IEC 60898-3

Edition 1.0 2019-04

INTERNATIONAL STANDARD

Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations –
Part 3: Circuit-breakers for DC operation

IEC 60898-3:2019-04(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org
The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC 60898-3

Edition 1.0 2019-04

INTERNATIONAL STANDARD

Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations –
Part 3: Circuit-breakers for DC operation

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.120.50 ISBN 978-2-8322-6676-2

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

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

Part 3: Circuit-breakers for DC 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 60898-3 has been prepared by sub-committee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

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

FDIS	Report on voting
23E/1122FDIS	23E/1126/RVD

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

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

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.

In this document, the following print types are used:

– Requirements proper: in roman type.

– *Test specifications: in italic type.*

– Explanatory matter: in smaller roman type.

The following differences exist in the countries indicated below.

– 4.7, Note 2: In China, other ranges of instantaneous tripping defined by the manufacturer are allowed.

– Clause 6, Notes 1 and 2: 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 Australia this marking on the circuit-breaker is mandatory but is not required to be visible after installation.

– H.1, Note: In CZ, DK, NL, NO and CH, the upper limit of current for use of screwless terminals is 16 A.

– H.3.3, Note 1 to entry: In the following countries only universal screwless type terminals are accepted: AT, BE, CN, DK, DE, ES, FR, IT, PT and SE.

– Clause I.1, Note: The use of circuit-breakers with flat quick-connect terminations for rated currents up to and including 20 A is accepted in BE, FR, IT, ES, PT and US.

– I.8.2.2, Note 1: The use for rated currents up to and including 20 A is accepted in BE, FR, IT, PT, ES and US.

– Clause J.1, Note: In Austria, Australia and Germany, the use of aluminium screw-type terminals for use with copper conductors is not allowed.

– In Austria and Germany, terminals for aluminium conductors only are not allowed.

– In Spain, the use of aluminium conductors is not allowed for final circuits in household and similar installations e.g. offices, shops.

– In Denmark, the minimum cross-sectional area for aluminium conductors is 16 mm^2.

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

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

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

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

Part 3: Circuit-breakers for DC operation

1 Scope

This part of IEC 60898 applies to DC circuit-breakers, having a rated DC voltage not exceeding 440 V, a rated current not exceeding 125 A and a rated short-circuit capacity not exceeding 10 000 A.

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 in compliance with this document are suitable for use in TN, TT, and, under specific conditions, IT systems.

This document 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 document 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 can be required.

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

This document does not apply to circuit-breakers for AC operation, which is covered by IEC 60898-1.

This document does not apply to circuit-breakers for AC and DC operation, which is covered by IEC 60898-2.

Circuit breakers according to this document have a high resistance against unwanted tripping, regardless whether caused by in-rush currents through loading of electronic loads or by switching operations in the circuit.

NOTE Circuit-breakers within the scope of this document can also be used for protection against electric shock in case of a 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 document 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.

Guidance on the coordination, under short-circuit conditions, between a circuit-breaker and another short-circuit protective device (SCPD) is given in Annex C.

Routine tests intended to reveal, as far as safety is concerned, unacceptable variations in material or manufacture are given in Annex G.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-441, *International Electrotechnical Vocabulary – Switchgear, controlgear and fuses* (available at http://www.electropedia.org)

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

IEC 60228:2004, *Conductors of insulated cables*

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

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

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

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

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

IEC 60695-2-11:2014, *Fire hazard testing – Part 2-11: Glowing/hot-wire based test methods – Glow- wire flammability test method for end-products (GWEPT)*

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Devices

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

[SOURCE: IEC 60050-441:2000, 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 60050-441:2000, 441-14-02, modified – The note has been deleted.]

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 60050-441:2000, 441-18-01, modified – The end of the definition has been changed.]

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

[SOURCE: IEC 60050-441:2000, 441-14-20, modified – "automatically" has been added.]

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

Note 1 to entry: See 3.3.10.8.

3.2 General terms

3.2.1
overcurrent
current exceeding the rated current

[SOURCE: IEC 60050-441:2000, 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
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
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
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
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

3.2.7.1
protected pole
pole provided with an overcurrent release

Note 1 to entry: See 3.3.6.

3.2.7.2
mid-point
common point between two symmetrical circuit elements the opposite ends of which are electrically connected to different line conductors of the same circuit

[SOURCE: IEC 60050-826:2004, 826-14-04]

3.2.7.3
mid-point conductor
conductor electrically connected to the mid-point and capable of contributing to the distribution of electric energy

[SOURCE: IEC 60050-826:2004, 826-14-08]

3.2.7.4
M-pole
pole intended to be connected to the mid-point conductor

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 the air outside the enclosure.

[SOURCE: IEC 60050-441:2000, 441-11-13, modified – "circuit breakers" is used instead of the generic term.]

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

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

[SOURCE: IEC 60050-441:2000, 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
in-rush current
transient current associated with energizing of transformers, cables, capacitor loads, etc.

[SOURCE: IEC 60050-448:1995, 448-11-30, modified – "reactors" has been changed to "capacitor loads".]

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 60050-441:2000, 441-15-08, modified – In the note, "injury" has been changed to "damage".]

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

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
overload release
overcurrent release intended for protection against overloads

3.3.8
conductive part
part which is capable of conducting current although it may not necessarily be used for carrying current in normal service

3.3.9
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.

3.3.10
terminal
conductive part of a device, provided for re-usable electrical connection to external circuits

3.3.10.1
screw-type terminal
terminal for the connection and subsequent disconnection of a conductor or the interconnection of two or more conductors, capable of being dismantled, the connection being made, directly or indirectly, by means of screws or nuts of any kind

3.3.10.2
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 can 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 D, Figure D.1.

[SOURCE: IEC 60050-442:1998, 442-06-22, modified – In Note 1 to entry, "part" has been changed to "clamping element" and Note 2 to entry has been added.]

3.3.10.3
screw terminal
terminal in which the conductor is clamped under the head of the screw and 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 D, Figure D.2.

3.3.10.4
stud terminal
screw-type terminal in which the conductor is clamped under a nut

Note 1 to entry: The clamping pressure can 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 D, Figure D.2.

[SOURCE: IEC 60050-442:1998, 442-06-23, modified – Note 2 to entry has been added.]

3.3.10.5
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 D, Figure D.3.

[SOURCE: IEC 60050-442:1998, 442-06-09, modified – "Terminal" has been changed to "screw-type terminal" and Note 1 to entry has been added.]

3.3.10.6
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 D, Figure D.4.

[SOURCE: IEC 60050-442:1998, 442-06-16, modified – "Screw-type terminal" has been changed to "screw terminal or stud terminal" and Note 1 to entry has been added.]

3.3.10.7
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 60050-442:1998, 442-06-13, modified – The term defined has been changed from "screwless-type clamping unit" to "screwless terminal", "clamping unit" has been changed to "connecting terminal" and the last part of the text has been added.]

3.3.10.8
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.

3.3.11
tapping screw
screw manufactured from a material having a greater resistance to deformation when applied by rotary insertion to a hole in a material having a lesser resistance to deformation

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

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.

3.3.11.1
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.

3.3.11.2
thread-cutting tapping screw
tapping screw having an interrupted thread, the thread being 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 60050-441:2000, 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 60050-441:2000, 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.

3.4.6
DC ripple factor
ratio of half the difference between the maximum and minimum value to the mean value of a pulsating direct current

Note 1 to entry: With low values of the DC ripple factor this quantity is approximately equal to the ratio of the difference to the sum of the maximum and the minimum values.

[SOURCE: IEC 60050-551:1998, 551-17-29, modified – "of a pulsating direct current to the mean value of this current" has been changed to "to the mean value of a pulsating direct current".]

3.5 Characteristic quantities

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 60050-441:2000, 441-17-01, modified – "circuit breakers" is used instead of the generic term and the Note to entry has been changed.]

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 60050-441:2000, 441-17-02, modified – "switching device" has been changed to "circuit-breaker" and "made" has been changed to "established".]

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 60050-441:2000, 441-17-04, modified – In the note, "device" has been changed to "circuit breaker".]

3.5.5
short-circuit making and breaking capacity
prospective current 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 specified 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 specified 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

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 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 60050-441:2000, 441-17-25, modified – modified: "switching device" has been changed to "circuit-breaker", "power frequency" has been deleted in Note 1 to entry and, 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 recovery voltage may be oscillatory or non-oscillatory or a combination of these, depending on the characteristics of the circuit and of the circuit-breaker.

