit	26
3.12 Definitions related to terminals and terminations	27
3.13 Definitions related to tests	30
4 Classification.....	30
4.1 General.....	30
4.2 Quantity of poles.....	30
4.3 Method of mounting	30
4.4 Method of connection.....	31
4.5 Method of operation	31
4.6 Mode of tripping.....	31
4.6.1 CBEs tripping by current (overcurrent).....	31
4.6.2 CBEs tripping by by overcurrent and voltage	31
CBE-switch	
4.7 Influence of the ambient temperature	31
4.8 Trip-free behaviour	32
4.9 Influence of the mounting position.....	32
4.10 Electrical performance	32
4.11 Suitability for isolation.....	32
5 Characteristics of CBEs.....	32
5.1 List of characteristics	32
5.2 Rated quantities.....	33
5.2.1 General	33
5.2.2 Rated voltages	33
5.2.3 Rated current (I_N)	33
5.2.4 Rated frequency	34
5.2.5 Rated switching capacity (rated making and breaking capacity)	34
5.2.6 Rated conditional short-circuit current (I_{NC})	34
5.2.7 Rated short-circuit capacity (I_{CN})	34
5.3 Standard and preferred values.....	34
5.3.1 Preferred values of rated voltage.....	34
5.3.2 Standard rated frequencies.....	35

5.3.3	Standard values of rated conditional short-circuit current.....	35
6	Marking and other product information.....	35
7	Standard conditions for operation in service	36
7.1	General.....	36
7.2	Ambient air temperature.....	36
7.2.1	Reference ambient air temperature T for calibration.....	36
7.2.2	Limits of ambient air temperature for operation in service	37
7.3	Altitude	37
7.4	Atmospheric conditions	37
8	Requirements for construction and operation.....	37
8.1	Mechanical design	37
8.1.1	General	37
8.1.2	Mechanism	37
8.1.3	Clearances and creepage distances (see Annex B)	38
8.1.4	Screws, current-carrying parts and connections.....	43
8.1.5	Screw-type and screwless terminals	43
8.1.6	Solder terminations.....	47
8.1.7	Flat quick-connect male tabs (Figures E.6 to E.13).....	47
8.2	Protection against electric shock.....	50
8.3	Temperature-rise	50
8.3.1	Temperature-rise limits.....	50
8.3.2	Ambient air temperature	51
8.4	Dielectric properties.....	51
8.4.1	Dielectric strength at power frequency	51
8.4.2	Clearances for insulation coordination	51
8.5	Conditions for automatic operation.....	52
8.5.1	Standard time-current zone	52
8.5.2	Tripping characteristic	52
8.5.3	Operating limits of overvoltage releases	53
8.5.4	Operating limits of undervoltage and zero-voltage releases	53
8.5.5	Electrical endurance of undervoltage releases.....	53
8.6	Electrical performance and behaviour at rated short-circuit capacity	54
8.7	Performance under conditional short-circuit current conditions.....	54
8.8	Resistance to mechanical shock and impact	54
8.9	Resistance to heat.....	54
8.10	Resistance to abnormal heat and to fire	54
8.11	Resistance to tracking.....	54
8.12	Resistance to rusting	54
9	Tests	58
9.1	Type tests and sequences	58
9.2	Test conditions	59
9.3	Test of indelibility of marking	60
9.4	Test of reliability of terminals, current-carrying parts and connections.....	60
9.4.1	Screw type and screwless terminals	60
9.4.2	Solder terminations.....	62
9.4.3	Flat quick-connect male tabs	62
9.5	Test of reliability of terminals for external conductors (see 3.12.15)	63
9.6	Test of protection against electric shock	64

