AS/NZS 60898.1:2024

Australian/New Zealand Standard™

Electrical accessories — Circuit-breakers for overcurrent protection for household and similar installations

Part 1: Circuit-breakers for a.c. operation (IEC 60898-1:2015 (ED. 2.1) MOD)

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This Joint Australian/New Zealand Standard™ was prepared by Joint Technical Committee EL-004, Electrical Accessories. It was approved on behalf of Standards Australia's Standards Development and Accreditation Committee on 25 May 2024 and by the New Zealand Standards Approval Board on 01 May 2024.

This Standard was published on 7 June 2024.

The following are represented on Committee EL-004:

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Australian Chamber of Commerce and Industry
Australian Industry Group
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CDB Group
Consumer Electronics Suppliers Association
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Electrical Regulatory Authorities Council, Australia
Engineers Australia
International Accreditation New Zealand
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This Standard was issued in draft form for comment as DR AS/NZS 60898.1:2023.

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ISBN 978 1 76139 661 8

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Electrical accessories — Circuit-breakers for overcurrent protection for household and similar installations

Part 1: Circuit-breakers for a.c. operation (IEC 60898-1:2015 (ED. 2.1) MOD)

Originated as AS/NZS 4898:1997.
Jointly revised and redesignated as AS/NZS 60898.1:2004.
Second edition AS/NZS 60898.1:2024.

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Preface

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-004, Electrical Accessories, to supersede AS/NZS 60898.1:2004.

The objective of this document is to provide Australian and New Zealand electrical industries, manufacturers and regulatory bodies with safety general requirements for circuit-breakers for a.c. operation. This document may be used as the basis for approval for sale or for connection to supply in Australian and New Zealand.

AS/NZS 60898.1:2004 will also remain current for a.c. and d.c. circuit breakers until the publication of the next edition of AS/NZS 60898.2 (adoption of IEC 60898-2:2016), which will contain clauses that supplement or modify the corresponding clauses in this document to provide the relevant requirements for a.c. and d.c. circuit breakers. This document is not to be used with AS/NZS 60898.2:2004. Regulatory authorities that reference this document in regulation may apply these requirements at a different time. Users of this document should consult with these authorities to confirm their requirements.

A list of all parts in the AS/NZS 60898 series can be found in the Standards Australia online catalogue.

This document will exist in parallel with AS/NZS 3111, *Approval and test specification—Miniature overcurrent circuit-breakers* (and any revisions thereof). Both this document and AS/NZS 3111 are acceptable for miniature overcurrent circuit-breakers.

The essential safety requirements in AS/NZS 3820 that could be applicable to miniature circuit-breakers are covered by this document taken in conjunction with any other relevant requirements affecting safety.

This document is an adoption with national modifications and has been reproduced from IEC 60898-1:2015+AMD1:2019 CSV (ED. 2.1), *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 1: Circuit-breakers for a.c. operation*. The modifications are additional requirements and are set out in Appendix ZZ, which has been added at the end of the source text.

Appendix ZZ lists the modifications to IEC 60898-1:2015+AMD1:2019 CSV (ED. 2.1) for the application of this document in Australia and New Zealand.

Modifications made to IEC 60898-1:2015+AMD1:2019 CSV (ED. 2.1) form the Australian/New Zealand variations for the purposes of the CB scheme for recognition of testing to standards for safety to electrical equipment.

As this document has been reproduced from an International document, the following apply:

(a) In the source text “this part of IEC 60898” should read “this document”.

(b) A full point substitutes for a comma when referring to a decimal marker.

Australian or Australian/New Zealand Standards that are identical adoptions of international normative references may be used interchangeably. Refer to the online catalogue for information on specific Standards.

The terms “normative” and “informative” are used in Standards to define the application of the appendices or annexes to which they apply. A “normative” appendix or annex is an integral part of a Standard, whereas an “informative” appendix or annex is only for information and guidance.

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Full document details: AS NZS 60898.1-2024

NOTES

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CONTENTS

FOREWORD 8
1 Scope 10
2 Normative references 11
3 Terms and definitions 12
3.1 Devices 12
3.2 General terms 13
3.3 Constructional elements 15
3.4 Conditions of operation 18
3.5 Characteristic quantities 18
3.6 Definitions related to insulation co-ordination 23
4 Classification 25
4.1 General 25
4.2 According to the number of poles: 25
4.3 According to the protection against external influences: 25
4.4 According to the method of mounting: 25
4.5 According to the methods of connection 25
4.5.1 According to the fixation system: 25
4.5.2 According to the type of terminals: 26
4.6 According to the instantaneous tripping current (see 3.5.17) 26
4.7 According to the I^2t characteristic 26
5 Characteristics of circuit-breakers 26
5.1 List of characteristics 26
5.2 Rated quantities 26
5.2.1 Rated voltages 26
5.2.2 Rated current (I_n) 27
5.2.3 Rated frequency 27
5.2.4 Rated short-circuit capacity (I_{cn}) 27
5.3 Standard and preferred values 27
5.3.1 Preferred values of rated voltage 27
5.3.2 Preferred values of rated current 28
5.3.3 Standard values of rated frequency 28
5.3.4 Values of rated short-circuit capacity 28
5.3.5 Standard ranges of instantaneous tripping 29
5.3.6 Standard values of rated impulse withstand voltage (U_{imp}) 29
6 Marking and other product information 30
7 Standard conditions for operation in service 32
7.1 General 32
7.2 Ambient air temperature range 32
7.3 Altitude 32
7.4 Atmospheric conditions 32
7.5 Conditions of installation 32
7.6 Pollution degree 32
8 Requirements for construction and operation 32
8.1 Mechanical design 32
8.1.1 General 32

AVA Documents
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Full document details: AS NZS 60898.1-2024

8.1.2 Mechanism 33
8.1.3 Clearances and creepage distances and solid insulation 34
8.1.4 Screws, current-carrying parts and connections 37
8.1.5 Terminals for external conductors 37
8.1.6 Non-interchangeability 40
8.1.7 Mechanical mounting of plug-in type circuit-breakers 40
8.2 Protection against electric shock 40
8.3 Dielectric properties and isolating capability 41
8.3.1 General 41
8.3.2 Dielectric strength at power frequency 41
8.3.3 Isolating capability 41
8.3.4 Dielectric strength at rated impulse withstand voltage (U_{imp}) 41
8.4 Temperature-rise 41
8.4.1 Temperature-rise limits 41
8.4.2 Ambient air temperature 42
8.5 Uninterrupted duty 42
8.6 Automatic operation 42
8.6.1 Standard time-current zone 42
8.6.2 Conventional quantities 43
8.6.3 Tripping characteristic 43
8.7 Mechanical and electrical endurance 44
8.8 Performance at short-circuit currents 44
8.9 Resistance to mechanical shock and impact 44
8.10 Resistance to heat 45
8.11 Resistance to abnormal heat and to fire 45
8.12 Resistance to rusting 45
8.13 Power loss 45
8.14 Electromagnetic immunity 45
8.15 Electromagnetic emission 45
9 Tests 46
9.1 Type tests and test sequences 46
9.2 Test conditions 46
9.3 Test of indelibility of marking 47
9.4 Test of reliability of screws, current-carrying parts and connections 48
9.5 Tests of reliability of screw-type terminals for external copper conductors 49
9.6 Test of protection against electric shock 51
9.7 Test of dielectric properties 51
9.7.1 Resistance to humidity 51
9.7.2 Insulation resistance of the main circuit 52
9.7.3 Dielectric strength of the main circuit 53
9.7.4 Insulation resistance and dielectric strength of auxiliary circuits 53
9.7.5 Verification of impulse withstand voltages (across clearances and across solid insulation) and of leakage current across open contacts 54
9.8 Test of temperature-rise and measurement of power loss 57
9.8.1 Ambient air temperature 57
9.8.2 Test procedure 57
9.8.3 Measurement of the temperature of parts 57
9.8.4 Temperature-rise of a part 57
9.8.5 Measurement of power loss 57

AVA Documents
Document Sharing Hub
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Full document details: AS NZS 60898.1-2024

9.9 28-day test 58
9.10 Test of tripping characteristic 58
9.10.1 General 58
9.10.2 Test of time-current characteristic 58
9.10.3 Test of instantaneous tripping, of correct opening of the contacts and of the trip-free function 58
9.10.4 Test of effect of single-pole loading on the tripping characteristic of multipole circuit-breakers 60
9.10.5 Test of effect of ambient temperature on the tripping characteristic 60
9.11 Verification of mechanical and electrical endurance 60
9.11.1 General test conditions 60
9.11.2 Test procedure 61
9.11.3 Condition of the circuit-breaker after test 61
9.12 Short-circuit tests 61
9.12.1 General 61
9.12.2 Values of test quantities 62
9.12.3 Tolerances on test quantities 62
9.12.4 Test circuit for short-circuit performance 63
9.12.5 Power factor of the test circuit 64
9.12.6 Measurement and verification of I^2t and of the peak current (I_p) 64
9.12.7 Calibration of the test circuit 64
9.12.8 Interpretation of records 65
9.12.9 Condition of the circuit-breaker for test 65
9.12.10 Behaviour of the circuit-breaker during short-circuit tests 66
9.12.11 Test procedure 67
9.12.12 Verification of the circuit breaker after short circuit tests.: 72
9.13 Mechanical stresses 72
9.13.1 Mechanical shock 72
9.13.2 Resistance to mechanical stresses and impact 73
9.14 Test of resistance to heat 76
9.15 Resistance to abnormal heat and to fire 77
9.16 Test of resistance to rusting 78
Annex A (informative) Determination of short-circuit power factor 92
Annex B (normative) Determination of clearances and creepage distances 93
Annex C (normative) Test sequences and number of samples 98
Annex D (informative) Co-ordination under short-circuit conditions between a circuit-breaker and another short-circuit protective device (SCPD) associated in the same circuit 104
Annex E (normative) Special requirements for auxiliary circuits for safety extra-low voltage 111
Annex F (informative) Examples of terminals 112
Annex G (informative) Correspondence between ISO and AWG copper conductors 115
Annex H (normative) Arrangement for short-circuit test 116
Annex I (normative) Routine tests 119
Annex J (normative) Particular requirements for circuit-breakers with screwless-type terminals for external copper conductors 120
Annex K (normative) Particular requirements for circuit-breakers with flat quick-connect terminations 129