[SOURCE: IEC 60050-441:2000, 441-17-26, modified – The second sentence of Note 1 to entry has been deleted and Note 2 to entry has been deleted.]

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 60050-441:2000, 441-17-37, modified – "or a fuse" and "or that fuse" have been deleted.]

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 60050-441:2000, 441-17-38, modified – "final arc extinction" has been changed to "final extinction".]

3.5.11
time constant
rise time $T = L/R$ (ms) of a prospective direct current to reach a value of 0,632 times the maximum peak current

3.5.12
break time
interval of time between the beginning of the opening time of a circuit-breaker and the end of the arcing time

3.5.13
Joule integral
I^2t
integral of the square of the current over a given time interval

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

3.5.14
I^2t 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

3.5.15
co-ordination between overcurrent protective devices in series

3.5.15.1
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]

3.5.15.2
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 60947-1:2007/AMD2:2014, 2-5-23, modified – "in series" has been added and the note has been deleted.]

3.5.15.3
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]

3.5.15.4
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

[SOURCE: IEC 60947-2:2016, 2.17.2]

3.5.15.5
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 60947-2:2016, 2.17.3]

3.5.15.6
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 C.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 60947-2:2016, 2.17.4]

3.5.15.7
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 60050-441:2000, 441-17-16, modified – Note 1 to entry has been added.]

3.5.15.8
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 document, the short-circuit protective device is generally a circuit-breaker or a fuse.

Note 2 to entry: This definition differs from IEC 60050-441:2000, 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]

3.5.15.9
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

Note 1 to entry: See IEC 60947-1:2007, 4.3.6.4.

3.5.16
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

3.5.17
conventional tripping current
I_t
specified value of current which causes the circuit-breaker to operate within a specified time (conventional time)

3.5.18
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, modified – "other influencing stresses" has been changed to "the influencing stresses" and the note has been deleted.]

3.6.2
working voltage
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, modified – "highest r.m.s. value of the a.c. or d.c. voltage across " has been replaced by "voltage across".]

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, modified – "specified" has been replaced by "specific".]

3.6.5
overvoltage category
numeral defining a transient overvoltage condition

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

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 replaces the existing note.]

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
clearance between open contacts of a pole of a mechanical switching device, meeting the safety requirements specified for isolation purposes

[SOURCE: IEC 60050-441:2000, 441-17-35, modified – "disconnectors" has been changed to "isolation purposes".]

3.6.12
clearance
shortest distance in air between two conductive parts along a string stretched the shortest way between these conductive parts

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.

Note 2 to entry: See Annex A.

[SOURCE: IEC 60050-441:2000, 441-17-31, modified – "the distance" has been changed to "shortest distance in air" and the notes have been added.]

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

Note 1 to entry: See Annex A.

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 60050-151:2001, 151-15-50, modified – "solid" has been deleted from "insulating material" and the Notes 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 two protected poles;
– three-pole circuit-breakers with two protected poles and non-polarized protected M pole.

NOTE 1 The non-polarized M-pole of three-pole circuit-breaker with two protected poles can consist of two polarized factory pre-wired poles.

NOTE 2 Three pole circuit-breakers are intended to protect a distribution system with 2 polarities and a mid-point. See Table 1.

NOTE 3 A pole of a non-polarized breaker can consist of two polarized factory pre-wired poles.

4.3 According to the current direction through the poles

– polarized circuit breaker;
– non-polarized circuit breaker.

4.4 According to the protection against external influences

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

4.5 According to the method of mounting

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

NOTE These types can be intended to be rail mounted.

4.6 According to the methods of connection

4.6.1 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.

4.6.2 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 terminals are given in Annex L.

4.7 According to the instantaneous tripping current (see 3.5.18)

– B-type;
– C-type.

NOTE 1 The selection of a particular type can depend on the installation rules.

NOTE 2 In China, other ranges of instantaneous tripping defined by the manufacturer are allowed.

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);
– current direction (see 4.3)
– protection against external influences (see 4.4);
– method of mounting (see 4.5);

– method of connection (see 4.6);
– value of rated operational voltage (see 5.2.1.1);
– value of rated direct current (see 5.2.2);
– range of instantaneous tripping current (see 4.7 and 5.3.4);
– value of rated short-circuit capacity (see 5.3.3);
– I^2t characteristic (see 3.5.14).

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.

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 value of rated impulse withstand voltage given in 5.3.5.

5.2.2 Rated direct current (I_n)

A rated direct current is the direct 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.

5.2.3 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 16).

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

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

The value of prospective short-circuit current is assigned by the manufacturer on one pole of a two-pole circuit breaker, which the device is designed to make, to carry for its opening time and to break under specified conditions

The standard values are those given in 5.3.3.

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage

The preferred values of rated voltages are given in Table 1.

Table 1 – Preferred values of rated voltage and corresponding supply systems

Circuit breaker	Single pole	Single pole	Two pole	Two pole	Three pole with non-polarized M-pole
Rated voltage of circuit-breaker V	200	200	200	400	400
Maximum supply system voltages V	2-wires 200	3-wires 200/400	2-wires 200	3-wires 200/400	3-wires 200/400
Maximum line to line voltage for IT-systems [a] V	200	200	200	200	200
[a] If not otherwise specified by the manufacturer.					

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 Values of rated short-circuit capacity

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.

5.3.4 Standard ranges of instantaneous tripping

The ranges of instantaneous tripping are given in Table 2.

Table 2 – Ranges of instantaneous tripping

Type	Range for DC
B	Above 4 I_n up to and including 7 I_n
C	Above 7 I_n up to and including 15 I_n

5.3.5 Standard value of rated impulse withstand voltage (U_{imp})

The standard value of the rated impulse withstand voltage (U_{imp}) is 4 kV.

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 with the symbol ⎓;
d) maximum line-to-line voltage for application in IT systems;
e) rated current without symbol "A", preceded by the symbol of instantaneous tripping (B or C), for example B16;
f) marking of polarity, if required (e.g. +, -, M);
g) rated short-circuit capacity for DC in amperes;
h) wiring diagram, unless the correct mode of connection is evident;
i) reference ambient air temperature, if different from 30 °C;
j) degree of protection (only if different from IP20);
k) making and breaking capacity of an individual protected pole of multipole circuit breakers (I_{cn1}), if different from I_{cn}.

If, for small devices, the space available does not allow all the above data to be marked, at least the information under e) shall be marked and visible when the circuit-breaker is installed.

The information under a), b), d), g), i), j) and k) may be marked on the side or on the back of the device and be visible only before the device is installed.

Alternatively, the information under h) may be on the inside of any cover which has to be removed in order to connect the supply wires. Any remaining information not marked shall be given in the manufacturer's literature.

The information under f) shall be placed near the corresponding terminals and visible from the front.

The suitability for isolation, which is provided by all circuit-breakers of this document, may be indicated by the symbol  on the device. When affixed, this marking may be included in a wiring diagram, where it may be combined with symbols of other functions, for example overload protection, or other symbols of technical committee 3 of IEC. 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 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), this shall be specified in the manufacturer's literature.

The manufacturer shall declare in his literature the minimum voltage for which the circuit-breaker is designed.

The manufacturer shall make available, on request, the I^2t characteristic (see 3.5.14).

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 60417-5008:2002-10 and the closed position by the symbol I (a short vertical straight line) IEC 60417-5007:2002-10. 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 60417-5008:2002-10.

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 e), 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 for the protective conductor, if any, shall be indicated by the symbol ⏚ (IEC 60417-5019:2006-08).

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.

7 Standard conditions for operation in service

7.1 General

Circuit-breakers complying with this document 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.

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 according to this document 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.

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 make and break substantially together, whether operated manually or automatically, even if an overload occurs on one protected pole only.

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

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.

For DC circuit breakers with poles consisting of series connected prewired (unpolarized) pole-modules, such “pole-assemblies” are treated as a single pole.

For three pole circuit-breakers, one of the poles shall be a non polarized M-pole. The non-polarized M-Pole may consist of two polarized factory pre-wired poles.

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 complying with requirements of 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, 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 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.

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 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 (see Annex A)

8.1.3.1 General

The minimum required clearances and creepage distances are given in Table 3 which is based on the circuit-breaker being designed for operating in an environment with pollution degree 2.

Parts of PCBs connected to the live parts 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.

NOTE 3 For clearances on printed wiring material, Note 3 in Table F.2 of IEC 60664-1:2007 applies: "For printed wiring material, the values for pollution degree 1 apply except that the value shall not be less than 0,04 mm, as specified in Table F.4." For creepage distances on printed wiring material, distances in Table F.4 in IEC 60664-1:2007 can be used if protected with a coating meeting IEC 60664-3 requirements and tests.