9.7	Test of dielectric properties.....	65
9.7.1	Resistance to humidity.....	65
9.7.2	Insulation resistance of the main circuit	65
9.7.3	Dielectric strength of the main circuit	66
9.7.4	Dielectric strength of the auxiliary circuits.....	66
9.7.5	Value of test voltage	66
9.7.6	Test for the verification of insulation coordination by impulse withstand voltage test.....	67
9.8	Test of temperature-rise.....	68
9.8.1	Ambient air temperature	68
9.8.2	Test procedure	68
9.8.3	Measurement of the temperature of parts	69
9.8.4	Temperature-rise of a part	69
9.9	28-day test.....	69
9.10	Test of tripping characteristics	69
9.10.1	General	69
9.10.2	Test of time-current characteristic.....	70
9.10.3	Test of instantaneous tripping (of the magnetic release)	70
9.10.4	Test of effect of single-pole loading on the tripping characteristic of multi-pole CBEs.....	70
9.10.5	Test of effect of ambient temperature on the tripping characteristic	70
9.11	Verification of electrical operational capability.....	70
9.11.1	General requirements	70
9.11.2	Behaviour at rated current (or under low overloads for R-type and J- type CBEs)	72
9.11.3	Behaviour at rated switching capacity	72
9.11.4	Behaviour at rated short-circuit capacity	72
9.11.5	Test of overvoltage releases at operating limits	74
9.11.6	Behaviour of undervoltage and zero-voltage releases.....	74
9.12	Conditional short-circuit current tests	74
9.12.1	General	74
9.12.2	Values of test quantities	75
9.12.3	Tolerances on test quantities	75
9.12.4	Test procedure	75
9.13	Test of resistance to mechanical shock and impact.....	77
9.14	Tests of resistance to heat.....	77
9.15	Test of resistance to abnormal heat and to fire	78
9.16	Test of resistance to tracking	78
9.17	Test of resistance to rusting.....	79
Annex A (normative)	Time-current zone (see 9.10 and Table 9).....	86
Annex B (normative)	Determination of clearances and creepage distances	87
Annex C (normative)	Test sequences and number of samples to be submitted for certification purposes.....	89
C.1	Test sequences	89
C.2	Number of samples to be submitted for full test procedure	90
C.3	Number of samples to be submitted for simplified test procedure in case of submitting simultaneously a series of CBEs of the same basic design.....	90
Annex D (normative)	Correspondence between ISO and AWG copper conductors	92
Annex E (normative)	Examples of terminals	93

Annex F (informative) Coordination between a CBE and a short-circuit protective device (SCPD) associated in the same circuit	102
F.1 Introduction General	102
F.2 Scope Overview	102
F.3 General requirements for co-ordination of a CBE with an associated SCPD	103
F.3.1 General considerations	103
F.3.2 Requirements concerning back-up protection	103
F.3.3 Requirements concerning discrimination	103
F.3.4 Required information	103
F.4 Verification of coordination	104
F.4.1 General considerations including the conditions for verification by desk study	104
F.4.2 Verification of discrimination	104
F.4.3 Verification of coordinated back-up protection	105
F.5 Examples of verification of coordination by desk study	106
Annex G (normative) Electromagnetic behaviour of CBEs	114
G.1 General	114
G.2 Immunity	114
G.2.1 CBEs not incorporating electronic circuits	114
G.2.2 CBEs incorporating electronic circuits	114
G.3 Emission	115
G.3.1 CBEs not incorporating electronic circuits	115
G.3.2 CBEs incorporating electronic circuits	115
Annex H (normative) Correlation between nominal voltage of the supply systems and the line-to-neutral voltage relevant for determining the rated impulse voltage	116
Annex I (normative) Routine or statistical tests	118
I.1 General	118
I.2 Verification of the tripping characteristic	118
I.3 Verification of dielectric strength	118
Annex J (normative) Additional requirements for electrical performance of E-type CBEs	120
Annex (normative) Additional requirements for electrical performance of CBE switches	120
Annex K (normative) Additional requirements for CBEs suitable for isolation	122
K.1 General	122
K.6 Marking and other product information	122
K.8 Requirements for construction and operation	122
Bibliography	120
Figure 1 – Thread-forming screw	80
Figure 2 – Thread-cutting screw	80
Figure 3 – Test circuits for overcurrent tests of CBEs	82
Figure 4 – Standard test finger (see IEC 60529)	83
Figure 5 – Ball pressure apparatus	84
Figure 6 – Arrangements and dimensions of the electrodes for the tracking test	84
Figure 7 – Test circuits for verification of the conditional short-circuit current	85
Figure A.1 – Time-current zone	86

