INTERNATIONAL STANDARD

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

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

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scope</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>Normative references</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Terms and definitions</td>
<td>13</td>
</tr>
<tr>
<td>3.1</td>
<td>Devices</td>
<td>13</td>
</tr>
<tr>
<td>3.2</td>
<td>General terms</td>
<td>14</td>
</tr>
<tr>
<td>3.3</td>
<td>Constructional elements</td>
<td>16</td>
</tr>
<tr>
<td>3.4</td>
<td>Conditions of operation</td>
<td>18</td>
</tr>
<tr>
<td>3.5</td>
<td>Characteristic quantities</td>
<td>19</td>
</tr>
<tr>
<td>3.6</td>
<td>Definitions related to insulation co-ordination</td>
<td>23</td>
</tr>
<tr>
<td>4</td>
<td>Classification</td>
<td>25</td>
</tr>
<tr>
<td>4.1</td>
<td>General</td>
<td>25</td>
</tr>
<tr>
<td>4.2</td>
<td>According to the number of poles</td>
<td>25</td>
</tr>
<tr>
<td>4.3</td>
<td>According to the protection against external influences</td>
<td>26</td>
</tr>
<tr>
<td>4.4</td>
<td>According to the method of mounting</td>
<td>26</td>
</tr>
<tr>
<td>4.5</td>
<td>According to the methods of connection</td>
<td>26</td>
</tr>
<tr>
<td>4.5.1</td>
<td>According to the fixation system</td>
<td>26</td>
</tr>
<tr>
<td>4.5.2</td>
<td>According to the type of terminals</td>
<td>26</td>
</tr>
<tr>
<td>4.6</td>
<td>According to the instantaneous tripping current (see 3.5.17)</td>
<td>26</td>
</tr>
<tr>
<td>4.7</td>
<td>According to the $I^2t$ characteristic</td>
<td>26</td>
</tr>
<tr>
<td>5</td>
<td>Characteristics of circuit-breakers</td>
<td>26</td>
</tr>
<tr>
<td>5.1</td>
<td>List of characteristics</td>
<td>26</td>
</tr>
<tr>
<td>5.2</td>
<td>Rated quantities</td>
<td>27</td>
</tr>
<tr>
<td>5.2.1</td>
<td>Rated voltages</td>
<td>27</td>
</tr>
<tr>
<td>5.2.2</td>
<td>Rated current ($I_n$)</td>
<td>27</td>
</tr>
<tr>
<td>5.2.3</td>
<td>Rated frequency</td>
<td>27</td>
</tr>
<tr>
<td>5.2.4</td>
<td>Rated short-circuit capacity ($I_{cn}$)</td>
<td>28</td>
</tr>
<tr>
<td>5.2.5</td>
<td>Rated making and breaking capacity of an individual pole ($I_{cn1}$)</td>
<td>28</td>
</tr>
<tr>
<td>5.3</td>
<td>Standard and preferred values</td>
<td>28</td>
</tr>
<tr>
<td>5.3.1</td>
<td>Preferred values of rated voltage</td>
<td>28</td>
</tr>
<tr>
<td>5.3.2</td>
<td>Preferred values of rated current</td>
<td>29</td>
</tr>
<tr>
<td>5.3.3</td>
<td>Standard values of rated frequency</td>
<td>29</td>
</tr>
<tr>
<td>5.3.4</td>
<td>Values of rated short-circuit capacity</td>
<td>29</td>
</tr>
<tr>
<td>5.3.5</td>
<td>Standard ranges of instantaneous tripping</td>
<td>30</td>
</tr>
<tr>
<td>5.3.6</td>
<td>Standard values of rated impulse withstand voltage ($U_{imp}$)</td>
<td>30</td>
</tr>
<tr>
<td>6</td>
<td>Marking and other product information</td>
<td>30</td>
</tr>
<tr>
<td>7</td>
<td>Standard conditions for operation in service</td>
<td>32</td>
</tr>
<tr>
<td>7.1</td>
<td>General</td>
<td>32</td>
</tr>
<tr>
<td>7.2</td>
<td>Ambient air temperature range</td>
<td>32</td>
</tr>
<tr>
<td>7.3</td>
<td>Altitude</td>
<td>32</td>
</tr>
<tr>
<td>7.4</td>
<td>Atmospheric conditions</td>
<td>33</td>
</tr>
<tr>
<td>7.5</td>
<td>Conditions of installation</td>
<td>33</td>
</tr>
<tr>
<td>7.6</td>
<td>Pollution degree</td>
<td>33</td>
</tr>
<tr>
<td>8</td>
<td>Requirements for construction and operation</td>
<td>33</td>
</tr>
<tr>
<td>8.1</td>
<td>Mechanical design</td>
<td>33</td>
</tr>
</tbody>
</table>
8.1.1 General ................................................................. 33
8.1.2 Mechanism .......................................................... 33
8.1.3 Clearances and creepage distances (see Annex B) .............. 35
8.1.4 Screws, current-carrying parts and connections .................. 37
8.1.5 Terminals for external conductors .................................... 38