Documents
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Annex L (normative) Specific requirements for circuit-breakers with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors 136

Bibliography 146

Figure 1 – Thread forming tapping screw (3.3.22) 79

Figure 2 – Thread cutting tapping screw (3.3.23) 79

Figure 3 – Typical diagram for all short circuit tests except for 9.12.11.2.2) 79

Figure 4 – Typical diagram for short circuit tests according to 9.12.11.2.2) 80

Figure 5 – Detail of impedance Z and Z_1 80

Figure 6 – Example of short-circuit making or breaking test record in the case of a single-pole device on single phase AC 82

Figure 7 – Mechanical shock test apparatus (9.13.1) 83

Figure 8 – Standard test finger (9.6) 84

Figure 9 – Mechanical impact test apparatus (9.13.2) 85

Figure 10 – Striking element for pendulum for mechanical impact test apparatus (9.13.2) 86

Figure 11 – Mounting support for mechanical impact test (9.13.2) 87

Figure 12 – Example of mounting of a flush-type circuit-breaker for mechanical impact test (9.13.2) 88

Figure 13 – Example of mounting of a panel board type circuit-breaker for mechanical impact test (9.13.2) 89

Figure 14 – Application of force for mechanical test on a rail-mounted circuit-breaker (9.13.2.4) 90

Figure 15 – Ball-pressure test apparatus 90

Figure 16 – Example of application of force for mechanical test on two-pole plug-in circuit-breaker, the holding in position of which depends solely on the plug-in connections (9.13.2.5) 91

Figure 17 – Diagrammatic representation (9.15) 91

Figure B.1 – Examples of methods of measuring creepage distances and clearances 97

Figure D.1 – Overcurrent co-ordination between a circuit-breaker and a fuse or back-up protection by a fuse – Operating characteristics 109

Figure D.2 – Total selectivity between two circuit-breakers 109

Figure D.3 – Back-up protection by a circuit-breaker – Operating characteristics 110

Figure F.1 – Examples of pillar terminals 112

Figure F.2 – Examples of screw terminals and stud terminals 113

Figure F.3 – Examples of saddle terminals 114

Figure F.4 – Examples of lug terminals 114

Figure H.1 – Example of test arrangement 117

Figure H.2 – Grid circuit 117

Figure H.3 – Grid circuit 118

Figure J.1 – Example of test set-up 126

Figure J.2 – Examples of screwless-type terminals 127

Figure K.1 – Example of position of the thermocouple for measurement of the temperature-rise 132

Figure K.2 – Dimensions of male tabs 133

Documents
Document Sharing Hub

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Full document details: AS NZS 60898.1-2024

Figure K.3 – Dimensions of round dimple detents (see Figure K.2) 134
Figure K.4 – Dimensions of rectangular dimple detents (see Figure K.2) 134
Figure K.5 – Dimensions of hole detents 134
Figure K.6 – Dimensions of female connectors 135
Figure L.1 – General arrangement for the test 144
Figure L.2 144
Figure L.3 145
Figure L.4 145
Figure L.5 145
Figure L.6 145

Table 1 – Preferred values of rated voltage 28
Table 2 – Ranges of instantaneous tripping 29
Table 3 – Rated impulse withstand voltage as a function of the nominal voltage of the installation 30
Table 4 – Minimum clearances and creepage distances 35
Table 5 – Connectable cross-sections of copper conductors for screw-type terminals 38
Table 6 – Temperature-rise values 42
Table 7 – Time-current operating characteristics 43
Table 8 – Maximum power loss per pole 45
Table 9 – List of type tests 46
Table 10 – Cross-sectional areas (S) of test copper conductors corresponding to the rated currents 47
Table 11 – Screw thread diameters and applied torques 49
Table 12 – Pulling forces 50
Table 13 – Test voltage of auxiliary circuits 54
Table 14 – Test voltage for verification of impulse withstand voltage 56
Table 15 – Test voltage for verifying the suitability for isolation, referred to the rated impulse withstand voltage of the circuit breakers and the altitude where the test is carried out 56
Table 16 – Applicability of short-circuit tests 62
Table 17 – Power factor ranges of the test circuit 64
Table 18 – Ratio k between service short-circuit capacity (I_{cs}) and rated short-circuit capacity (I_{cn}) 69
Table 19 – Test procedure for I_{cs} in the case of single- and two-pole circuit-breakers 69
Table 20 – Test procedure for I_{cs} in the case of three- and four-pole circuit-breakers 70
Table 21 – Test procedure for I_{cs} in the case of three-phase tests for single-pole circuit-breakers of rated voltage 230/400 V 70
Table 22 – The test procedure for I_{cn} 71
Table 23 – Test procedure for I_{cn} in the case of three-phase tests for single-pole circuit-breakers of rated voltage 230/400 V 71
Table C.1 – Test sequences 99
Table C.2 – Number of samples for full test procedure 100
Table C.3 – Reduction of samples for series of circuit-breakers having different numbers of poles 102

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Full document details: AS NZS 60898.1-2024

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Table C.4 – Test sequences for a series of circuit-breakers being of different instantaneous tripping classifications 103

Table J.1 – Conductors and their theoretical diameters 123

Table J.2 – Cross-sections of copper conductors connectable to screwless-type terminals 123

Table J.3 – Pull forces 125

Table K.1 – Informative table on colour code of female connectors in relationship with the cross section of the conductor 130

Table K.2 – Overload test forces 131

Table K.3 – Dimensions of tabs 132

Table K.4 – Dimensions of female connectors 135

Table L.1 – Marking for terminals 137

Table L.2 – Connectable cross-sections of aluminium conductors for screw-type terminals 138

Table L.3 – List of tests according to the material of conductors and terminals 139

Table L.4 – Connectable conductors and their theoretical diameters 139

Table L.5 – Cross sections (*S*) of aluminium test conductors corresponding to the rated currents 140

Table L.6 – Test conductor length 141

Table L.7 – Equalizer and busbar dimensions 141

Table L.8 – Test current as a function of rated current 143

Table L.9 – Example of calculation for determining the average temperature deviation *D* 143

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTRICAL ACCESSORIES – CIRCUIT-BREAKERS FOR OVERCURRENT PROTECTION FOR HOUSEHOLD AND SIMILAR INSTALLATIONS –

Part 1: Circuit-breakers for a.c. operation

FOREWORD

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

IEC 60898-1 edition 2.1 contains the second edition (2015-03) [documents 23E/881/FDIS and 23E/894/RVD] and its corrigendum (2015-11), its amendment 1 (2019-12) [documents 23E/1156/FDIS and 23E/1157/RVD] and its corrigendum (2020-03). The contents of the corrigendum of the amendment only applies to the French version.

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

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International Standard IEC 60898-1 has been prepared by sub-committee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

This second edition constitutes a technical revision.

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

a) Revision of 9.5 Terminals

b) Revision of the test of glow wire

c) Simplification of the figures for short circuit tests.

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

The following differing practices of a less permanent nature exist in the countries indicated below.

– Annex J, Clause J.1: Upper limit of current for use of screwless terminals is 16 A (CZ, DK, NL and CH; upper limit of current for use of screwless terminals is 30 A (Japan).

– J.3.3: Only universal screwless-type terminals are accepted (AT, BE, CN, DK, DE, ES, FR, IT, PT, SE and CH).

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.

A list of all parts in the IEC 60898 series, published under the general title *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations*, can be found on the IEC website.

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

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

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ELECTRICAL ACCESSORIES – CIRCUIT-BREAKERS FOR OVERCURRENT PROTECTION FOR HOUSEHOLD AND SIMILAR INSTALLATIONS –

Part 1: Circuit-breakers for a.c. operation

1 Scope

This part of IEC 60898 applies to a.c. air-break circuit-breakers for operation at 50 Hz, 60 Hz or 50/60 Hz, having a rated voltage not exceeding 440 V (between phases), a rated current not exceeding 125 A and a rated short-circuit capacity not exceeding 25 000 A.

As far as possible, it is in line with the requirements contained in IEC 60947-2.

NOTE 1 Additional requirements are necessary for circuit-breakers used in locations having more severe overvoltage conditions.

These circuit-breakers are intended for the protection against overcurrents of wiring installations of buildings and similar applications; they are designed for use by uninstructed people and do not require maintenance.

They are intended for use in an environment with pollution degree 2 and overvoltage category III.

For an environment with a higher pollution degree, enclosures giving the appropriate degree of protection are used.

They are suitable for isolation.

Circuit-breakers of this standard, with exception of those rated 120 V or 120/240 V (see Table 1), are suitable for use in IT systems.

This standard also applies to circuit-breakers having more than one rated current, provided that the means for changing from one discrete rating to another is not accessible in normal service and that the rating cannot be changed without the use of a tool.

This standard does not apply to

– circuit-breakers intended to protect motors;
– circuit-breakers, the current setting of which is adjustable by means accessible to the user.