Figure B.1 – Illustrations of the application of the recommendations for creepage distances	88
Figure E.1 – Examples of pillar terminals	93
Figure E.2 – Examples of screw terminals and stud terminals	94
Figure E.3 – Examples of saddle terminals	95
Figure E.4 – Examples of lug terminals	95
Figure E.5 – Examples of screwless terminals	96
Figure E.6 – Dimensions of male tabs	97
Figure E.7 – Dimensions of round dimple detents of male tabs (see Figure E.6)	98
Figure E.8 – Dimensions of rectangular dimple detents of male tabs (see Figure E.6).....	98
Figure E.9 – Dimensions of hole detents of male tabs (see Figure E.6).....	98
Figure E.10 – Dimensions of male tabs	99
Figure E.11 – Dimensions of male tabs	99
Figure E.12 – Dimensions of male tabs	99
Figure E.13 – Dimensions of male tabs for two different sizes of female connectors (see 8.1.7.1)	100
Figure E.14 – Dimensions of female connectors for male tabs	101
Figure F.1 – Thermal only CBE, backed up by thermal magnetic circuit-breaker	107
Figure F.2 – Thermal only CBE, backed up by a fuse	108
Figure F.3 – Thermal-magnetic CBE backed up by thermal-magnetic circuit-breaker	109
Figure F.4 – Hydraulic-magnetic CBE backed up by thermal-magnetic circuit-breaker.....	110
Figure F.5 – Thermal CBE backed up by a hydraulic-magnetic circuit-breaker	110
Figure F.6 – Energy-limiting CBE, backed up by thermal-magnetic circuit-breaker	111
Figure F.7 – Energy-limiting CBE, backed up by a fuse.....	112
Figure F.8 – Examples illustrating proper and improper coordination	113
Table 1 – Minimum clearances for basic and reinforced insulation	40
Table 2 – Minimum creepage distances	42
Table 3 – Connectable cross-sectional areas of external copper conductors for screw-type and screwless terminals	44
Table 4 – Minimum distance between clamping screw and the end of conductor when fully inserted	45
Table 5 – Dimensions of tabs in millimetres – Dimensions <i>A, B, C, D, E, F, J, M, N, P</i> and <i>Q</i>	48
Table 6 – Dimensions of tabs in millimetres – Dimensions <i>H, I, T, K, R, G, L, S</i> and <i>U</i>	49
Table 7 – Dimensions in millimetres of combined male tabs for two different sizes of female connectors	49
Table 8 – Temperature-rise values for CBEs for different reference ambient air temperatures (<i>T</i>)	51
Table 9 – Time-current operating characteristics.....	52
Table 10 – Operating limits of undervoltage and zero-voltage releases (for AC and DC)	53
Table 11 – Test conditions for electrical performance for CBEs intended for general use, including inductive circuits.....	55
Table 12 – Test conditions for electrical performance of CBEs used in essentially resistive circuits only (see Clause 6, item d)	57
Table 13 – List of type tests	59