8.1.6 Non-interchangeability .................................................. 40
8.1.7 Mechanical mounting of plug-in type circuit-breakers .......... 41
8.2 Protection against electric shock .......................................... 41
8.3 Dielectric properties and isolating capability ......................... 41
  8.3.1 General ................................................................. 41
  8.3.2 Dielectric strength at power frequency ............................. 42
  8.3.3 Isolating capability ...................................................... 42
  8.3.4 Dielectric strength at rated impulse withstand voltage (U_imp) 42
8.4 Temperature-rise .............................................................. 42
  8.4.1 Temperature-rise limits ............................................... 42
  8.4.2 Ambient air temperature .............................................. 42
8.5 Intermittent duty ............................................................... 43
8.6 Automatic operation .......................................................... 43
  8.6.1 Standard time-current zone ........................................... 43
  8.6.2 Conventional quantities ............................................... 44
  8.6.3 Tripping characteristic ................................................. 44
8.7 Mechanical and electrical endurance ..................................... 45
8.8 Performance at short-circuit currents ................................. 45
8.9 Resistance to mechanical shock and impact .......................... 45
8.10 Resistance to heat .......................................................... 45
8.11 Resistance to abnormal heat and to fire .............................. 46
8.12 Resistance to rusting ....................................................... 46
8.13 Power loss ................................................................. 46
9 Tests .................................................................................. 46
  9.1 Type tests and test sequences .......................................... 46
  9.2 Test conditions ............................................................. 47
  9.3 Test of indelibility of marking .......................................... 48
  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 50
  9.6 Test of protection against electric shock .............................. 51
  9.7 Test of dielectric properties .............................................. 52
    9.7.1 Resistance to humidity .............................................. 52
    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 54
    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 ....................................................... 58
    9.8.3 Measurement of the temperature of parts ..................... 58
    9.8.4 Temperature-rise of a part ......................................... 58
    9.8.5 Measurement of power loss ....................................... 58
  9.9 28-day test .................................................................... 58
9.10 Test of tripping characteristic ................................................................. 59
  9.10.1 General ........................................................................................................ 59
  9.10.2 Test of time-current characteristic ............................................................ 59
  9.10.3 Test of instantaneous tripping, of correct opening of the contacts and of the trip-free function ................................................................. 59
  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 ............................ 61
  9.11.1 General test conditions ............................................................................ 61
  9.11.2 Test procedure ....................................................................................... 61
  9.11.3 Condition of the circuit-breaker after test ............................................... 62