For circuit-breakers having a degree of protection higher than IP20 according to IEC 60529, for use in locations where arduous 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 does not apply to circuit-breakers for a.c. and d.c. operation,which is covered by IEC 60898-2.

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This document does not apply to circuit-breakers for DC operation that are covered by IEC 60898-3.

This standard does not apply to circuit-breakers which incorporate residual current tripping devices, which is covered by IEC 61009-1, IEC 61009-2-1, and IEC 61009-2-2.

A guide for coordination under short-circuit conditions between a circuit-breaker and another short-circuit protective device (SCPDs) is given in Annex D. For more severe overvoltage conditions, circuit-breakers complying with other standards (e.g. IEC 60947-2) should be used.

NOTE 2 Circuit-breakers within the scope of this standard can also be used for protection against electric shock in case of fault, depending on their tripping characteristics and on the characteristics of the installation. The criterion of application for such purposes is dealt with by installation rules.

This standard contains all 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 circuit-breakers;
b) the conditions with which circuit-breakers 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 (see Annex C);
f) the co-ordination under short-circuit conditions with another short-circuit protective device (SCPD) associated in the same circuit (see Annex D);
g) the routine tests to be carried out on each circuit-breaker to reveal unacceptable variations in material or manufacture, likely to affect safety (see Annex I).

2 Normative references

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

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)*. Available from: http://www.electropedia.org/

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*

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IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60417, *Graphical symbols for use on equipment*. Available from: http://www.graphical-symbols.info/equipment

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

IEC 60664-1:2007, *Insulation co-ordination 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 60695-2-11:2000, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow- wire flammability test method for end-products*

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

IEC 60947-2:2006, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 61545:1996, *Connecting devices – Devices for the connection of aluminium conductors in clamping units of any material and copper conductors in aluminium bodied clamping units*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-441, as well as the following apply.

3.1 Devices

3.1.1
switching device
device designed to make or break the current in one or more electric circuits

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

3.1.2
mechanical switching device
switching device designed to close and open one or more electric circuits by means of separable contacts

[SOURCE: IEC 60050-441:1984, 441-14-02]

3.1.3
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 and breaks the current when this exceeds a given value for a sufficient time

[SOURCE: IEC 60050-441:1984, 441-18-01, modified – "The fuse comprises all the parts that form the complete device" has been deleted.]

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3.1.4
circuit-breaker
<mechanical> mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time, and automatically breaking currents under specified abnormal circuit conditions such as those of short-circuit

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

3.1.5
plug-in circuit-breaker
circuit-breaker having one or more plug-in terminals (see 3.3.20) and designed for use with appropriate means for the plug-in connection

3.2 General terms

3.2.1
overcurrent
current exceeding the rated current

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

3.2.2
overload current
overcurrent occurring in an electrically undamaged circuit

Note 1 to entry: An overload current may cause damage if sustained for a sufficient time.

3.2.3
short-circuit current
overcurrent resulting from a fault of negligible impedance between points intended to be at different potentials in normal service

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

3.2.4
main circuit
<of a circuit-breaker> all the conductive parts of a circuit-breaker included in the circuit which it is designed to close and open

3.2.5
control circuit
<of a circuit-breaker> circuit (other than a path of the main circuit) intended for the closing operation or opening operation, or both, of the circuit-breaker

3.2.6
auxiliary circuit
<of a circuit-breaker> all the conductive parts of a circuit-breaker intended to be included in a circuit other than the main circuit and the control circuit of the circuit-breaker

3.2.7
pole
<of a circuit-breaker> that part of a circuit-breaker 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

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3.2.7.1
protected pole
pole provided with an overcurrent release (see 3.3.6)

3.2.7.2
unprotected pole
pole without overcurrent release (see 3.3.6), but otherwise generally capable of the same performance as a protected pole of the same circuit-breaker

Note 1 to entry: To ensure compliance with this requirement, the unprotected pole may be of the same construction as the protected pole(s), or of a particular construction.

Note 2 to entry: If the short-circuit capacity of the unprotected pole is different from that of the protected pole(s), this has to be indicated by the manufacturer.

3.2.7.3
switched neutral pole
pole only intended to switch the neutral, and not intended to have a short-circuit capacity

3.2.8
closed position
position in which the predetermined continuity of the main circuit of the circuit-breaker is secured

3.2.9
open position
position in which the predetermined clearance between open contacts in the main circuit of the circuit-breaker is secured

3.2.10
air temperature

3.2.10.1
ambient air temperature
temperature, determined under prescribed conditions, of the air surrounding the circuit-breaker

Note 1 to entry: For circuit breakers installed inside an enclosure, it is the temperature of air outside the enclosure

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

3.2.10.2
reference ambient air temperature
ambient air temperature on which the time-current characteristics are based

3.2.11
operation
transfer of the moving contact(s) from the open position to the closed position or vice versa

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

3.2.12
operating cycle
succession of operations from one position to another and back to the first position

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3.2.13
operating sequence
<of a mechanical switching device> succession of specified operations with specified time intervals

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

3.2.14
uninterrupted duty
duty in which the main contacts of a circuit-breaker remain closed whilst carrying a steady current without interruption for long periods (which could be weeks, months, or even years)

3.2.15
type test
test of one or more devices made to a certain design to show that the design meets certain requirements

[SOURCE: IEC 60050-411:1996, 411-53-01, modified – "machines" and "specifications" have been replaced by "devices" and "requirements", respectively.]

3.2.16
routine test
test to which each individual device is subjected during or after manufacture to ascertain whether it complies with certain criteria

[SOURCE: IEC 60050-411:1996, 411-53-02, modified – "machine" has been replaced with "device".]

3.3 Constructional elements

3.3.1
main contact
contact included in the main circuit of a circuit-breaker and intended to carry in the closed position the current of the main circuit

3.3.2
arcing contact
contact on which the arc is intended to be established

Note 1 to entry: An arcing contact may serve as a main contact. It may also be a separate contact so designed that it opens after and closes before another contact, which it is intended to protect from damage.

[SOURCE: IEC 60050-441:1984, 441-15-08]

3.3.3
control contact
contact included in a control circuit of a circuit-breaker and mechanically operated by the circuit-breaker

3.3.4
auxiliary contact
contact included in an auxiliary circuit and mechanically operated by the circuit-breaker (e.g. for indicating the position of the contacts)

3.3.5
release
device, mechanically connected to (or integrated into) a circuit-breaker, which releases the holding means and permits the automatic opening of the circuit-breaker

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3.3.6
overcurrent release
release which causes a circuit-breaker to open, with or without time-delay, when the current in the release exceeds a pre-determined value

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

3.3.7
inverse time-delay overcurrent release
overcurrent release which operates after a time-delay inversely dependent upon the value of the overcurrent

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

3.3.8
direct overcurrent release
overcurrent release directly energized by the current in the main circuit of a circuit-breaker

3.3.9
overload release
overcurrent release intended for protection against overloads

3.3.10
conductive part
part which is capable of conducting current although it may not necessarily be used for carrying current in normal service

3.3.11
exposed conductive part
conductive part which can be readily touched and which normally is not live, but which may become live under fault conditions

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

3.3.12
terminal
conductive part of a device, provided for re-usable electrical connection to external circuits

3.3.12.1
screw-type terminal
terminal for the connection and subsequent disconnection of a conductor or the inter-connection 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

3.3.12.2
pillar terminal
screw-type terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw(s).

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

Note 2 to entry: Examples of pillar terminals are shown in Annex F, Figure F.1.

[SOURCE: IEC 60050-442:1984, 442-06-22]

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3.3.12.3
screw terminal
terminal in which the conductor is clamped under the head of the screwand where the clamping pressure can 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 1 to entry: Examples of screw terminals are shown in Annex F, Figure F.2.

[SOURCE: IEC 60050-442:1984, 442-06-08]

3.3.12.4
stud terminal
screw-type terminal in which the conductor is clamped under a nut.

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

Note 2 to entry: Examples of stud terminals are shown in Annex F, Figure F.2.

[SOURCE: IEC 60050-442:1984, 442-06-23]

3.3.12.5
saddle terminal
screw-type terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts

Note 1 to entry: Examples of saddle terminals are shown in Annex F, Figure F.3.

[SOURCE: IEC 60050-442:1984, 442-06-09]

3.3.12.6
lug terminal
screw terminal or stud terminal, designed for clamping a cable lug or a bar directly or indirectly by means of a screw or nut

Note 1 to entry: Examples of lug terminals are shown in Annex F, Figure F.4.

[SOURCE: IEC 60050-442:1984, 442-06-16]

3.3.12.7
screwless terminal
connecting terminal for the connection and subsequent disconnection of one conductor or the interconnection of two or more conductors capable of being dismantled, the connection being made, directly or indirectly, by means of springs, wedges, eccentrics or cones, etc., without special preparation of the conductor other than removal of insulation

[SOURCE: IEC 60050-442:1984, 442-06-13 modified by adding the last part of the text]

3.3.12.8
plug-in terminal
terminal the electrical connection and disconnection of which can be effected without displacing the conductors of the corresponding circuit

Note 1 to entry: The connection is effected without the use of a tool and is provided by the resilience of the fixed and/or moving parts and/or by springs

3.3.13
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.

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Note 1 to entry: The screw is made with a tapered thread, the taper being applied to the core diameter of the thread at the end section of the screw.

Note 2 to entry: 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

3.3.13.1
thread-forming tapping screw
tapping screw having an uninterrupted thread

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

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

3.3.13.2
thread-cutting tapping screw
tapping screw having an interrupted thread. The thread is intended to remove material from the hole.