Table 14 – Standard cross-sections of copper conductors corresponding to the rated currents	60
Table 15 – Screw-thread diameter and applied torques.....	61
Table 16 – Insertion and withdrawal forces	62
Table 17 – Push/pull force	63
Table 18 – Pulling forces	63
Table 19 – Make-up of conductors for the test of 9.5.4.....	64
Table 20 – Test voltages.....	67
Table 21 – Impulse withstand test voltages for verification of insulation coordination	68
Table 22 – Power factor and time constant of test circuit	75
Table C.1 – Test sequences	89
Table C.2 – Number of samples for full test procedure.....	90
Table C.3 – Reduction of samples for simplified test procedure	91
Table D.1 – Correspondence between ISO and AWG conductor cross-sections	92
Table G.1 – Minimum EMC immunity performances of CBEs.....	115
Table H.1 – Nominal voltages and corresponding rated impulse voltages.....	116
Table K.1 – Minimum clearances for CBEs suitable for isolation, between live parts separated when the contacts are in the open position, as a function of the rated impulse withstand voltage	123
Table K.2 – Minimum creepage distances for CBEs suitable for isolation, between live parts separated when the contacts are in the open position	123
Table K.3 – Test voltages for verifying isolation across the open contacts, as a function of the rated impulse withstand voltage and the altitude where the test is carried out	125

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CIRCUIT-BREAKERS FOR EQUIPMENT (CBE)

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 60934 has been prepared by subcommittee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

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

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

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

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

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

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

a) clarifications for type testing purposes.

In this standard, the following print types are used:

- Requirements proper: in roman type.
- *Test specifications: in italic type.*
- Explanatory matter: in smaller roman type.

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

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

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

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. systems*¹⁾~~

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Circuit-breakers for equipment (CBE)

Disjoncteurs pour équipement (DPE)



CONTENTS

FOREWORD.....	8
1 Scope.....	10
2 Normative references	11
3 Terms and definitions	12
3.1 Definitions related to protection and switching devices.....	12
3.2 General terms.....	13
3.3 Definitions related to current.....	15
3.4 Definitions related to voltage.....	16
3.5 Definitions related to constructional elements of a CBE	16
3.6 Definitions related to releases in CBEs	18
3.7 Definitions related to insulation coordination	20
3.8 Definitions related to operation of CBEs.....	22
3.9 Definitions related to the operating characteristic of CBEs	23
3.10 Definitions related to characteristic quantities	23
3.11 Definitions concerning coordination of CBEs and SCPDs associated in the same circuit	24
3.12 Definitions related to terminals and terminations.....	25
3.13 Definitions related to tests	28
4 Classification.....	28
4.1 General.....	28
4.2 Quantity of poles.....	28
4.3 Method of mounting	28
4.4 Method of connection.....	29
4.5 Method of operation	29
4.6 Mode of tripping.....	29
4.6.1 CBEs tripping by current (overcurrent).....	29
4.6.2 CBEs tripping by voltage	29
4.7 Influence of the ambient temperature	30
4.8 Trip-free behaviour	30
4.9 Influence of the mounting position.....	30
4.10 Electrical performance	30
4.11 Suitability for isolation.....	30
5 Characteristics of CBEs.....	30
5.1 List of characteristics	30
5.2 Rated quantities.....	30
5.2.1 General	30
5.2.2 Rated voltages	30
5.2.3 Rated current (I_n)	31
5.2.4 Rated frequency	31
5.2.5 Rated switching capacity (rated making and breaking capacity).....	31
5.2.6 Rated conditional short-circuit current (I_{nc})	32
5.2.7 Rated short-circuit capacity (I_{cn})	32
5.3 Standard and preferred values.....	32
5.3.1 Preferred values of rated voltage.....	32
5.3.2 Standard rated frequencies.....	32
5.3.3 Standard values of rated conditional short-circuit current.....	32