9.12 Short-circuit tests ...................................................................................... 62
  9.12.1 General ........................................................................................................ 62
  9.12.2 Values of test quantities ........................................................................... 63
  9.12.3 Tolerances on test quantities .................................................................... 63
  9.12.4 Test circuit for short-circuit performance ............................................... 63
  9.12.5 Power factor of the test circuit ................................................................. 65
  9.12.6 Measurement and verification of $i^2t$ and of the peak current ($I_p$) .... 65
  9.12.7 Calibration of the test circuit ................................................................. 65
  9.12.8 Interpretation of records ........................................................................... 65
  9.12.9 Condition of the circuit-breaker for test .................................................. 66
  9.12.10 Behaviour of the circuit-breaker during short-circuit tests .................... 67
  9.12.11 Test procedure ....................................................................................... 67
  9.12.12 Verification of the circuit breaker after short circuit tests: .................... 72

9.13 Mechanical stresses .................................................................................. 73
  9.13.1 Mechanical shock .................................................................................. 73
  9.13.2 Resistance to mechanical stresses and impact ....................................... 74

9.14 Test of resistance to heat ........................................................................ 77

9.15 Resistance to abnormal heat and to fire ................................................... 78

9.16 Test of resistance to rusting .................................................................... 79

Annex A (informative) Determination of short-circuit power factor .................. 93
  A.1 General ........................................................................................................ 93
  A.2 Method 1 – Determination from d.c. component .......................................... 93
  A.3 Method 2 – Determination with pilot generator ......................................... 93

Annex B (normative) Determination of clearances and creepage distances .... 94
  B.1 General ........................................................................................................ 94
  B.2 Orientation and location of a creepage distance ......................................... 94
  B.3 Creepage distances where more than one material is used ....................... 94
  B.4 Creepage distances split by floating conductive part ................................ 94
  B.5 Measurement of creepage distances and clearances ................................ 94

Annex C (normative) Test sequences and number of samples ......................... 99
  C.1 Test sequences ........................................................................................................ 99
  C.2 Number of samples to be submitted for full test procedure and acceptance criteria ........................................................................................................ 101
  C.3 Number of samples to be submitted for simplified test procedure ............ 101

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 .................................................. 105
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 ............................................................................................................................ 57
Table 16 – Applicability of short-circuit tests ..................................................................... 63
Table 17 – Power factor ranges of the test circuit ................................................................. 65
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 ...... 70
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 ................................................................. 71
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 ........................................................................... 72
Table C.1 – Test sequences ............................................................................................... 100
Table C.2 – Number of samples for full test procedure ........................................................ 101
Table C.3 – Reduction of samples for series of circuit-breakers having different numbers of poles ...................................................................................................................... 103
Table C.4 – Test sequences for a series of circuit-breakers being of different instantaneous tripping classifications .......................................................................................... 104
Table J.1 – Connectable conductors ................................................................................... 124
Table J.2 – Cross-sections of copper conductors connectable to screwless-type terminals ............................................................................................................................. 124
Table J.3 – Pull forces ........................................................................................................ 126
Table K.1 – Informative table on colour code of female connectors in relationship with the cross section of the conductor .................................................................................. 131
Table K.2 – Overload test forces ......................................................................................... 132
Table K.3 – Dimensions of tabs .......................................................................................... 133
Table K.4 – Dimensions of female connectors ..................................................................... 136
Table L.1 – Marking for terminals ........................................................................................ 138
Table L.2 – Connectable cross-sections of aluminium conductors for screw-type terminals .............................................................................................................................. 139
Table L.3 – List of tests according to the material of conductors and terminals ................ 140
Table L.4 – Connectable conductors and their theoretical diameters ................................ 140
Table L.5 – Cross sections ($S$) of aluminium test conductors corresponding to the rated currents ......................................................................................................................... 141
Table L.6 – Test conductor length ........................................................................................ 142
Table L.7 – Equalizer and busbar dimensions ..................................................................... 142
Table L.8 – Test current as a function of rated current ........................................................ 144
Table L.9 – Example of calculation for determining the average temperature deviation $D$... 144
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.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

<table>
<thead>
<tr>
<th>FDIS</th>
<th>Report on voting</th>
</tr>
</thead>
<tbody>
<tr>
<td>23E/881/FDIS</td>
<td>23E/894/RVD</td>
</tr>
</tbody>
</table>

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

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

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 this publication will remain unchanged until the stability date indicated on the IEC website 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.

A bilingual version of this publication may be issued at a later date.
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.

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 for not being maintained.

They are intended for use in an environment with pollution degree 2.

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.

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 co-ordination 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.

For an environment with a higher pollution degree, enclosures giving the appropriate degree of protection should be used.
NOTE 1 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 (SCP D) 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*

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


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

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