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

3.4 Conditions of operation

3.4.1
closing operation
operation by which the circuit-breaker is brought from the open position to the closed position

3.4.2
opening operation
operation by which the circuit-breaker is brought from the closed position to the open position

3.4.3
dependent manual operation
operation solely by means of directly applied manual energy, such that the speed and force of the operation are dependent upon the action of the operator

[SOURCE: IEC 60050-441:1984, 441-16-13]

3.4.4
independent manual operation
stored energy operation where the energy originates from manual power, stored and released in one continuous operation, such that the speed and force of the operation are independent of the action of the operator

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

3.4.5
trip-free circuit-breaker
circuit-breaker, the moving contacts of which return to and remain in the open position when the automatic opening operation is initiated after the initiation of the closing operation, even if the closing command is maintained

Note 1 to entry: To ensure proper breaking of the current which may have been established, it may be necessary that the contacts momentarily reach the closed position.

3.5 Characteristic quantities

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

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3.5.1
rated value
stated value of any one of the characteristic quantities that serve to define the working conditions for which the circuit-breaker is designed and built

3.5.2
prospective current
current that would flow in the circuit if each pole of the circuit-breaker were replaced by a conductor of negligible impedance

Note 1 to entry: The prospective current may be qualified in the same manner as an actual current, for example prospective breaking current, prospective peak current.

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

3.5.3
prospective peak current
peak value of a prospective current during the transient period following initiation

Note 1 to entry: The definition assumes that the current is established by an ideal circuit-breaker, that is, with instantaneous transition from infinite to zero impedance. For circuits where the current can follow several different paths, for example polyphase circuits, it further assumes that the current is established simultaneously in all poles, even if the current in only one pole is considered.

[SOURCE: IEC 60050-441:1984, 441-17-02]

3.5.4
maximum prospective peak current
prospective peak current when the initiation of the current takes place at the instant which leads to the highest possible value

Note 1 to entry: For a multipole circuit-breaker in a polyphase circuit, the maximum prospective peak current refers to a single pole only.

[SOURCE: IEC 60050-441:1984, 441-17-04]

3.5.5
short-circuit making and breaking capacity
alternating component of the prospective current, expressed by its r.m.s. value, which the circuit-breaker is designed to make, to carry for its opening time and to break under specified conditions

3.5.5.1
ultimate short-circuit breaking capacity
breaking capacity for which the prescribed conditions according to a specified test sequence do not include the capability of the circuit-breaker to carry 0,85 times its non-tripping current for the conventional time

3.5.5.2
service short-circuit breaking capacity
breaking capacity for which the prescribed conditions according to a specified test sequence include the capability of the circuit-breaker to carry 0,85 times its non-tripping current for the conventional time

3.5.6
breaking current
current in a pole of a circuit-breaker at the instant of initiation of the arc during a breaking operation

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3.5.7
applied voltage
voltage which exists across the terminals of a pole of a circuit-breaker just before the making of the current

Note 1 to entry: This definition refers to a single-pole device. For a multipole device the applied voltage is the voltage across the supply terminals of the device.

3.5.8
recovery voltage
voltage which appears across the terminals of a pole of a circuit-breaker after the breaking of the current

Note 1 to entry: This voltage may be considered in two successive intervals of time, one during which a transient voltage exists, followed by a second one during which the power-frequency or the steady-state recovery voltage alone exists.

Note 2 to entry: This definition refers to a single-pole device. For a multipole device the recovery voltage is the voltage across the supply terminals of the device.

[SOURCE: IEC 60050-441:1984, 441-17-25, modified –Note 2 to entry has been added.]

3.5.8.1
transient recovery voltage
recovery voltage during the time in which it has a significant transient character

Note 1 to entry: The transient voltage may be oscillatory or non-oscillatory or a combination of these, depending on the characteristics of the circuit and of the circuit-breaker. It includes the voltage shift of the neutral of a polyphase circuit.

[SOURCE: IEC 60050-441:1984, 441-17-26, modified –Note 2 has been deleted.]

3.5.8.2
power-frequency recovery voltage
recovery voltage after the transient voltage phenomena have subsided

[SOURCE: IEC 60050-441:1984, 441-17-27]

3.5.9
opening time
time measured from the instant at which, the circuit-breaker being in the closed position, the current in the main circuit reaches the operating value of the overcurrent release to the instant when the arcing contacts have separated in all poles

Note 1 to entry: The opening time is commonly referred to as tripping time, although, strictly speaking, tripping time applies to the time between the instant of initiation of the opening time and the instant at which the opening command becomes irreversible.

3.5.10
arcing time

3.5.10.1
arcing time of a pole
interval of time between the instant of initiation of the arc in a pole and the instant of final arc extinction in that pole

[SOURCE: IEC 60050-441:1984, 441-17-37, modified – “or a fuse” and "or that fuse" have been deleted.]

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3.5.10.2
arcing time of a multipole circuit-breaker
interval of time between the instant of first initiation of an arc and the instant of final extinction in all poles

[SOURCE: IEC 60050-441:1984, 441-17-38]

3.5.11
break time
interval of time between the beginning of the opening time of a circuit-breaker and the end of the arcing time

3.5.12
I*²*t
Joule integral
integral of the square of the current over a given time interval

$$I^2t = \int_{t_0}^{t_1} i^2 \, \mathrm{d}t$$

3.5.13
***I*²*t* characteristic of a circuit-breaker**
curve giving the maximum values of I^2t as a function of the prospective current under stated conditions of operation

3.5.14
co-ordination between overcurrent protective devices in series

3.5.14.1
overcurrent protective co-ordination of overcurrent protective devices
co-ordination of two or more overcurrent protective devices in series to ensure overcurrent selectivity) and/or back-up protection

[SOURCE: IEC 60947-1:2007, 2.5.22]

3.5.14.2
overcurrent selectivity
co-ordination of the operating characteristics of two or more overcurrent protective devices in series such that, on the incidence of overcurrents within stated limits, the device intended to operate within these limits does so, while the other(s) does (do) not

[SOURCE: IEC 60947-2:2016, 2.17.1, modified – "in series" has been added.]

3.5.14.3
back-up protection
overcurrent co-ordination of two overcurrent protective devices in series, where the protective device, generally but not necessarily on the supply side, effects the overcurrent protection with or without the assistance of the other protective device and prevents excessive stress on the latter

[SOURCE: IEC 60947-1:2007, 2.5.24]

3.5.14.4
total selectivity
overcurrent selectivity where, in the presence of two overcurrent protective devices in series, the protective device on the load side effects the protection without causing the other protective device to operate

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[SOURCE: IEC 60947-2:2006, 2.17.2]

3.5.14.5
partial selectivity
overcurrent selectivity where, in the presence of two overcurrent protective devices in series, the protective device on the load side effects the protection up to a given level of overcurrent, without causing the other protective device to operate

[SOURCE: IEC 60947-2:2006, 2.17.3]

3.5.14.6
selectivity limit current
I_s
current co-ordinate of the intersection between the total time-current characteristic of the protective device on the load side and the pre-arcing (for fuses), or tripping (for circuit-breakers) time-current characteristic of the other protective device

Note 1 to entry: The selectivity limit current (see Figure D.1) is a limiting value of current

– below which, in the presence of two overcurrent protective devices in series, the protective device on the load side completes its breaking operation in time to prevent the other protective device from starting its operation (i.e. selectivity is ensured);
– above which, in the presence of two overcurrent protective devices in series, the protective device on the load side may not complete its breaking operation in time to prevent the other protective device from starting its operation (i.e. selectivity is not ensured)

[SOURCE: IEC 60947-2:2006, 2.17.4]

3.5.14.7
take-over current
I_B
current co-ordinate of the intersection between the time-current characteristics of two overcurrent protective devices

Note 1 to entry: The take-over current is the current co-ordinate of the intersection between the maximum break-time / current characteristics of two overcurrent protective devices in series.

[SOURCE: IEC 60050-441:1984, 441-17-16]

3.5.14.8
conditional short-circuit current (of a circuit or a switching device)
prospective current that a circuit or a switching device, protected by a specified short-circuit protective device, can satisfactorily withstand for the total operating time of that device under specified conditions of use and behaviour

Note 1 to entry: For the purpose of this standard, the short-circuit protective device is generally a circuit-breaker or a fuse.

Note 2 to entry: This definition differs from IEC 60050-441:1984, 441-17-20 by broadening the concept of current limiting device into a short-circuit protective device, the function of which is not only to limit the current.

[SOURCE: IEC 60947-1:2007, 2.5.29]

3.5.14.9
rated conditional short-circuit current
I_{nc}
value of prospective current, stated by the manufacturer, which the equipment, protected by a short-circuit protective device specified by the manufacturer, can withstand satisfactorily for the operating time of this device under the test conditions in the relevant product standard

[SOURCE: IEC 60947-1:2007, 4.3.6.4]

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3.5.15
conventional non-tripping current
I_{nt}
specified value of current which the circuit-breaker is capable of carrying for a specified time (conventional time) without tripping

3.5.16
conventional tripping current
I_t
specified value of current which causes the circuit-breaker to operate within a specified time (conventional time)

3.5.17
instantaneous tripping current
minimum value of current causing the circuit-breaker to operate automatically without intentional time-delay

3.6 Definitions related to insulation co-ordination

3.6.1
insulation coordination
mutual correlation of insulation characteristics of electrical equipment taking into account the expected micro-environment and the influencing stresses

[SOURCE: IEC 60664-1:2007, 3.1]

3.6.2
working voltage
highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

Note 1 to entry: Transients are disregarded.