8.1.3.2 Clearances

Compliance for item 1 in Table 3 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 for item 2 and 4 in Table 3 is checked by measurement and, if required, by the tests of 9.7.5.2.

The clearances of items 2 and 4 (except accessible surface 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 for items 2 and 4 is always checked by the test of 9.7.5.2.

NOTE 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 for item 3 in Table 3 is checked by measurement.

8.1.3.3 Creepage distances

Compliance for item 1, 2, 3 and 4 in Table 3 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.

8.1.3.4 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.

Table 3 – 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} 4 kV												
Description/item	200 400	>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]	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]	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]	8,0		3,0	6,0	8,0		3,0	6,0	8,0		3,0	6,0	8,0
		Rated voltage V											
		200 400				200 400				200 400			
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 [b] – metal covers or boxes [b] – other accessible metal parts [c] – metal frames supporting flush-type circuit-breakers	3,0	4,0				3,0				3,0			

Care should be taken to provide adequate clearances and creepage distances between live parts of different polarity of circuit-breakers, e.g. of the plug-in type mounted close to one another. NOTE The parts of the M pole, 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 picked up from the tables. For determination of creepage distances, see Annex A. [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 1mm, provided that the sum of distances is greater than prescribed in item 1 of Table 3.

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.

NOTE 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 8.1.4.4 do not apply to contacts, magnetic circuits, heater elements, bimetals, shunts, electronic components, including circuit boards, or to screws, nuts, washers, clamping plates, similar parts of terminals and parts of the test circuit.

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.

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 H or Annex I, 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 4;

NOTE 1 Examples of possible designs of screw-type terminals are given in Annex D.

- or terminals for external untreated aluminium conductors according to Annex J;
- or with aluminium screw-type terminals for use with copper or with aluminium conductors according to Annex J.

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

Rated current [b] A		Range of nominal cross-section to be clamped [a] mm²	
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 mm² up to 6 mm² 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 mm² up to 50 mm² and shall be in compliance with class 2 of IEC 60228:2004, related to stranded conductors for single-core.

NOTE 2 For AWG copper conductors, see Annex E.

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.

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 9.5.1.

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 9.5.1.

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 sufficiently limited so as to prevent non-compliance with the requirements of this document.

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 document.

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 D) provide sufficient resilience to comply with this requirement; for other designs, special provisions, such as the use of an adequately resilient part which is not likely to be removed inadvertently, can be necessary.

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 4 has been fully inserted and fully clamped by applying the torques according to Table 10.

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 of the tapping screw type.

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 holding in position 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 holding in position 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 holding in position 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 to 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.

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 8.2.

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 properties

Circuit breakers shall have adequate dielectric properties.

Control circuits connected to the main circuit shall not be damaged by high DC voltage due to insulation measurements which are normally carried out after circuit breakers are installed.

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

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 3 and by the tests of 9.7.5.3 and 9.7.5.4.

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 5, 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.

Table 5 – 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 5 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 6.

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 6 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.

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

Table 6 – Time-current operating characteristics

Test	Type	Test current DC	Initial condition	Limits of tripping or non-tripping time	Result to be obtained	Remarks
a	B, C	1,13 I_n	Cold*	$t \leq$ 1 h ($I_n \leq$ 63 A) $t \leq$ 2 h ($I_n >$ 63 A)	No tripping	
b	B, C	1,45 I_n	Immediately following test a	$t <$ 1 h ($I_n \leq$ 63 A) $t <$ 2 h ($I_n >$ 63 A)	Tripping	Current steadily increased within 5 s
c	B, C	2,55 I_n	Cold*	1 s < t < 60 s ($I_n \leq$ 32 A) 1 s < t < 120 s ($I_n >$ 32 A)	Tripping	
d	B C	4 I_n 7 I_n	Cold*	0,1 < t < 45 s ($I_n \leq$ 32 A) 0,1 < t < 90 s ($I_n >$ 32 A) 0,1 < t < 15 s ($I_n \leq$ 32 A) 0,1 < t < 30 s ($I_n >$ 32 A)	Tripping	Current established by closing an auxiliary switch
e	B C	7 I_n 15 I_n	Cold*	t < 0,1 s	Tripping	Current established by closing an auxiliary switch
* The term "cold" means without previous loading, at the reference calibration temperature.						

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.

NOTE Conditions of temperature and mounting different from those specified in 9.2 (e.g. mounting in a special enclosure, grouping of several circuit-breakers in the same enclosure) can affect the tripping characteristic of circuit-breakers.

The manufacturer shall be prepared to give information on the variation of the tripping characteristic for ambient temperatures differing from the reference value, within the limits of 7.2.

8.6.3.2 Effect of single-pole loading of multipole circuit-breakers on the tripping characteristic

When circuit-breakers having more than one protected pole are loaded on only one of the protected poles, starting from cold, with a current equal to

– 1,1 times the conventional tripping current, for two-pole circuit-breakers with two protected poles,
– 1,2 times the conventional tripping current, for three-pole,

the circuit-breakers shall trip within the conventional time specified in 8.6.2.1.

Compliance is checked by the test of 9.10.4.

8.6.3.3 Effect of the ambient air temperature on the tripping characteristic

Ambient temperatures other than the reference temperature, within the limits of –5 °C and +40 °C, shall not unacceptably affect the tripping characteristic of circuit-breakers.

Compliance is checked by the tests of 9.10.5.

8.7 Mechanical and electrical endurance

Circuit-breakers shall be capable of performing an adequate number of cycles with rated current.

Compliance is checked by the test of 9.11.

8.8 Performance at short-circuit currents and at small DC currents

Circuit-breakers shall be capable of performing a specified number of short-circuit operations, during which they shall neither endanger the operator nor initiate a flashover between live conductive parts or between live conductive parts and earth.

Compliance is checked by the tests of 9.12.

It is required that circuit-breakers be able to make and to break any value of current up to and including the value corresponding to the rated short-circuit capacity up to the specified time constant according to 9.12.5. It is also required that the corresponding values of I^2t lie below the I^2t characteristic (see 3.5.14).

If not otherwise specified, the tests are performed at 105 % (±5 %) of the rated operational voltage.

8.9 Resistance to mechanical shock and impact

Circuit-breakers shall have adequate mechanical behaviour so as to withstand the stresses imposed during installation and use.

Compliance is checked by the tests of 9.13.

8.10 Resistance to heat

Circuit-breakers shall be sufficiently resistant to heat.

Compliance is checked by the test of 9.14.

8.11 Resistance to abnormal heat and to fire

External circuit-breaker parts made of insulating material shall not be likely to ignite and to spread fire if current-carrying parts in their vicinity attain a high temperature under fault or overload conditions.

Compliance is checked by inspection and by the test of 9.15.

8.12 Resistance to rusting

Ferrous parts shall be adequately protected against rusting.

Compliance is checked by the test of 9.16.

8.13 Behaviour in case of making inrush current

In the case of making high capacitive load or the load of similar features, circuit-breakers shall be capable of undergoing the effects of inrush currents at the instant of making and without unwanted tripping or welding of contacts.

Compliance is checked by the test of 9.17.

8.14 Power loss

Circuit-breakers shall not have excessive power loss. The maximum permissible values per pole are indicated in Table 7.

Compliance is checked by the test of 9.8.5.

Table 7 – Maximum power loss per pole

Range of rated current I_n A	Maximum power loss per pole W
$I_n \leq 10$	3
$10 < I_n \leq 16$	3,5
$16 < I_n \leq 25$	4,5
$25 < I_n \leq 32$	6
$32 < I_n \leq 40$	7,5
$40 < I_n \leq 50$	9
$50 < I_n \leq 63$	13
$63 < I_n \leq 100$	15
$100 < I_n \leq 125$	20

8.15 Requirement of small DC currents

Circuit breakers shall be capable of performing an adequate number of cycles with low DC current.

Compliance is checked by the test of 9.12.11.2.3.

9 Tests

9.1 Type tests and test sequences

The characteristics of circuit-breakers are verified by means of type tests.

Type tests required by this document are listed in Table 8.

Table 8 – List of type tests

Test	Subclause
Indelibility of marking	9.3
Reliability of screws, current-carrying parts and connections	9.4
Reliability of terminals for external conductors	9.5
Protection against electric shock	9.6
Dielectric properties and isolating capability	9.7
Temperature rise	9.8
28-day test	9.9
Tripping characteristic	9.10
Mechanical and electrical endurance	9.11
Short-circuit	9.12
Resistance to mechanical shock and impact	9.13
Resistance to heat	9.14
Resistance to abnormal heat and to fire	9.15
Resistance to rusting	9.16
Verification of the behaviour in case of making inrush current	9.17

For the purpose of verification of conformity with this document, type tests are carried out in test sequences.