6	Marking and other product information.....	33
7	Standard conditions for operation in service	34
7.1	General.....	34
7.2	Ambient air temperature.....	34
7.2.1	Reference ambient air temperature T for calibration.....	34
7.2.2	Limits of ambient air temperature for operation in service	34
7.3	Altitude	34
7.4	Atmospheric conditions	35
8	Requirements for construction and operation.....	35
8.1	Mechanical design	35
8.1.1	General	35
8.1.2	Mechanism	35
8.1.3	Clearances and creepage distances (see Annex B)	36
8.1.4	Screws, current-carrying parts and connections.....	39
8.1.5	Screw-type and screwless terminals	40
8.1.6	Solder terminations.....	43
8.1.7	Flat quick-connect male tabs (Figures E.6 to E.13)	43
8.2	Protection against electric shock.....	46
8.3	Temperature-rise	46
8.3.1	Temperature-rise limits	46
8.3.2	Ambient air temperature	47
8.4	Dielectric properties	47
8.4.1	Dielectric strength at power frequency	47
8.4.2	Clearances for insulation coordination	47
8.5	Conditions for automatic operation.....	48
8.5.1	Standard time-current zone	48
8.5.2	Tripping characteristic	48
8.5.3	Operating limits of overvoltage releases	49
8.5.4	Operating limits of undervoltage and zero-voltage releases	49
8.5.5	Electrical endurance of undervoltage releases	49
8.6	Electrical performance and behaviour at rated short-circuit capacity	49
8.7	Performance under conditional short-circuit current conditions.....	50
8.8	Resistance to mechanical shock and impact	50
8.9	Resistance to heat	50
8.10	Resistance to abnormal heat and to fire	50
8.11	Resistance to tracking.....	50
8.12	Resistance to rusting	50
9	Tests	52
9.1	Type tests and sequences	52
9.2	Test conditions	53
9.3	Test of indelibility of marking	54
9.4	Test of reliability of terminals, current-carrying parts and connections.....	54
9.4.1	Screw type and screwless terminals	54
9.4.2	Solder terminations.....	56
9.4.3	Flat quick-connect male tabs	56
9.5	Test of reliability of terminals for external conductors (see 3.12.15)	57
9.6	Test of protection against electric shock	58
9.7	Test of dielectric properties.....	59

9.7.1	Resistance to humidity.....	59
9.7.2	Insulation resistance of the main circuit	59
9.7.3	Dielectric strength of the main circuit	60
9.7.4	Dielectric strength of the auxiliary circuits.....	60
9.7.5	Value of test voltage	60
9.7.6	Test for the verification of insulation coordination by impulse withstand voltage test.....	61
9.8	Test of temperature-rise.....	62
9.8.1	Ambient air temperature	62
9.8.2	Test procedure	62
9.8.3	Measurement of the temperature of parts	63
9.8.4	Temperature-rise of a part	63
9.9	28-day test.....	63
9.10	Test of tripping characteristics	63
9.10.1	General	63
9.10.2	Test of time-current characteristic.....	64
9.10.3	Test of instantaneous tripping (of the magnetic release)	64
9.10.4	Test of effect of single-pole loading on the tripping characteristic of multi-pole CBEs.....	64
9.10.5	Test of effect of ambient temperature on the tripping characteristic	64
9.11	Verification of electrical operational capability.....	64
9.11.1	General requirements	64
9.11.2	Behaviour at rated current (or under low overloads for R-type and J-type CBEs)	66
9.11.3	Behaviour at rated switching capacity	66
9.11.4	Behaviour at rated short-circuit capacity	66
9.11.5	Test of overvoltage releases at operating limits	68
9.11.6	Behaviour of undervoltage and zero-voltage releases.....	68
9.12	Conditional short-circuit current tests.....	68
9.12.1	General	68
9.12.2	Values of test quantities	69
9.12.3	Tolerances on test quantities	69
9.12.4	Test procedure	69
9.13	Test of resistance to mechanical shock and impact.....	71
9.14	Tests of resistance to heat.....	71
9.15	Test of resistance to abnormal heat and to fire	72
9.16	Test of resistance to tracking	72
9.17	Test of resistance to rusting.....	73
Annex A (normative)	Time-current zone (see 9.10 and Table 9).....	79
Annex B (normative)	Determination of clearances and creepage distances	80
Annex C (normative)	Test sequences and number of samples to be submitted for certification purposes.....	82
C.1	Test sequences	82
C.2	Number of samples to be submitted for full test procedure.....	83
C.3	Number of samples to be submitted for simplified test procedure in case of submitting simultaneously a series of CBEs of the same basic design.....	83
Annex D (normative)	Correspondence between ISO and AWG copper conductors	85
Annex E (normative)	Examples of terminals.....	86
Annex F (informative)	Coordination between a CBE and a short-circuit protective device (SCPD) associated in the same circuit.....	95