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

[SOURCE: IEC 60664-1:2007, 3.5]

3.6.3
overvoltage
any voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions

[SOURCE: IEC 60664-1:2007, 3.7]

3.6.4
impulse withstand voltage
highest peak value of impulse voltage of prescribed form and polarity, which does not cause breakdown of the insulation under specific conditions

[SOURCE: IEC 60664-1:2007, 3.8.1]

3.6.5
overvoltage category
numeral defining a transient overvoltage condition

[SOURCE: IEC 60664-1:2007, .3.10, modified – The notes have been deleted.]

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3.6.6
macro-environment
environment of the room or other location, in which the equipment is installed or used

[SOURCE: IEC 60664-1:2007, 3.12.1]

3.6.7
micro-environment
immediate environment of the insulation which particularly influences the dimensioning of the creepage distances

[SOURCE: IEC 60664-1:2007, 3.12.2]

3.6.8
pollution
any addition of foreign matter, solid, liquid or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation

[SOURCE: IEC 60664-1:2007, 3.11]

3.6.9
pollution degree
numeral characterising the expected pollution of the micro-environment

Note 1 to entry: The pollution degree to which equipment is exposed may be different from that of the macro-environment where the equipment is located because of protection offered by means such as an enclosure or internal heating to prevent absorption or condensation of moisture.

[SOURCE: IEC 60664-1:2007, 3.13, modified – Note 1 to entry has been added.]

3.6.10
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

[SOURCE: IEC 60947-1:2007, 2.1.19,]

3.6.11
isolating distance
<of a pole of a mechanical switching device> clearance between open contacts, meeting the safety requirements specified for isolation purposes

[SOURCE: IEC 60050-441:1984, 441-17-35]

3.6.12
clearance
shortest distance in air between two conductive parts along a string stretched the shortest way between these conductive parts (see Annex B)

Note 1 to entry: For the purpose of determining a clearance to accessible parts, the accessible surface of an insulating enclosure is considered conductive as if it was covered by a metal foil wherever it can be touched by a hand or a standard test finger according to Figure 8.

[SOURCE: IEC 60050-441:1984, 441-17-31, modified – Note 1 to entry has been added.]

3.6.13
creepage distance
shortest distance along the surface of an insulating material between two conductive parts

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Note 1 to entry: See Annex B.

Note 2 to entry: For the purpose of determining a creepage distance to accessible parts, the accessible surface of an insulating enclosure is considered conductive as if it was covered by a metal foil wherever it can be touched by a hand or a standard test finger according to Figure 8.

[SOURCE: IEC 60050-151:1984, 151-15-50 modified – Notes 1 and 2 to entry have been added.]

4 Classification

4.1 General

Circuit-breakers are classified according to several criteria.

4.2 According to the number of poles:

– single-pole circuit-breakers;
– two-pole-circuit-breakers with one protected pole;
– two-pole circuit-breakers with two protected poles;
– three-pole circuit-breakers with three protected poles;
– four-pole circuit-breakers with three protected poles;
– four-pole circuit-breakers with four protected poles.

NOTE The pole which is not a protected pole can be

– "unprotected" (see 3.2.7.2), or
– "switched neutral" (see 3.2.7.3).

4.3 According to the protection against external influences:

– enclosed-type (not requiring an appropriate enclosure);
– unenclosed-type (for use with an appropriate enclosure).

4.4 According to the method of mounting:

– surface-type;
– flush-type;
– panel board type, also referred to as distribution board type.

NOTE These types may be intended to be rail mounted.

4.5 According to the methods of connection

4.5.1 According to the fixation system:

– circuit-breakers, the electrical connections of which are not associated with the mechanical mounting;
– circuit-breakers, the electrical connections of which are associated with the mechanical mounting.

NOTE Examples of this type are:

– plug-in type;
– bolt-on type;
– screw-in type.

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

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4.5.2 According to the type of terminals:

– circuit-breakers with screw-type terminals for external copper conductors;

– circuit-breakers with screwless type terminals for external copper conductors;

NOTE 1 The requirements for circuit-breakers equipped with this type of terminals are given in Annex J.

– circuit-breakers with flat quick-connect terminals for external copper conductors;

NOTE 2 The requirements for circuit-breakers equipped with this type of terminals are given in Annex K.

– circuit-breakers with screw-type terminals for external aluminium conductors;

NOTE 3 The requirements for circuit-breakers with this type of terminal are given in Annex L .

4.6 According to the instantaneous tripping current (see 3.5.17)

– B-type;

– C-type;

– D-type.

NOTE The selection of a particular type can depend on the installation rules.

4.7 According to the I^2t characteristic

In addition to the I^2t characteristic provided by the manufacturer, circuit-breakers may be classified according to their I^2t characteristic.

5 Characteristics of circuit-breakers

5.1 List of characteristics

The characteristics of a circuit-breaker shall be stated in the following terms:

– number of poles (see 4.2);

– protection against external influences (see 4.3);

– method of mounting (see 4.4);

– method of connection (see 4.5);

– value of rated operational voltage (see 5.3.1);

– value of rated current (see 5.3.2);

– value of rated frequency (see 5.3.3);

– range of instantaneous tripping current (see 4.6 and 5.3.5);

– value of rated short-circuit capacity (see 5.3.4);

– I^2t characteristic (see 3.5.13);

– I^2t classification (see 4.7).

5.2 Rated quantities

5.2.1 Rated voltages

5.2.1.1 Rated operational voltage (U_e)

The rated operational voltage (hereinafter referred to as rated voltage) of a circuit-breaker is the value of voltage, assigned by the manufacturer, to which its performance (particularly the short-circuit performance) is referred.

NOTE The same circuit-breaker can be assigned a number of rated voltages and associated rated short-circuit capacities.

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5.2.1.2 Rated insulation voltage (U_i)

The rated insulation voltage of a circuit-breaker is the value of voltage, assigned by the manufacturer, to which dielectric test voltages and creepage distances are referred.

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

5.2.1.3 Rated impulse withstand voltage (U_{imp})

The rated impulse withstand voltage of a circuit-breaker shall be equal to or higher than the standard values of rated impulse withstand voltage given in Table 3.

5.2.2 Rated current (I_n)

A current assigned by the manufacturer as the current which the circuit-breaker is designed to carry in uninterrupted duty (see 3.2.14), at a specified reference ambient air temperature.

The standard reference ambient air temperature is 30 °C. If a different reference ambient air temperature for the circuit-breaker is used, the effect on the overload protection of cables shall be taken into account, since this is also based on a reference ambient air temperature of 30 °C according to installation rules.

NOTE The reference ambient air temperature for the overload protection of cables has been fixed at 25 °C according to IEC 60364.

5.2.3 Rated frequency

The rated frequency of a circuit-breaker is the power frequency for which the circuit-breaker is designed and to which the values of the other characteristics correspond.

The same circuit-breaker may be assigned a number of rated frequencies.

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

The rated short-circuit capacity of a circuit-breaker is the value of the ultimate short-circuit breaking capacity (see 3.5.5.1) assigned to that circuit-breaker by the manufacturer.

NOTE A circuit-breaker having a given rated short-circuit capacity has a corresponding service short-circuit capacity (I_{cs}) (see Table 18).

Rated making and breaking capacity of an individual pole (I_{cn1})

The value of the limiting short-circuit making and breaking capacity on each individual protected pole of multipole circuit breakers.

NOTE The corresponding rated quantity of RCBOs is the rated residual making and breaking capacity $I_{\Delta m}$ (see 5.2.7 of IEC 61009-1:2010).

The standard values are those given in 5.3.4.1.

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage

Preferred values of rated voltage are given in Table 1.

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Table 1 – Preferred values of rated voltage

Circuit-breakers	Circuit supplying the circuit-breaker See also IEC 60364-1	Rated voltage of circuit-breakers for use in systems 230 V, 230/400 V, 400 V V	Rated voltage of circuit-breakers for use in systems 120/240V, 240 V V
Single pole	Single phase (phase to neutral or phase to phase)	230	
	Three-phase (4-wire)	230	
	Single phase (phase to earthed middle conductor, or phase to neutral)		120 240
	Single phase (phase to neutral) or three phase, using three single-pole circuit-breakers (3-wire or 4-wire)	230/400	
Two-pole	Single phase (phase to neutral or phase to phase)	230	
	Single phase (phase to phase)	400	240
	Single phase (phase to phase, 3-wire)		120/240
	Three phase (4-wire)	230	
Three-pole	Three phase (3-wire or 4-wire)	400	240
	Single phase (3-wire)		120/240
Four-pole	Three phase (4-wire)	400	

NOTE 1 Wherever in this standard there is a reference to 230 V or 400 V, they can be read as 220 V or 240 V, 380 V or 415 V, respectively.

NOTE 2 Wherever in this standard there is a reference to 120 V, 240 V or 120/240 V, they can be read as 100 V, 200 V or 100/200 V, respectively.

5.3.2 Preferred values of rated current

Preferred values of rated current are:

6 A, 8 A, 10 A, 13 A, 16 A, 20 A, 25 A, 32 A, 40 A, 50 A, 63 A, 80 A, 100 A and 125 A.

5.3.3 Standard values of rated frequency

Standard values of rated frequency are 50 Hz and 60 Hz.

5.3.4 Values of rated short-circuit capacity

5.3.4.1 Standard values up to and including 10 000 A

Standard values of rated short-circuit capacities up to and including 10 000 A are:

1 500 A, 3 000 A, 4 500 A, 6 000 A, 10 000 A.

NOTE The values of 1 000 A, 2 000 A, 2 500 A, 5 000 A, 7 500 A and 9 000 A are also considered as standard in some countries.

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The corresponding power factor ranges are given in 9.12.5.

5.3.4.2 Values above 10 000 A up to and including 25 000 A

For values above 10 000 A up to and including 25 000 A the preferred value is 20 000 A.

The corresponding power factor range is given in 9.12.5.