The test sequences and the number of samples to be submitted are stated in Annex B of this document.

Unless otherwise specified, each type test (or sequence of type tests) is carried out on circuit-breakers in a clean and new condition.

9.2 Test conditions

The circuit-breaker is mounted individually, vertically and in free air at an ambient temperature between 20 °C and 25 °C, unless otherwise specified, and is protected against undue external heating or cooling.

Circuit-breakers designed for installation in an individual enclosure are tested in the smallest of such enclosures specified by the manufacturer.

Unless otherwise specified, the circuit-breakers are wired with the appropriate cable specified in Table 9 and are fixed on a dull, black-painted plywood board of about 20 mm thickness, the method of fixing complying with any requirements relating to the means of mounting recommended by the manufacturer.

For circuit-breakers without the marking of polarity, two samples shall be connected in one current direction, the third sample shall be connected in the reversed current direction.

Where a tolerance is not specifically specified, type tests are carried out at values not less severe than those specified in this document.

Unless otherwise specified, DC test voltages and currents shall have a ripple of $\omega \leq$ 5 % or have the minimum instantaneous value no lower than the required test value –5 % and shall have no maximum instantaneous value higher than +10 % of the required test value.

During the tests, no maintenance or dismantling of the samples is allowed.

For the tests of 9.8, 9.9, 9.10 and 9.11, the circuit-breaker is connected as follows.

a) The connections are made by means of single-core, PVC insulated copper cables, according to IEC 60227 (all parts).

b) Unless otherwise specified, the tests are carried out with DC current.

c) The connections are in free air and spaced not less than the distance between the terminals.

d) The minimum length of each temporary connection from terminal to terminal is:

- *1 m for cross-sections up to and including 10 mm^2;*
- *2 m for cross-sections larger than 10 mm^2.*

The tightening torques to be applied to the terminal screws are two-thirds of those specified in Table 10.

Table 9 – Cross-sectional areas (S) of test copper conductors corresponding to the rated currents

S mm²	Values of the rated current I_n A
1	$I_n \leq 6$
1,5	$6 < I_n \leq 13$
2,5	$13 < I_n \leq 20$
4	$20 < I_n \leq 25$
6	$25 < I_n \leq 32$
10	$32 < I_n \leq 50$
16	$50 < I_n \leq 63$
25	$63 < I_n \leq 80$
35	$80 < I_n \leq 100$
50	$100 < I_n \leq 125$

NOTE For AWG copper conductors, see Annex E.

9.3 Test of indelibility of marking

The test is made by rubbing the marking by hand for 15 s with a piece of cotton soaked with water and again for 15 s with a piece of cotton soaked with aliphatic solvent hexane with a content of aromatics of maximum 0,1 % by volume, a kauributanol value of 29, an initial boiling-point of approximately 65 °C, a dry-point of approximately 69 °C and a density of approximately 0,68 g/cm³.

Alternately the following solvent could be used: n-hexane 95 % (Chemical Abstracts Service Registry Number CAS RN: 110-54-3).

NOTE n-hexane 95 % (Chemical Abstracts Service Registry Number CAS RN: 110-54-3) is available from a variety of chemical suppliers as a high pressure liquid chromatography (HPLC) solvent.

Marking made by impression, moulding, or engraving is not subjected to this test.

After this test, the marking shall be easily legible.

The marking shall also remain easily legible after all the tests of this document.

It shall not be easily possible to remove labels and they shall show no curling.

9.4 Test of reliability of screws, current-carrying parts and connections

Compliance with the requirements of 8.1.4 is checked by inspection and, for screws and nuts which are operated when mounting and connecting up the circuit-breaker, by the following test.

The screws or nuts are tightened and loosened

- *ten times for screws in engagement with a thread of insulating material;*
- *five times in all other cases.*

Screws or nuts in engagement with a thread of insulating material are completely removed and reinserted each time.

The test is made by means of a suitable test screwdriver or spanner applying a torque as shown in Table 10.

The screws and nuts shall not be tightened in jerks.

The conductor is moved each time the screw or nut is loosened.

Table 10 – Screw thread diameters and applied torques

Nominal diameter of thread mm	Torque Nm		
	I	II	III
Up to and including 2,8	0,2	0,4	0,4
over 2,8 up to and including 3,0	0,25	0,5	0,5
over 3,0 up to and including 3,2	0,3	0,6	0,6
over 3,2 up to and including 3,6	0,4	0,8	0,8
over 3,6 up to and including 4,1	0,7	1,2	1,2
over 4,1 up to and including 4,7	0,8	1,8	1,8
over 4,7 up to and including 5,3	0,8	2,0	2,0
over 5,3 up to and including 6,0	1,2	2,5	3,0
over 6,0 up to and including 8,0	2,5	3,5	6,0
over 8,0 up to and including 10,0	3,5	4,0	10,0
Column I applies to screws without heads if the screw, when tightened, does not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the diameter of the screw. Column II applies to other screws which are tightened by means of a screwdriver. Column III applies to screws and nuts which are tightened by means other than a screwdriver. Where a screw has a hexagonal head with a slot for tightening with a screwdriver and the values in columns II and III are different, the test is made twice, first applying to the hexagonal head the torque specified in column III and then, on another sample, applying the torque specified in column II by means of a screwdriver. If the values in columns II and III are the same, only the test with the screwdriver is made.			

During the test, the screwed connections shall not work loose and there shall be no damage, such as breakage of screws or damage to the head slots, threads, washers or stirrups, that will impair the further use of the circuit-breaker.

Moreover, enclosures and covers shall not be damaged.

Plug-in connections are tested by plugging the circuit-breaker in and pulling it out five times.

After the test, the connections shall not have become loose nor shall their electrical function be impaired.

9.5 Tests of reliability of screw-type terminals for external copper conductors

9.5.1 *Compliance with the requirements of 8.1.5 is checked by inspection, by the test of 9.4, for which a rigid copper conductor having the largest cross-section specified in Table 4 is placed in the terminal (for nominal cross-sections exceeding 6 mm^2, a rigid stranded conductor is used; for other nominal cross-sections, a solid conductor is used), and by the tests of 9.5.2 and 9.5.3.*

These last tests are made using a suitable test screwdriver or spanner.

9.5.2 *The terminals are fitted with copper conductors of the same type (rigid solid or rigid stranded or flexible) of the smallest and largest cross-sectional as specified in Table 4.*

The terminal shall be suitable for all types of conductors of the same type (rigid – solid or stranded – or flexible), unless otherwise specified by the manufacturer.

The terminal shall be suitable for all types of conductors: rigid (solid or stranded) and flexible, unless otherwise specified by the manufacturer.

Terminals shall be tested with the minimum and maximum cross-section of each type of conductors on new terminals as follows:

– *tests for solid conductors shall use conductors having cross-sections from 1 mm^2 up to 6 mm^2, as applicable;*
– *tests for stranded conductors shall use conductors having cross-sections from 1,5 mm^2 up to 50 mm^2, as applicable;*
– *tests for flexible conductors shall use conductors having cross-sections from 1 mm^2 up to 35 mm^2, as applicable.*

The conductor is inserted into the terminal for the minimum distance specified or, where no distance is specified, until it just projects from the far side, and in the position most likely to assist the wire to escape.

The clamping screws are then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 10.

Each conductor is then subjected to a pull of the value, in Newtons, shown in Table 11. The pull is applied without jerks, for 1 min, in the direction of the axis of the conductor space.

When it is necessary, the tested values, for the different cross-sections with the relevant pulling force, shall be clearly indicated in the test report.

Table 11 – Pulling forces

Cross-section of the conductor inserted in the terminal mm^2	**1 up to and including 4**	**Above 4 up to and including 6**	**Above 6 up to and including 10**	**Above 10 up to and including 16**	**Above 16 up to and including 50**
Pull N	50	60	80	90	100

During the test, the conductor shall not move noticeably in the terminal.

9.5.3 *The terminals are fitted with copper conductors of the smallest and largest cross-sectional areas specified in Table 4, solid or stranded, whichever is the most unfavourable, and the terminal screws are tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 10.*

The terminal screws are then loosened and the part of the conductor which may have been affected by the terminal is inspected.

The conductors shall show no undue damage nor severed wires.

NOTE Conductors are considered to be unduly damaged if they show deep or sharp indentations.