F.1	General.....	95
F.2	Overview.....	95
F.3	General requirements for co-ordination of a CBE with an associated SCPD	96
F.3.1	General considerations	96
F.3.2	Requirements concerning back-up protection	96
F.3.3	Requirements concerning discrimination.....	96
F.3.4	Required information	96
F.4	Verification of coordination.....	97
F.4.1	General considerations including the conditions for verification by desk study	97
F.4.2	Verification of discrimination	97
F.4.3	Verification of coordinated back-up protection	98
F.5	Examples of verification of coordination by desk study.....	99
Annex G (normative)	Electromagnetic behaviour of CBEs	107
G.1	General.....	107
G.2	Immunity.....	107
G.2.1	CBEs not incorporating electronic circuits.....	107
G.2.2	CBEs incorporating electronic circuits.....	107
G.3	Emission.....	108
G.3.1	CBEs not incorporating electronic circuits.....	108
G.3.2	CBEs incorporating electronic circuits.....	108
Annex H (normative)	Correlation between nominal voltage of the supply systems and the line-to-neutral voltage relevant for determining the rated impulse voltage	109
Annex I (normative)	Routine or statistical tests	110
I.1	General.....	110
I.2	Verification of the tripping characteristic	110
I.3	Verification of dielectric strength	110
Annex J (normative)	Additional requirements for electrical performance of E-type CBEs	112
Annex K (normative)	Additional requirements for CBEs suitable for isolation	113
K.1	General.....	113
K.6	Marking and other product information	113
K.8	Requirements for construction and operation	113
Bibliography.....		117
Figure 1	– Thread-forming screw	74
Figure 2	– Thread-cutting screw.....	74
Figure 3	– Test circuits for overcurrent tests of CBEs	75
Figure 4	– Standard test finger (see IEC 60529)	76
Figure 5	– Ball pressure apparatus	77
Figure 6	– Arrangements and dimensions of the electrodes for the tracking test	77
Figure 7	– Test circuits for verification of the conditional short-circuit current.....	78
Figure A.1	– Time-current zone.....	79
Figure B.1	– Illustrations of the application of the recommendations for creepage distances	81
Figure E.1	– Examples of pillar terminals	86
Figure E.2	– Examples of screw terminals and stud terminals	87