5.3.5 Standard ranges of instantaneous tripping

Standard ranges of instantaneous tripping are given in Table 2.

Table 2 – Ranges of instantaneous tripping

Type	Range
B	Above 3 I_n up to and including 5 I_n
C	Above 5 I_n up to and including 10 I_n
D	Above 10 I_n up to and including 20 I_n [a]
[a] For special cases values up to 50 I_n may also be used.	

5.3.6 Standard values of rated impulse withstand voltage (U_{imp})

Table 3 gives the standard values of rated impulse withstand voltages as a function of the nominal voltage of the installation.

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Table 3 – Rated impulse withstand voltage as a function of the nominal voltage of the installation

Rated impulse withstand voltage U_{imp} kV	Nominal voltage of the installation	
	Three-phase systems V	Single-phase system with mid-point earthed V
2,5[a]		120/240[b]
4[a]	230/400	120/240, 240[c]
NOTE 1 For test voltages to check the insulation, see Table 14. NOTE 2 For test voltages to check the isolation distance across open contacts, see Table 15.		
[a] The values 3 kV and 5 kV, respectively, are used for verifying the isolating distances across open contacts at the altitude of 2 000 m (see Table 15). [b] For installation practice in Japan. [c] For installation practice in North American countries.		

6 Marking and other product information

Each circuit-breaker shall be marked in a durable manner with the following:

a) manufacturer's name or trade mark;

b) type designation, catalogue number or serial number;

c) rated voltage(s);

d) rated current without symbol "A", preceded by the symbol of instantaneous tripping (B, C or D), for example B 16;

e) rated frequency if the circuit-breaker is designed only for one frequency (see 5.3.3);

f) rated short-circuit capacity, in amperes;

g) wiring diagram, unless the correct mode of connection is evident;

h) reference ambient air temperature, if different from 30 °C;

i) degree of protection (only if different from IP20);

j) for type D circuit-breakers: the maximum instantaneous tripping current, if higher than 20 I_n (see Table 2);

k) rated impulse withstand voltage U_{imp} if it is 2,5 kV.

l) making and breaking capacity on an individual protected pole of multipole circuit breakers (I_{cn1}), if different from I_{cn}.

Marking d) shall be readily visible when the circuit-breaker is installed. If, for small devices, the available space is insufficient, markings a), b), c), e), f), h), i), j) and l) may be put on the side or on the back of the circuit-breaker. Marking g) may be on the inside of any cover which has to be removed in order to connect the supply wires but shall not be on a label loosely attached to the circuit-breaker. Any other information not marked shall be given in the manufacturer's documentation.

The suitability for isolation, which is provided by all circuit-breakers of this standard, may be indicated by the symbol ⊣ (IEC 60417-6169-1) on the device. When affixed, this marking may be included in a wiring diagram, where it may be combined with symbols of other functions, e.g. overload protection, or other symbols of IEC 60417. When the symbol is used on its own (i.e. not in a wiring diagram), combination with symbols of other functions is not allowed.

NOTE 1 In the following countries: DK, FI, NO, SE and ZA the marking of the symbol on the circuit-breaker is mandatory to indicate that the device provides isolation for the installation downstream. In these countries it is

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required that the symbol be clearly and unmistakably visible when the circuit-breaker is installed as in service and the actuator is accessible.

NOTE 2 In Australia this marking on the circuit-breaker is mandatory but is not required to be visible after installation.

If a degree of protection higher than IP20 according to IEC 60529 is marked on the device, it shall comply with it, whichever the method of installation. If the higher degree of protection is obtained only by a specific method of installation and/or with the use of specific accessories (e.g. terminal covers, enclosures, etc.), this shall be specified in the manufacturer's literature.

The manufacturer shall make available, on request, the I^2t characteristic (see 3.5.13).

The manufacturer may indicate the I^2t classification (see 4.7) and mark the circuit-breakers accordingly.

For circuit-breakers other than those operated by means of push-buttons the open position shall be indicated by the symbol O (a circle) IEC 60417-5008 and the closed position by the symbol I (a short vertical straight line) IEC 60417-5007. Additional national symbols for this indication are allowed. Provisionally the use of this national indication alone is allowed. These indications shall be readily visible when the circuit-breaker is installed.

For circuit-breakers operated by means of two push-buttons, only the push-button designed for the opening operation shall be red and/or be marked with the symbol O (IEC 60417-5008).

Red shall not be used for any other push-button of the circuit-breaker.

If a push-button is used for closing the contacts and is clearly identified as such, its depressed position is sufficient to indicate the closed position.

If a single push-button is used for closing and opening the contacts and is identified as such, the button remaining in its depressed position is sufficient to indicate the closed position. On the other hand, if the button does not remain depressed, an additional means indicating the position of the contacts shall be provided.

For circuit-breakers with multiple current ratings, the maximum value shall be marked in accordance with marking d), and in addition the value for which the circuit-breaker is adjusted shall be indicated without ambiguity.

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

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

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

NOTE 3 The symbol ⏚ , (IEC 60417-5017), previously recommended, will be progressively superseded by the preferred symbol IEC 60417-5019 given above.

For rail-mounted circuit-breakers, appropriate rail(s) shall be indicated in the manufacturer's documentation.

Marking shall be indelible and easily legible, and shall not be placed on screws, washers or other removable parts.

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

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7 Standard conditions for operation in service

7.1 General

Circuit-breakers complying with this standard shall be capable of operating under the following standard conditions.

7.2 Ambient air temperature range

The ambient air temperature does not exceed +40 °C and its average over a period of 24 h does not exceed +35 °C.

The lower limit of the ambient air temperature is –5 °C.

Circuit-breakers intended to be used in ambient air temperatures above +40 °C (particularly in tropical countries) or below –5 °C shall either be specially designed or be used according to the information given in the manufacturer's catalogue.

7.3 Altitude

In general 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. Circuit-breakers intended to be so used shall be designed specially or used according to an agreement between manufacturer and user. Information given in the manufacturer's catalogue may take the place of such an agreement.

7.4 Atmospheric conditions

The air is clean and its relative humidity does not exceed 50 % at a maximum temperature of +40 °C.

Higher relative humidities may be permitted at lower temperatures, for example 90 % at +20 °C.

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

7.5 Conditions of installation

The circuit-breaker shall be installed in accordance with the manufacturer's instructions.

7.6 Pollution degree

Circuit-breakers to this standard are intended for environment with pollution degree 2, i.e. normally only non-conductive pollution occurs; occasionally, however, a temporary conductivity caused by condensation may be expected.

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 General

Circuit-breakers shall be so designed and constructed that, in normal use, their performance is reliable and without danger to the user or surroundings.

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

8.1.2 Mechanism

The moving contacts of all poles of multipole circuit-breakers shall be so mechanically coupled that all poles, except the switched neutral, if any, make and break substantially together, whether operated manually or automatically, even if an overload occurs on one protected pole only.

The switched neutral pole (see 3.2.7.3) of four-pole circuit-breakers shall not close after and shall not open before the protected poles.

Compliance is checked by inspection and by manual test, using any appropriate means (e.g. indicator lights, oscilloscope, etc.).

If a pole having an appropriate short-circuit making and breaking capacity is used as a neutral pole and the circuit-breaker has an independent manual operation (see 3.4.4), then all poles, including the neutral pole, may operate substantially together.

Circuit-breakers shall have a trip-free mechanism.

Compliance with the above requirements is checked by inspection, by manual test and, for the trip-free function, by the test of 9.10.3.

It shall be possible to switch the circuit-breaker on and off by hand. For plug-in type circuit-breakers without operating handle, this requirement is not considered met by the fact that the circuit-breaker can be removed from its base.

Circuit-breakers shall be so constructed that the moving contacts can come to rest only in the closed position (see 3.2.8) or in the open position (see 3.2.9), even when the operating means is released in an intermediate position.

Circuit-breakers shall provide in the open position (see 3.2.9) an isolation distance in accordance with the requirements necessary to satisfy the isolating function (see 8.3). Indication of the open and closed position of the main contacts shall be provided by one or both of the following means:

– the position of the actuator (this being preferred), or
– a separate mechanical indicator.

If a separate mechanical indicator is used to indicate the position of the main contacts, this shall show the colour red for the closed position (ON) and the colour green for the open position (OFF).

The means of indication of the contact position shall be reliable.

Compliance is checked by inspection and by the tests of 9.10.3.

Circuit-breakers shall be designed so that the actuator, front plate or cover can only be correctly fitted in a manner which ensures correct indication of the contact position.

Compliance is checked by inspection and by the tests of 9.12.12.1 and 9.12.12.2.

Where the operating means is used to indicate the position of the contacts, the operating means, when released, shall automatically take up the position corresponding to that of the moving contact(s); in this case, the operating means shall have two distinct rest positions

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corresponding to the position of the contacts but, 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.

A cover sealed in position by the manufacturer is considered to be a non-removable part.

If the cover is used as a guiding means for push-buttons, it shall not be possible to remove the buttons from the outside of the circuit-breaker.

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.

If the operating means has an "up-down" movement, when the circuit-breaker is mounted as in normal use, the contacts shall be closed by the up movement.

NOTE 1 Provisionally in certain countries down-closing movement is allowed.

Compliance is checked by inspection and by manual test.

When means are provided or specified by the manufacturer to lock the operating means in the open position, locking in that position shall only be possible when the main contacts are in the open position.

NOTE 2 Locking of the operating means in the closed position is possible for particular applications.

Compliance is checked by inspection, taking into account the instructions of the manufacturer.

8.1.3 Clearances and creepage distances and solid insulation

The minimum required clearances and creepage distances are given in Table 4 which is based on the circuit-breaker being designed for operating in an environment with pollution degree 2.