During the test, terminals shall not work loose and there shall be no damage, such as breakage of screws or damage to the head slots, threads, washers or stirrups, that will impair the further use of the terminal.

9.5.4 *The terminals are fitted with the largest cross-sectional areas specified in Table 4, for rigid stranded copper conductor.*

Before insertion in the terminal, the strands of the conductor are suitably reshaped.

The conductor is inserted into the terminal until the conductor reaches the bottom of the terminal or just projects from the far side of the terminal and in the position most likely to permit a strand (or strands) to escape. The clamping screw or nut is then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 10.

After the test, no strand of the conductor shall have escaped outside the retaining device.

9.6 Test of protection against electric shock

This verification is applicable to those parts of circuit breakers which are exposed to the operator when mounted as for normal use.

The test is made with the standard test finger shown in Figure 8, on the sample mounted as for normal use (see note to 8.1.6) and fitted with the conductors of the smallest and largest cross-sectional areas specified in Table 4.

The standard test finger shall be so designed that each of the jointed sections can be turned through an angle of 90° with respect to the axis of the finger, in the same direction only.

The test finger is applied in every possible bending position of a real finger, an electrical contact indicator being used to show contact with live parts.

It is recommended that a lamp be used for the indication of contact and that the voltage be not less than 40 V.

Circuit-breakers with enclosures or covers of thermoplastic material are subjected to the following additional test, which is carried out at an ambient temperature of 35 °C ± 2 °C, the circuit-breakers being at this temperature.

The circuit-breakers are subjected for 1 min to a force of 75 N, applied through the tip of a straight unjointed test finger of the same dimensions as the standard test finger. This finger is applied to all places where yielding of insulating material could impair the safety of the circuit-breaker, but is not applied to knock-outs.

During this test, enclosures or covers shall not deform to such an extent that live parts can be touched with the unjointed test finger.

Unenclosed circuit-breakers having parts not intended to be covered by an enclosure are submitted to the test with a metal front panel, and mounted as for normal use (see 8.1.6).

9.7 Test of dielectric properties

9.7.1 Resistance to humidity

9.7.1.1 Preparation of the circuit-breaker for test

Parts which can be removed without the aid of a tool are removed and subjected to the humidity treatment with the main part; spring lids are kept open during this treatment.

Inlet openings, if any, are left open; if knock-outs are provided, one of them is opened.

9.7.1.2 Test conditions

The humidity treatment is carried out in a humidity cabinet containing air with a relative humidity maintained between 91 % and 95 %.

The temperature of the air in which the sample is placed is maintained within ±1 °C of any convenient value T between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the sample is brought to a temperature between T and $T + 4$ °C.

9.7.1.3 Test procedure

The sample is kept in the cabinet for 48 h.

NOTE 1 A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water having a sufficiently large contact surface with the air.

NOTE 2 In order to achieve the specified conditions within the cabinet constant circulation of the air within is ensured and, in general, a cabinet which is thermally insulated is used.

9.7.1.4 Condition of the circuit-breaker after the test

After this treatment, the sample shall show no damage within the meaning of this document and shall withstand the tests of 9.7.2, 9.7.3, 9.7.4, and 9.7.5.2.

9.7.2 Insulation resistance of the main circuit

The circuit-breaker having been treated as specified in 9.7.1 is then removed from the cabinet.

After an interval between 30 min and 60 min following this treatment, the insulation resistance is measured 5 s after application of a DC voltage of approximately 500 V, in the following order:

a) *with the circuit-breaker in the open position, between each pair of the terminals which are electrically connected together when the circuit-breaker is in the closed position, in turn on each pole;*
b) *with the circuit-breaker in the closed position, in turn between each pole and the others connected together, electronic components connected between current paths being disconnected for the test;*
c) *with the circuit-breaker in the closed position, between all poles connected together and the frame, including a metal foil or part in contact with the outer surface of the housing of insulating material but with the terminal areas kept completely free to avoid flashover between terminals and the metal foil;*
d) *for circuit-breakers with a metal enclosure having an internal lining of insulating material, between the frame and a metal foil in contact with the inner surface of the lining of insulating material including bushings and similar devices.*

The measurements a), b) and c) are carried out after having connected all auxiliary circuits to the frame.

The term "frame" includes:

– *all accessible metal parts and a metal foil in contact with the surfaces of insulating material which are accessible after installation as for normal use;*

– *the surface on which the base of the circuit-breaker is mounted, covered, if necessary, with a metal foil;*

– *screws and other devices for fixing the base to its support;*

– *screws for fixing covers which have to be removed when mounting the circuit-breaker,*

– *metal parts of operating means referred to in 8.2.*

If the circuit-breaker is provided with a terminal intended for the interconnection of protective conductors, this terminal is connected to the frame.

For the measurements according to b), c) and d) , the metal foil is applied in such a way that the sealing compound, if any, is effectively tested.

The insulation resistance shall be not less than

– *2 MΩ for the measurements according to items a) and b);*

– *5 MΩ for the other measurements.*

9.7.3 Dielectric strength of the main circuit

After the circuit-breaker has passed the tests of 9.7.2, the test voltage specified is applied for 1 min between the parts indicated in 9.7.2.

For this test, DC or AC voltage may be used.

NOTE A test performed in AC is deemed to be sufficient to assess the product also for DC.

The test voltage shall have practically sinusoidal waveform, and a frequency between 45 Hz and 65 Hz.

The DC test voltage shall be substantially free of ripple. This requirement is fulfilled if the ratio between the peak values of the voltage and the average value is 1,0 % ± 3 %.

The source of the test voltage shall be capable of supplying a short-circuit current of at least 0,2 A.

No overcurrent tripping device of the transformer shall operate when the current in the output circuit is lower than 100 mA.

The values of the test voltage shall be as follows:

– 2 000 *V AC or 2 830 V DC for items a) to c) of 9.7.2;*

– 2 500 *V AC or 3 535 V DC for item d) of 9.7.2.*

Initially, not more than half the specified voltage is applied, then it is raised to the full value within 5 s.

No flashover or breakdown shall occur during the test.

Glow discharges without drop in the voltage are neglected.

9.7.4 Insulation resistance and dielectric strength of auxiliary circuits

Insulation resistance and dielectric strength shall be verified according to items a), b) and c).

a) *The measurement of the insulation resistance and the dielectric strength tests for the auxiliary circuits are carried out immediately after the measurement of the insulation* *resistance and the dielectric strength tests for the main circuit, under the conditions given in b) and c) below.*

b) *The measurements of the insulation resistance are carried out:*

- *between the auxiliary circuits connected to each other and to the frame;*
- *between each of the parts of the auxiliary circuits which might be isolated from the other parts in normal service and the whole of the other parts connected together, at a voltage of approximately 500 V DC, after this voltage has been applied for 1 min.*

The insulation resistance shall be not less than 2 MΩ.

c) *A substantially sinusoidal voltage at rated frequency is applied for 1 min between the parts listed under b).*

The voltage values to be applied are specified in Table 12.

Table 12 – Test voltage of auxiliary circuits

Rated voltage of auxiliary circuits (AC or DC) V		**Test voltage** V	
Greater than	**Up to and including**	**AC**	**DC**
0	30	600	850
30	50	1 000	1 415
50	110	1 500	2 120
110	250	2 000	2 830
250	500	2 500	3 535

At the beginning of the test, the voltage shall not exceed half the value specified. It is then increased steadily to the full value in not less than 5 s, but not more than 20 s.

During the test, there shall be no flashover or perforation.

NOTE 1 Discharges which do not correspond to a voltage drop are disregarded.

NOTE 2 In the case of circuit breakers in which the auxiliary circuit is not accessible for verification of the requirements given in b), the tests can be made on samples specially prepared by the manufacturer or according to his instructions.

NOTE 3 Auxiliary circuits do not include the control circuit of circuit breakers functionally dependent on line voltage.

NOTE 4 Control circuits other than those of secondary circuit of detection transformers and control circuits connected to the main circuit are submitted to the same tests as the auxiliary circuits.

9.7.5 Verification of impulse withstand voltages (across clearances and across solid insulation) and of leakage current across open contacts

9.7.5.1 General testing procedure for the impulse withstand voltage tests

The impulses are given by a generator producing positive and negative impulses having a front time of 1,2 μs, and a time to half-value of 50 μs, the tolerances being as follow:

- *±5 % for the peak value;*
- *±30 % for the front time;*
- *±20 % for the time to half-value.*

For each test, five positive impulses and five negative impulses are applied. The interval between consecutive impulses being at least 1 s for impulses of the same polarity and being at least 10 s for impulses of the opposite polarity.