Figure E.3 – Examples of saddle terminals	88
Figure E.4 – Examples of lug terminals	88
Figure E.5 – Examples of screwless terminals	89
Figure E.6 – Dimensions of male tabs	90
Figure E.7 – Dimensions of round dimple detents of male tabs (see Figure E.6)	91
Figure E.8 – Dimensions of rectangular dimple detents of male tabs (see Figure E.6).....	91
Figure E.9 – Dimensions of hole detents of male tabs (see Figure E.6).....	91
Figure E.10 – Dimensions of male tabs	92
Figure E.11 – Dimensions of male tabs	92
Figure E.12 – Dimensions of male tabs	92
Figure E.13 – Dimensions of male tabs for two different sizes of female connectors (see 8.1.7.1)	93
Figure E.14 – Dimensions of female connectors for male tabs	94
Figure F.1 – Thermal only CBE, backed up by thermal magnetic circuit-breaker	100
Figure F.2 – Thermal only CBE, backed up by a fuse	101
Figure F.3 – Thermal-magnetic CBE backed up by thermal-magnetic circuit-breaker	102
Figure F.4 – Hydraulic-magnetic CBE backed up by thermal-magnetic circuit-breaker.....	103
Figure F.5 – Thermal CBE backed up by a hydraulic-magnetic circuit-breaker	103
Figure F.6 – Energy-limiting CBE, backed up by thermal-magnetic circuit-breaker	104
Figure F.7 – Energy-limiting CBE, backed up by a fuse.....	105
Figure F.8 – Examples illustrating proper and improper coordination	106
Table 1 – Minimum clearances for basic and reinforced insulation	37
Table 2 – Minimum creepage distances	38
Table 3 – Connectable cross-sectional areas of external copper conductors for screw- type and screwless terminals	40
Table 4 – Minimum distance between clamping screw and the end of conductor when fully inserted	42
Table 5 – Dimensions of tabs in millimetres – Dimensions <i>A, B, C, D, E, F, J, M, N, P</i> and <i>Q</i>	44
Table 6 – Dimensions of tabs in millimetres – Dimensions <i>H, I, T, K, R, G, L, S</i> and <i>U</i>	45
Table 7 – Dimensions in millimetres of combined male tabs for two different sizes of female connectors	45
Table 8 – Temperature-rise values for CBEs for different reference ambient air temperatures (<i>T</i>)	47
Table 9 – Time-current operating characteristics.....	48
Table 10 – Operating limits of undervoltage and zero-voltage releases (for AC and DC)	49
Table 11 – Test conditions for electrical performance for CBEs intended for general use, including inductive circuits.....	51
Table 12 – Test conditions for electrical performance of CBEs used in essentially resistive circuits only (see Clause 6, item d)	52
Table 13 – List of type tests	53
Table 14 – Standard cross-sections of copper conductors corresponding to the rated currents	54
Table 15 – Screw-thread diameter and applied torques.....	55
Table 16 – Insertion and withdrawal forces	56

Table 17 – Push/pull force	57
Table 18 – Pulling forces	57
Table 19 – Make-up of conductors for the test of 9.5.4.....	58
Table 20 – Test voltages.....	61
Table 21 – Impulse withstand test voltages for verification of insulation coordination	62
Table 22 – Power factor and time constant of test circuit	69
Table C.1 – Test sequences	82
Table C.2 – Number of samples for full test procedure.....	83
Table C.3 – Reduction of samples for simplified test procedure	84
Table D.1 – Correspondence between ISO and AWG conductor cross-sections	85
Table G.1 – Minimum EMC immunity performances of CBEs.....	108
Table H.1 – Nominal voltages and corresponding rated impulse voltages.....	109
Table K.1 – Minimum clearances for CBEs suitable for isolation, between live parts separated when the contacts are in the open position, as a function of the rated impulse withstand voltage	114
Table K.2 – Minimum creepage distances for CBEs suitable for isolation, between live parts separated when the contacts are in the open position	114
Table K.3 – Test voltages for verifying isolation across the open contacts, as a function of the rated impulse withstand voltage and the altitude where the test is carried out	116

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CIRCUIT-BREAKERS FOR EQUIPMENT (CBE)

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60934 has been prepared by subcommittee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

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

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

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

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

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

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

a) clarifications for type testing purposes.

In this standard, the following print types are used:

- Requirements proper: in roman type.
- *Test specifications: in italic type.*
- Explanatory matter: in smaller roman type.

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

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

CIRCUIT-BREAKERS FOR EQUIPMENT (CBE)

1 Scope

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

NOTE The term "equipment" includes appliances.

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

CBEs according to this document have:

- a rated voltage not exceeding 440 V AC (between phases) and/or DC not exceeding 250 V;
- a rated current not exceeding 125 A;
- a short-circuit capacity (I_{cn}) of at least $6 \times I_n$ (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 60060-1:2010, *High-voltage test techniques – Part 1: General definitions and test requirements*

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

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

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

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

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

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

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

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

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

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

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

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

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

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