Parts of PCBs connected to live parts and protected against pollution by the use of a type 2 protection according to IEC 60664-3 are exempted from this verification.

The insulating materials are classified into material groups on the basis of their comparative tracking index (CTI) according to IEC 60664-1.

NOTE 1 The comparative tracking index (CTI) is declared by the manufacturer on the basis of tests carried out on the insulating material.

NOTE 2 Information on the requirements for design of solid insulation is provided in IEC 60664-1.

For clearances on printed wiring material, footnote 3 in Table F.2 of IEC 60664-1:2007 applies. For creepage distances on printed wiring material, the distances from Table F.4 of IEC 60664-1:2007 for pollution degree 1 can be applied only if protected with a coating meeting IEC 60664-3 requirements and tests.

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Table 4 – Minimum clearances and creepage distances

	Minimum clearances mm			Minimum creepage distances [e, f] mm											
				Group IIIa [h] (175 V ≤ CTI < 400 V)[d]				Group II (400 V ≤ CTI < 600 V)[d]				Group I (600 V ≤ CTI)[d]			
	Rated voltage V			Working voltage[e] V											
	U_{imp}														
	2,5 kV	4 kV	4 kV												
Description/item	120/240 120	120/240 240	230/400 230 400	> 25 ≤ 50[i]	120	250	400	> 25 ≤ 50[i]	120	250	400	> 25 ≤ 50[i]	120	250	400
1. Between live parts which are separated when the main contacts are in the open position[a, j]	2,0	4,0	4,0	1,2	2,0	4,0	4,0	0,9	2,0	4,0	4,0	0,6	2,0	4,0	4,0
2. Between live parts of different polarity[a]	1,5	3,0	3,0	1,2	1,5	3,0	4,0	0,9	1,5	3,0	3,0	0,6	1,5	3,0	3,0
3. Between circuits supplied from different sources, one of which being PELV or SELV[g]	3,0	6,0	8,0		3,0	6,0	8,0		3,0	6,0	8,0		3,0	6,0	8,0
				Rated voltage V											
				120/240		230/400		120/240		230/400		120/240		230/400	
4. Between live parts and – accessible surfaces of operating means – screws or other means for fixing covers which have to be removed when mounting the circuit-breaker – surface on which the circuit-breaker is mounted[b] – screws or other means for fixing the circuit-breaker – metal covers or boxes[b] – other accessible metal parts[c] – metal frames supporting flush-type circuit-breakers	1,5	3,0	3,0	1,5		4,0		1,5		3,0		1,5		3,0	

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Care should be taken to provide adequate clearances and creepage distances between live parts of different polarity of circuit-breakers, for example of the plug-in type mounted close to one another. If the surfaces adjacent to the circuit-breaker do not meet the clearance and creepage distance requirements, appropriate information will be provided for installation purposes. NOTE 1 The values given for 400 V are also valid for 440 V. NOTE 2 The parts of the neutral path, if any, are considered to be live parts.
[a] For auxiliary and control contacts the values are given in the relevant standard. [b] The values are doubled if clearances and creepage distances between live parts of the device and the metallic screen or the surface on which the circuit-breaker is mounted are not dependent on the design of the circuit-breaker only, so that they can be reduced when the circuit-breaker is mounted in the most unfavourable condition. [c] Including a metal foil in contact with the surfaces of insulating material which are accessible after installation for normal use. The foil is pushed into corners, grooves, etc., by means of a straight unjointed test finger according to 9.6 (see Figure 8). [d] See IEC 60112. [e] Interpolation is allowed in determining creepage distances corresponding to voltage values intermediate to those listed as working voltage. When interpolating, linear interpolation shall be used and values shall be rounded to the same number of digits as the values taken from the tables. For determination of creepage distances, see Annex B. [f] Creepage distances cannot be less than the associated clearances. [g] To cover all different voltages including ELV in an auxiliary contact. [h] For material group IIIb (100 V ≤ CTI < 175 V) the values for material group IIIa multiplied by 1,6 apply. [i] For working voltages up to and including 25 V, reference may be made to IEC 60664-1. [j] The clearance and creepage distances between the metal parts within the arc chamber may be less than 1 mm, provided that the sum of distances is greater than specified in item 1 of Table 4.

8.1.3.1 Clearances

Compliance as regards item 1 in Table 4 is checked by measurement and by the tests of 9.7.5.4.

The test is carried out with samples not submitted to the humidity treatment described in 9.7.1.

Compliance as regards items 2 and 4 in Table 4 is checked by measurement and, if the clearances are reduced, by the tests of 9.7.5.2.

The clearances of items 2 and 4 (except for accessible surfaces after installation, see note) may be reduced provided that the measured clearances are not shorter than the minimum allowed in IEC 60664-1 for homogenous field conditions. In this case, compliance as regards items 2 and 4 is always checked by the test of 9.7.5.2.

NOTE An accessible surface after installation means any surface accessible by the user when the circuit-breaker is installed according to the manufacturer's instructions. The test finger can be applied to determine whether a surface is accessible or not.

Compliance as regards item 3 in Table 4 is checked by measurement.

8.1.3.2 Creepage distances

Compliance as regards items 1, 2, 3 and 4 of Table 4 is checked by measurement.

NOTE All measurements required in 8.1.3 are carried out in Test sequence A on one sample. Tests according to 9.7.2 to 9.7.5 are carried out in Test sequence B on three samples.

8.1.3.3 Solid insulation

Compliance is checked by the tests according to 9.7.2, 9.7.3, 9.7.4 and 9.7.5, as applicable.

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8.1.4 Screws, current-carrying parts and connections

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

Screws operated when mounting the circuit-breaker during installation shall not be of the thread-cutting type.

NOTE 1 Screws (or nuts) which are operated when mounting the circuit-breaker include screws for fixing covers or cover-plates, but not connecting means for screwed conduits and for fixing the base of a circuit-breaker.

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

NOTE 2 Screwed connections are considered as checked by the tests of 9.8, 9.9, 9.12, 9.13 and 9.14.

8.1.4.2 For screws in engagement with a thread of insulating material and which are operated when mounting the circuit-breaker during installation, correct introduction of the screw into the screw hole or nut shall be ensured.

Compliance is checked by inspection and by manual test.

The requirement with regard to correct introduction is met, if introduction of the screw in a slanting manner is prevented, for example by guiding the screw by the part to be fixed by a recess in the female thread, or by the use of a screw with the leading thread removed.

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

Compliance is checked by inspection.

NOTE The suitability of the material is considered in respect of the stability of the dimensions.

8.1.4.4 Current-carrying parts including parts intended for protective conductors, if any, shall be made of a metal having, under the conditions occurring in the equipment, mechanical strength, electrical conductivity and resistance to corrosion adequate for their intended use.

EXAMPLE Examples of suitable materials are given below:

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

In case of using ferrous alloys or suitably coated ferrous alloys, compliance to resistance to corrosion is checked by a test of resistance to rusting (see 9.16).

The requirements of this subclause do not apply to contacts, magnetic circuits, heater elements, bimetals, shunts, electronic components, including printed circuit board or to screws, nuts, washers, clamping plates, similar parts of terminals and parts of the test circuit.

Compliance is checked by inspection in accordance with the manufacturer's declaration.

8.1.5 Terminals for external conductors

8.1.5.1 Terminals for external conductors shall be such that the conductors may be connected so as to ensure that the necessary contact pressure is maintained permanently.

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Connection arrangements intended for busbar connection are admissible, provided they are not used for the connection of cables.

Such arrangements may be either of the plug-in or of the bolt-on type.

The terminals shall be readily accessible under the intended conditions of use.

Compliance is checked by inspection, by the tests of 9.5 for screw-type terminals, by specific tests for plug-in or bolt-on circuit-breakers included in this document, or by the tests of Annex J or K, as relevant for the type of connection.

8.1.5.2 Circuit breakers shall be provided with:

– either terminals which shall allow the connection of copper conductors having nominal cross-sectional areas as shown in Table 5;

NOTE Examples of possible designs of screw-type terminals are given in Annex F.

– or terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors according to Annex L.

Compliance is checked by inspection, by measurement and by fitting, in turn, one conductor of the smallest and one of the largest cross-sectional area as specified.

Table 5 – Connectable cross-sections of copper conductors for screw-type terminals

Rated current [b] A		**Range of nominal cross-section to be clamped** [a] mm^2	
Greater than	**Up to and including**	**Rigid (solid or stranded** [c]**) conductors**	**Flexible conductors**
–	13	1 to 2,5	1 to 2,5
13	16	1 to 4	1 to 4
16	25	1,5 to 6	1,5 to 6
25	32	2,5 to 10	2,5 to 6
32	50	4 to 16	4 to 10
50	80	10 to 25	10 to 16
80	100	16 to 35	16 to 25
100	125	25 to 50	25 to 35

[a] It is required that, for current ratings up to and including 50 A, terminals be designed to clamp solid conductors as well as rigid stranded conductors. Nevertheless, it is permitted that terminals for conductors having cross-sections from 1 mm^2 up to 6 mm^2 be designed to clamp solid conductors only.

[b] A range of CBs having the same fundamental design and having the same design and construction of terminals, the terminals are fitted with copper conductors of the smallest cross-section for the minimum rated current and largest cross-section for the maximum rated current, as specified, solid and stranded, as applicable.

[c] Rigid stranded conductors shall be used for conductors having cross-sections from 1,5 mm^2 up to 50 mm^2 and shall be in compliance with class 2 of IEC 60228:2004, related to stranded conductors for single-core.

NOTE 2 For the correspondence between ISO and AWG copper conductors see Annex G.