When performing the impulse voltage test on a complete circuit-breaker, the attenuation or amplification of the test voltage shall be taken into account. It needs to be ensured that the required value of the test voltage is applied across the terminals of the equipment under test.

The surge impedance of the test apparatus shall have a nominal value of 500 Ω.

In 9.7.5.2, for the verification of clearances within the basic insulation, on a complete circuit-breaker, a very low impedance of the generator is needed for the test. For this purpose, a hybrid generator with a virtual impedance of 2 Ω is appropriate if internal components are not disconnected before testing. However, in any case, a measurement of the correct test voltage directly at the clearance is required.

The shape of the impulses is adjusted with the circuit-breaker under test connected to the impulse generator. For this purpose, appropriate voltage dividers and voltage sensors shall be used.

Small oscillations in the impulses are allowed provided that their amplitude near the peak of the impulse is less than 5 % of the peak value.

For oscillations on the first half of the front, amplitudes up to 10 % of the peak value are allowed.

There shall be no disruptive discharge (sparkover, flashover or puncture) during the tests.

Partial discharges in clearances which do not result in breakdown are disregarded.

NOTE The use of an oscilloscope can be necessary to observe the impulse voltage in order to detect disruptive discharge.

9.7.5.2 Verification of clearances with the impulse withstand voltage

If the measurement of clearances of items 2 and 4 of Table 3 does not show any reduced clearance, this test is not applied.

The test is carried out on a circuit breaker fixed on a metal support and being in the closed position.

The test impulse voltage value shall be chosen in Table 13 in accordance with the rated impulse voltage of the circuit breaker as given in Table 3. These values are corrected for barometric pressure and/or altitude at which the tests are carried out, according to Table 13.

Tests are made applying the impulse voltage between:

– in turn between each pole and the others connected together;
– between all poles connected together and the frame including a metal foil or part in contact with the outer surface of the housing of insulating material but with the terminal areas kept completely free to avoid flashover between terminals and the metal foil;
– for circuit-breakers with a metal enclosure having an internal lining of insulating material, between the frame and a metal foil in contact with the inner surface of the lining of insulating material, including bushings and similar devices.

NOTE 1 The term "frame" is defined in 9.7.2.

Where applicable, the metal foil is applied in such a way that the sealing compound, if any, is effectively tested.

There shall be no disruptive discharge. If, however, only one such disruptive discharge occurs, ten additional impulses having the same polarity as that which caused the disruptive discharge are applied, the connections being the same as those with which the failure occurred.

No further disruptive discharge shall occur.

NOTE 2 The expression " disruptive discharge" is used to cover the phenomena associated with the failure of insulation under electric stress, which include a drop in the voltage and the flowing of current.

Table 13 – Test voltage for verification of impulse withstand voltage

Rated impulse withstand voltage U_{imp} kV	Test voltages at corresponding altitude $U_{1,2/50}$ AC peak kV				
	Sea level	200 m	500 m	1 000 m	2 000 m
4	4,9	4,8	4,7	4,4	4,0

9.7.5.3 Verification of leakage currents across open contacts (suitability for isolation)

Each pole of circuit-breakers having been submitted to the tests of 9.12.11.2, or 9.12.11.3, or 9.12.11.4.2 or 9.12.11.4.3 or 9.12.11.4.4 is supplied at a voltage 1,1 times its rated operational voltage, the circuit-breaker being in the open position.

The leakage current flowing across the open contacts is measured and shall not exceed 2 mA.

9.7.5.4 Verification of resistance of the insulation of open contacts against an impulse voltage (suitability for isolation)

The test impulse voltage values shall be chosen from Table 14, in accordance with the rated voltage of the installation for which the circuit breaker is intended to be used as given in Table 3. These values are corrected for barometric pressure and/or altitude at which the tests are carried out, according to Table 14.

Table 14 – 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

Nominal voltage of the installation V	Test voltages at corresponding altitude $U_{1,2/50}$ AC peak kV				
	Sea level	200 m	500 m	1 000 m	2 000 m
Two wire system 200 V/ Three wire system 200 V, 400 V, 200/400 V	6,2	6,0	5,8	5,6	5,0

The series of tests is carried out on a circuit-breaker fixed on a metal support as in normal use and with the contact in the open position.

The impulses are applied between:

– the line terminals connected together;

– and the load terminals connected together with the contacts in the open position.

There shall be no disruptive discharges during the test.

9.8 Test of temperature rise and measurement of power loss

9.8.1 Ambient air temperature

The ambient air temperature shall be measured during the last quarter of the test period by means of at least two thermometers or thermocouples symmetrically positioned around the circuit-breaker at about half its height and at a distance of about 1 m from the circuit-breaker.

The thermometers or thermocouples shall be protected against draughts and radiant heat.

9.8.2 Test procedure

A current equal to I_n *at any convenient voltage is passed simultaneously through all the poles of the circuit-breaker for a period of time sufficient for the temperature rise to reach the steady-state value or for the conventional time, whichever is the longer.*

In practice, this condition is reached when the variation of the temperature rise does not exceed 1 K/h.

For three-pole circuit-breakers, the test is first made by passing the specified current through the two lines poles only.

The test is then repeated by passing the same current through the pole intended for the connection of the M pole and the adjacent line pole.

With the agreement of the manufacturer, the tests on three-pole circuit-breakers may also be replaced by a single test with all poles in series including the M pole.

During the test, the temperature rises shall not exceed the values shown in Table 5.

9.8.3 Measurement of the temperature of parts

The temperature of the different parts referred to in Table 5 shall be measured by means of fine wire thermocouples or by equivalent means at the nearest accessible position to the hottest spot.

Good heat conductivity between the thermocouple and the surface of the part under test shall be ensured.

9.8.4 Temperature rise of a part

The temperature rise of a part is the difference between the temperature of this part measured in accordance with 9.8.3, and the ambient air temperature measured in accordance with 9.8.1.

9.8.5 Measurement of power loss

A current equal to I_n*, with a supply voltage of a value not less than 30 V, is passed, in a substantially resistive circuit, through each pole of the circuit-breaker.*

NOTE 1 A test voltage of a value less than 30 V can be used subject to the manufacturer's agreement.

The power loss per pole, calculated on the basis of the voltage drop measured under steady state conditions between its terminals, shall not exceed the relevant values given in Table 7.

NOTE 2 The voltage drop measurement can be made during the temperature rise test, provided that the test conditions of 9.8.5 are fulfilled.

9.9 28-day test

The circuit-breaker is subjected to 28 cycles, each cycle comprising 21 h with a current equal to the rated current at an open circuit voltage of at least 30 V, and 3 h without current under the test conditions of 9.2.

NOTE A test voltage of a value less than 30 V can be used subject to the manufacturer's agreement.

The circuit-breaker is in the closed position, the current being established and interrupted by an auxiliary switch. During this test the circuit-breaker shall not trip.

During the last period of current flow, the temperature rise of the terminals shall be measured.

This temperature rise shall not exceed the value measured during the temperature rise test (see 9.8) by more than 15 K.

Immediately after this measurement of the temperature rise, the current is steadily increased within 5 s to the conventional tripping current.

The circuit-breaker shall trip within the conventional time, the conventional tripping current being referred to calibration temperature, using the information given by the manufacturer.

9.10 Test of tripping characteristic

9.10.1 General

This test is made to verify that the circuit-breaker complies with the requirements of 8.6.1.

9.10.2 Test of time-current characteristic

9.10.2.1 A direct current equal to 1,13 I_n (conventional non-tripping current) is passed for the conventional time (see 8.6.1 and 8.6.2.1) through all poles, starting from cold (see Table 6).

The circuit-breaker shall not trip.

The current is then steadily increased within 5 s to 1,45 I_n (conventional tripping current).

The circuit-breaker shall trip within the conventional time.

9.10.2.2 A direct current equal to 2,55 I_n is passed through all poles, starting from cold.

The opening time shall not be less than 1 s and shall not be more than

- *60 s for rated currents up to and including 32 A;*
- *120 s for rated currents greater than 32 A.*

9.10.3 Test of instantaneous tripping, of correct opening of the contacts and of the trip-free function

9.10.3.1 General test conditions

For the lower values of the test current of 9.10.3.2, and 9.10.3.3 respectively, the test is made once, at any convenient voltage with all poles connected in series.

For the upper values of the test current, a time constant of $T \leq 1$ ms, the test is made, on each protected pole, at rated voltage.

The sequence of operation is

$$O - t - CO - t - CO - t - CO$$

the interval t being as defined in 9.12.11.1.