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

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

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8.1.5.4 Terminals for rated currents up to and including 32 A shall allow the conductors to be connected without special preparation.

Compliance is checked by inspection.

NOTE The term "special preparation" covers soldering of the wire of the conductor, use of cable lugs, formation of eyelets, etc., but not the reshaping of the conductor before its introduction into the terminal or the twisting of a flexible conductor to consolidate the end.

8.1.5.5 Terminals shall have adequate mechanical strength. Screws and nuts for clamping the conductors shall have a metric ISO thread or a thread comparable in pitch and mechanical strength.

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

NOTE Provisionally, SI, BA and UN threads can be used as they are virtually equivalent in pitch and mechanical strength to metric ISO threads.

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

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

8.1.5.7 Terminals shall be so designed that they clamp the conductor reliably and between metal surfaces.

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

8.1.5.8 Terminals shall be so designed or positioned that neither a rigid solid conductor nor a wire of a stranded conductor can slip out while the clamping screws or nuts are tightened.

This requirement does not apply to lug terminals.

Compliance is checked by the test of 9.5.4.

8.1.5.9 Terminals shall be so fixed or located that, when the clamping screws or nuts are tightened or loosened, the terminals shall not work loose from their fixings to circuit-breakers.

NOTE 1 These requirements do not imply that the terminals are so designed that their rotation or displacement is prevented, but any movement is to be sufficiently limited so as to prevent non-compliance with the requirements of this standard.

NOTE 2 The use of sealing compound or resin is considered to be sufficient for preventing a terminal from working loose, provided that

– the sealing compound or resin is not subject to stress during normal use, and
– the effectiveness of the sealing compound or resin is not impaired by temperatures attained by the terminal under the most unfavourable conditions specified in this standard.

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

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

Compliance is checked by manual test.

NOTE In general, the designs of terminals (examples of which are shown in Annex F) can provide sufficient esilience to comply with this requirement; for other designs, special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, can be necessary.

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8.1.5.11 Pillar terminals shall allow full insertion and reliable clamping of the conductor.

Compliance is checked by inspection after a rigid conductor of the largest cross-sectional area specified for the relevant rated current in Table 5 has been fully inserted and fully clamped by applying the torques according to Table 11.

8.1.5.12 Screws and nuts of terminals intended for the connection of external conductors shall be in engagement with a metal thread and the screws shall not be the thread cutting type.

Compliance is checked by inspection.

8.1.6 Non-interchangeability

For circuit-breakers intended to be mounted on bases forming a unit therewith (plug-in type or screw-in type) it shall not be possible, without the aid of a tool, to replace a circuit-breaker when mounted and wired as for normal use by another of the same make having a higher rated current.

Compliance is checked by inspection.

NOTE The expression "as for normal use" implies that the circuit-breaker is installed according to the manufacturer's instructions.

8.1.7 Mechanical mounting of plug-in type circuit-breakers

8.1.7.1 General

The mechanical mounting of plug-in type circuit-breakers, the retention of which does not depend solely on their plug-in connection(s), shall be reliable and have adequate stability.

8.1.7.2 Plug-in type circuit-breakers, the retention of which does not depend solely on their plug-in connection(s)

Compliance of the mechanical mounting is checked by the relevant tests of 9.13.

8.1.7.3 Plug-in type circuit-breakers, the retention of which depends solely on their plug-in connection(s)

Compliance of the mechanical mounting is checked by the relevant tests of 9.13.

8.2 Protection against electric shock

Circuit-breakers shall be so designed that, when they are mounted and wired as for normal use (see note in 8.1.6), live parts are not accessible.

A part is considered to be "accessible" if it can be touched by the test finger (see 9.6).

For circuit-breakers other than those of the plug-in type, external parts, other than screws or other means for fixing covers and labels, which are accessible when the circuit-breakers are mounted and wired as for normal use, shall either be of insulating material or be lined throughout with insulating material, unless the live parts are within an internal enclosure of insulating material.

Linings shall be fixed in such a way that they are not likely to be lost during installation of the circuit-breakers. They shall have adequate thickness and mechanical strength and shall provide adequate protection at places where sharp edges occur.

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Inlet openings for cables or conduits shall either be of insulating material or be provided with bushings or similar devices of insulating material. Such devices shall be reliably fixed and shall have adequate mechanical strength.

For plug-in circuit-breakers, external parts other than screws or other means for fixing covers, which are accessible in normal conditions of use, shall be of insulating material.

Metallic operating means shall be insulated from live parts and their exposed conductive parts shall be covered by insulating material. This requirement does not apply to means for coupling insulated operating means of several poles.

It shall be possible to replace plug-in circuit-breakers easily without touching live parts.

Lacquer or enamel are not considered to provide adequate insulation for the purpose of this subclause.

Compliance is checked by inspection and by the test of 9.6.

8.3 Dielectric properties and isolating capability

8.3.1 General

Circuit-breakers shall have adequate dielectric properties and shall ensure isolation.

8.3.2 Dielectric strength at power frequency

Circuit-breakers shall have adequate dielectric properties at power frequency.

Compliance is checked by the tests of 9.7.1, 9.7.2 and 9.7.3 on the circuit-breaker in new condition.

Moreover, after the endurance tests of 9.11 and after the short-circuit tests of 9.12, the circuit-breakers shall withstand the test of 9.7.3 but at the reduced test voltage specified in 9.11.3 and 9.12.12.2 respectively and without the previous humidity treatment of 9.7.1.

8.3.3 Isolating capability

Circuit-breakers shall be suitable for isolation.

Compliance is checked by the verification of compliance with the minimum clearances and creepage distances of item 1 of Table 4 and by the tests of 9.7.5.1 and 9.7.5.3.

8.3.4 Dielectric strength at rated impulse withstand voltage (U_{imp})

Circuit-breakers shall adequately withstand impulse voltages.

Compliance is checked by the tests of 9.7.5.2.

8.4 Temperature-rise

8.4.1 Temperature-rise limits

The temperature rises of the parts of a circuit-breaker specified in Table 6, measured under the conditions specified in 9.8.2, shall not exceed the limiting values stated in that table.

The circuit-breaker shall not suffer damage impairing its functions and its safe use.

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Table 6 – Temperature-rise values

Parts [a] [b]	Temperature-rise K
Terminals for external connections [c]	60
External parts liable to be touched during manual operation of the circuit-breaker, including operating means of insulating material and metallic means for coupling insulated operating means of several poles	40
External metallic parts of operating means	25
Other external parts, including that face of the circuit-breaker in direct contact with the mounting surface	60

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

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

c For plug-in type circuit-breakers, the terminals of the base on which they are installed.

8.4.2 Ambient air temperature

The temperature-rise limits given in Table 6 are applicable only if the ambient air temperatures remain between the limits given in 7.2.

8.5 Uninterrupted duty

Circuit-breakers shall operate reliably even after long service.

Compliance is checked by the test of 9.9.

8.6 Automatic operation

8.6.1 Standard time-current zone

The tripping characteristic of circuit-breakers shall be such that they ensure adequate protection of the circuit, without premature operation.

The zone of the time-current characteristic (tripping characteristic) of a circuit-breaker is defined by the conditions and the values stated in Table 7.

This table refers to a circuit-breaker mounted in accordance with the reference conditions (see 9.2) operating at the reference calibration temperature of 30 °C, with a tolerance of $^{+5}_{0}\,°C$.

Compliance is checked by the tests specified in 9.10.

The test may be made at any convenient temperature, the results being referred to 30 °C, using the information given by the manufacturer.

In any case the variation from the test current of Table 7 shall not exceed 1,2 %/ per K of calibration temperature variation.

If the circuit-breakers are marked for a calibration temperature different from 30 °C, they are tested for that different temperature.

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The manufacturer shall be prepared to give information on the variation of the tripping characteristic for calibration temperatures differing from the reference value.

Table 7 – Time-current operating characteristics

Test	Type	Test current	Initial condition	Limits of tripping or non-tripping time	Result to be obtained	Remarks
a	B, C, D	1,13 I_n	Cold [a]	$t \leq 1$ h (for $I_n \leq 63$ A) $t \leq 2$ h (for $I_n > 63$ A)	No tripping	
b	B, C, D	1,45 I_n	Immediately following test a	$t < 1$ h (for $I_n \leq 63$ A) $t < 2$ h (for $I_n > 63$ A)	Tripping	Current steadily increased within 5 s
c	B, C, D	2,55 I_n	Cold [a]	1 s $< t <$ 60 s (for $I_n \leq 32$ A) 1 s $< t <$ 120 s (for $I_n > 32$ A)	Tripping	
d	B C D	3 I_n 5 I_n 10 I_n	Cold [a]	$t \leq 0{,}1$ s	No tripping	Current established by closing an auxiliary switch
e	B C D	5 I_n 10 I_n 20 I_n [b]	Cold [a]	$t < 0{,}1$ s	Tripping	Current established by closing an auxiliary switch

NOTE An additional test, intermediate between c and d, is under consideration for circuit-breakers of type D.

[a] The term "cold" means without previous loading.

[b] 50 I_n for special cases.

8.6.2 Conventional quantities

8.6.2.1 Conventional time

The conventional time is 1 h for circuit-breakers of rated current up to and including 63 A, and 2 h for circuit-breakers of rated current above 63 A.

8.6.2.2 Conventional non-tripping current (I_{nt})

The conventional non-tripping current of a circuit-breaker is 1,13 times its rated current.

8.6.2.3 Conventional tripping current (I_t)

The conventional tripping current of a circuit-breaker is 1,45 times its rated current.

8.6.3 Tripping characteristic

8.6.3.1 General

The tripping characteristic of circuit-breakers shall be contained within the zone defined in 8.6.1.

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