During the whole O operation, the operating means is deliberately held in the closed position. The trip free function shall work properly and the tripping time of the O operation is measured. After tripping the blocked position is abandoned.

In case of circuit-breakers with dependent manual operation, the circuit-breaker shall be operated with an operating speed, during actuation, of 0,1 m/s ± 25 %, this speed being measured where and when the operating means of the test apparatus touches the operating means of the circuit-breaker under test. For rotary knobs, the angular velocity shall correspond substantially to the above conditions, referred to the speed of the operating means (at its extremities) of the circuit-breaker under test.

After each operation all the indicating means shall show the open position of the contacts.

9.10.3.2 For circuit-breakers of the B-type

A direct current equal to 4 I_n is passed through all poles connected in series, starting from cold.

The opening time shall be not less than 0,1 s and not more than:

- *45 s for rated currents up to and including 32 A;*
- *90 s for rated currents above 32 A.*

A direct current equal to 7 I_n is then passed through each pole separately, again starting from cold.

The circuit-breaker shall trip in a time less than 0,1 s.

9.10.3.3 For circuit-breakers of the C-type

A direct current equal to 7 I_n is passed through all poles connected in series, starting from cold.

The opening time shall be not less than 0,1 s and not more than:

- *15 s for rated currents up to and including 32 A;*
- *30 s for rated currents above 32 A.*

A direct current equal to 15 I_n is then passed through each pole separately, again starting from cold.

The circuit-breaker shall trip in a time less than 0,1 s.

9.10.4 Test of effect of single-pole loading on the tripping characteristic of multipole circuit-breakers

Compliance is checked by testing the circuit-breaker connected in accordance with 9.2, under the conditions specified in 8.6.3.2.

The circuit-breaker shall trip within the conventional time (see 8.6.2.1).

9.10.5 Test of effect of ambient temperature on the tripping characteristic

Compliance is checked by the following tests.

a) *The circuit-breaker is placed in an ambient temperature of (35 ± 2) K below the ambient air reference temperature until it has attained steady-state temperature.*

   A current equal to 1,13 I_n (conventional non-tripping current) is passed through all poles for the conventional time. The current is then steadily increased within 5 s to 1,9 I_n.

   The circuit-breaker shall trip within the conventional time.

b) *The circuit-breaker is placed in an ambient temperature of (10 ± 2) K above the ambient air reference temperature until it has attained steady-state temperature.*

   A current equal to I_n is passed through all poles.

The circuit-breaker shall not trip within the conventional time.

9.11 Verification of mechanical and electrical endurance

9.11.1 General test conditions

The circuit-breaker is fixed to a metal support unless it is designed for installation in an individual enclosure, in which case it shall be mounted accordingly, as specified in 9.2.

The test is made at rated voltage, at a current adjusted to the rated current by means of resistors and reactors in series, connected to the load terminals.

If air-core reactors are used, a resistor taking approximately 0,6 % of the current through the reactors is connected in parallel with each reactor.

The direct current shall have a time constant of T = 2 ms (with a tolerance of $^{+15}_{\ 0}$ %).

For single-pole circuit-breakers and for two-pole circuit-breakers with two protected poles, the metal support is connected to one side of the supply for the first half of the total number of operations and to the other side for the second half.

For three-pole circuit-breakers, the metal support is connected to the mid-point of the supply.

The circuit-breaker is connected to the circuit with conductors of the appropriate size indicated in Table 9.

9.11.2 Test procedure

The circuit-breaker is submitted to 1 000 operating cycles with rated current and to 3 000 operating cycles without load.

Each operating cycle consists of a making operation followed by a breaking operation.

For circuit-breakers of rated current up to and including 32 A, the operating frequency shall be 240 operating cycles per hour. During each operating cycle, the circuit-breaker shall remain open for at least 13 s.

For circuit-breakers of rated current above 32 A, the operating frequency shall be 120 operating cycles per hour. During each operating cycle, the circuit-breaker shall remain open for at least 28 s.

For three pole circuit-breakers 3 samples are tested as follows:

- one sample connected between plus and minus poles;
- one sample connected between plus and M-pole;
- one sample connected between minus and M-pole.

In addition, three pole circuit-breakers with non-polarized poles 3 additional samples are tested as follows:

- *one sample connected between plus and minus in the other polarity;*
- *one sample connected between plus and M-pole in the other polarity;*
- *one sample connected between minus and M-pole in the other polarity.*

The circuit-breaker shall be operated as in normal conditions of use.

Care shall be taken that

- *the test apparatus does not damage the circuit-breaker under test;*
- *the free movement of the operating means of the circuit-breaker under test is not impeded;*
- *the speed of the operating means of the test apparatus is not unduly affected by the operating means of the circuit-breaker under test.*

In case of circuit-breakers with dependent manual operation, the circuit-breaker shall be operated with an operating speed, during actuation, of 0,1 m/s ± 25 %, this speed being measured at the extremity when and where the operating means of the test apparatus touches the actuating means of the circuit-breaker under test. For rotary knobs, the angular velocity shall correspond substantially to the above conditions, referred to the speed of the operating means (at its extremities) of the circuit-breaker under test.

9.11.3 Condition of the circuit-breaker after test

Following the test of 9.11.2, the sample shall not show

- *undue wear;*
- *discrepancy between the position of the moving contacts and of the corresponding position of the indicating device;*
- *damage to the enclosure permitting access to live parts by the test finger (see 9.6);*
- *loosening of electrical or mechanical connections;*
- *seepage of sealing compound.*

Moreover, the circuit-breaker shall comply with the test of 9.10.2.2 and shall withstand the dielectric strength test according to 9.7.3, but at a voltage 500 V AC or 707 V DC less than the value specified in 9.7.3 and without previous humidity treatment.

9.12 Short-circuit tests

9.12.1 General

Standard tests for the verification of the short-circuit performance consist of sequences of making and breaking operations, appropriate to the performance to be checked, which are summarized in Table 15.

The short circuit tests shall be performed at a convenient temperature within the range according to 7.2.

All circuit-breakers are tested at 500 A or 10 I_n, whichever is the higher, according to 9.12.11.2 and at 1 500 A according to 9.12.11.3.

Circuit-breakers having a rated short-circuit capacity above 1 500 A are additionally tested

– *at service short-circuit (breaking) capacity (see 3.5.5.2) according to 9.12.11.4.2 and 9.12.12.1; the service short-circuit capacity is obtained by multiplying the rated short-circuit capacity by a factor k, the values of which are given in Table 16;*

– *at rated short-circuit capacity (see 5.2.4) according to 9.12.11.4.3 and to 9.12.12.2 if the factor k is less than 1, in which case new samples shall be used.*

Table 15 – Applicability of tests

Kind of test	Circuit-breaker to be tested	Verification after tests according to subclause
Test at reduced short-circuit currents (9.12.11.2.1)	All circuit-breakers	
Test to verify suitability for IT systems (9.12.11.2.2)	All circuit-breakers	9.12.12.1
Tests at 1 500 A (9.12.11.3)	All circuit-breakers	
Tests at service short-circuit capacity (9.12.11.4.2)	Circuit-breakers with $I_{cn} > 1\,500$ A	9.12.12.1
Tests at rated short-circuit capacity (9.12.11.4.3)	Circuit-breakers with $I_{cn} > I_{cs}$	9.12.12.2
Tests at the making and breaking capacity on an individual pole (9.12.11.4.4)	Multipole circuit-breakers	9.12.12.2
Verification of small DC currents (9.12.11.2.3)	All circuit-breakers	9.12.11.2.3

9.12.2 Values of test quantities

All the tests concerning the verification of the rated short-circuit capacity shall be performed with the values stated by the manufacturer in accordance with the relevant tables of this document.

The value of the applied voltage shall be equal to 105 % of the rated voltage of the circuit-breaker under test.

9.12.3 Tolerances on test quantities

The tests are considered as valid if the values recorded in the test report differ from the values specified within the following tolerances:

– *current* $^{+5}_{0}$ *%*

– *voltage (including recovery voltage): ±5 %*

– *time constant* $^{0}_{-10}$ *%.*

9.12.4 Test circuit for short-circuit performance

Figures 3, 4 and 5 give the diagrams of the circuits to be used for the tests concerning:

– a single-pole circuit-breaker,

– a two-pole circuit-breaker with two protected poles,

– a three-pole circuit-breaker with two protected poles and non-polarized protected M-pole.

The resistances and reactances of the impedances Z and Z_1 shall be adjustable to satisfy the specified test conditions. The reactors shall preferably be air-cored. They shall always be connected in series with the resistors and their value shall be obtained by series coupling of individual reactors; parallel connecting of reactors is permitted when these reactors have practically the same time constant.

Since the transient recovery voltage (see 3.5.8.1) characteristics of test circuits including air-cored reactors are not representative of usual service conditions, the air-cored reactor in any phase shall be shunted by a resistor taking approximately 0,6 % of the current through the reactor.

If iron-core reactors are used, the iron-core power losses of these reactors shall not exceed the losses that would be absorbed by the resistors connected in parallel with the air-cored reactors.

There shall be one and only one point of the test circuit which is earthed; this may be the short-circuit link of the test circuit or the mid-point point of the supply or any other convenient point. In any case, the earthing method shall be stated in the test report.

In each test circuit for testing the rated short-circuit capacity, the impedances Z are inserted between the supply source S and the circuit-breaker under test.

When tests are made with current less than the rated short-circuit breaking capacity, the additional impedances Z_1 shall be inserted on the load side of the circuit-breaker.

For the tests at both the rated and the service short-circuit capacities, the circuit-breaker shall be connected with cables (rigid or flexible) having a length of 0,75 m per pole with the maximum cross-section, corresponding to the rated current, according to the rigid conductor column of Table 4.

When testing a single-pole circuit-breaker or a single pole of multiple circuit breakers, a resistor R2 of about 0,5 Ω is connected in series with the frame and with the copper wire F to the mid-point (M) conductor for approximately half the number of operations of the circuit-breaker, and to the corresponding phase either point C or B for the remaining operations.

When testing a two-pole circuit-breaker with two protected poles or a three-pole circuit-breaker with two protected poles and non-polarized protected M-pole, a resistor R2 of about 0,5 Ω is connected in series with the frame and with the copper wire F to the mid-point conductor (M).

The copper wire F shall be at least 50 mm in length and

– *0,1 mm in diameter for circuit-breakers to be tested in free air, mounted on a metal support,*
– *0,3 mm in diameter for circuit-breakers to be tested in the smallest individual enclosure specified by the manufacturer.*

Resistors R_1 drawing a current of 10 A per phase are connected on the supply side of the circuit-breaker, between the impedances for adjusting the prospective current to the rated short-circuit capacity of the circuit-breaker.

9.12.5 Time constant of the test circuits

If not otherwise specified, the time constant shall be: $T = L / R$ = 5 ms.

9.12.6 Measurement and verification of I^2t and of the peak current (I_p)

The I^2t and I_p values shall be measured during the tests of 9.12.11.2, 9.12.11.3 and 9.12.11.4, with the exception of the case that the instantaneous tripping device does not operate due to too low short-circuit current and the circuit-breaker is operated later on by thermal tripping.

The maximum I^2t values measured shall be recorded in the test report and they shall not exceed the corresponding values of the I^2t characteristic declared by the manufacturer.

9.12.7 Calibration of the test circuit

To calibrate the test circuit, links G, having negligible impedance compared with that of the test circuit, are connected in the positions shown in Figures 3, 4 and 5.

To obtain a prospective current equal to the rated short-circuit capacity of the circuit-breaker at the requested time constant, impedances Z are inserted on the supply side of the links G.

To obtain a test current lower than the rated short-circuit capacity of the circuit breaker, additional impedances Z_1 are inserted on the load side of the links G, as shown in Figures 3, 4 and 5.

9.12.8 Interpretation of records

9.12.8.1 Determination of the applied and recovery DC voltages

The applied voltage and the recovery voltage are determined from the record taken during the break test.

The voltage on the supply side shall be measured after arc extinction and after high frequency phenomena have subsided.

9.12.8.2 Determination of the prospective short-circuit current

The maximum value of the prospective current is indicated as A_2 in Figure 6.

NOTE The value of the prospective current is taken as being equal to the maximum value A_2 as determined from the calibration curve because circuit-breakers according to this document break the current before it has reached its maximum value.

9.12.9 Condition of the circuit-breaker for test

9.12.9.1 General

Circuit-breakers shall be tested in free air according to 9.12.9.2, unless they are designed for use only in enclosures specified by the manufacturer or they are intended for use in individual enclosures only, in which cases they shall be tested according to 9.12.9.3 or, with the agreement of the manufacturer, according to 9.12.9.2.

NOTE An individual enclosure is an enclosure designed to accept one device only.

The circuit-breaker shall be operated manually or by means of a test apparatus, simulating as closely as possible the normal closing operation.

Care shall be taken that

- *the test apparatus does not damage the circuit-breaker under test;*
- *the free movement of the operating means of the circuit-breaker under test is not impeded;*
- *the speed of the operating means of the test apparatus is not unduly affected by the operating means of the circuit-breaker under test.*

In case of circuit-breakers with dependent manual operation, the circuit-breaker shall be operated with an operating speed, during actuation, of 0,1 m/s ± 25 %, this speed being measured where and when the operating means of the test apparatus touches the operating means of the circuit-breaker under test. For rotary knobs, the angular velocity shall correspond substantially to the above conditions, referred to the speed of the operating means (at its extremities) of the circuit-breaker under test.

9.12.9.2 Test in free air

The circuit-breaker under test is mounted as shown in Figure F.1.

The polyethylene foil and the barrier of insulating material specified in Annex F are placed as shown in Figure F.1 for O operations only.

The grid(s) specified in Annex F shall be so positioned that the bulk of the emitted ionized gases passes through the grid(s). The grid(s) shall be placed in the most unfavourable position(s). If the position of the vents is not obvious, or if there are no vents, appropriate information should be provided by the manufacturer.

The grid circuit(s) (see Figure F.3) shall be connected to the points B and C according to the test circuit diagrams of Figures 3, 4 or 5, as applicable.

For the test of single-pole circuit-breakers suitable for 3-wire systems, the grid circuit(s) shall, however, be connected between L+ and L-, to the points B and C' according to the test circuit diagram of Figure 3.

The resistor R′ shall have a resistance of 1,5 Ω. The copper wire F′ (see Figure F.3) shall have a length of 50 mm and a diameter of 0,12 mm for circuit-breakers having a rated voltage of 200 V and 0,16 mm for a circuit-breaker having a rated voltage of 400 V.

For test currents up to and including 1 500 A, the distance "a" shall be 35 mm.

For higher short-circuit currents up to I_{cn}*, the distance "a" may be increased, in which case it shall be chosen from the series (40, 45, 50, 55, ...) mm and stated by the manufacturer.*

For test currents greater than 1 500 A, any additional barriers or insulating means which allow a shorter distance "a" shall also be stated by the manufacturer.

9.12.9.3 Test in enclosures

The test shall be performed with the circuit-breaker placed in an enclosure having the most unfavourable configuration under the most unfavourable conditions. The grid and the barrier of insulating material shown in Figure F.1 are omitted.

NOTE This means that if other circuit-breakers (or other devices) are normally mounted in the direction(s) in which the grid(s) would be placed, these circuit-breakers (or other devices) are installed there. They are supplied as in normal use, but via F′ and R′ as defined in 9.12.9.1 and connected as shown in the appropriate Figure (3, 4 or 5).

In accordance with the manufacturer's instructions, barriers or other means, or adequate clearances may be necessary to prevent ionized gases from affecting the installation.

The polyethylene foil as described in Annex F is placed as shown in Figure F.1 at a distance of 10 mm from the operating means, for O operations only.

9.12.10 Behaviour of the circuit-breaker during short-circuit tests

During the operating sequence of 9.12.11.2 or 9.12.11.3 or 9.12.11.4, the circuit-breaker shall not endanger the operator and shall permit reclosing after the time t as specified in 9.12.11.1, without removing it from the test arrangement.

The polyethylene foil shall show no holes visible with normal or corrected vision without additional magnification.

Furthermore, there shall be no permanent arcing, no flashover between poles or between poles and frame, no melting of the fuse F and, where applicable, of the fuse F′.

9.12.11 Test procedure

9.12.11.1 General

The test procedure consists of a sequence of operations.

The following symbols are used for defining the sequence of operations:

O represents an opening operation;

CO represents a closing operation followed by an automatic opening;

t represents the time interval between two successive short-circuit operations which shall be 3 min or such longer time as may be required by the thermal overcurrent release in order to permit the reclosing of the circuit-breaker. This longer time shall be indicated by the manufacturer.

The actual value of t shall be stated in the test report. If the sample does not allow reclosing after the time indicated by the manufacturer, it is considered as having failed the test.

After arc extinction, the recovery voltage shall be maintained for a duration not less than 0,1 s.

9.12.11.2 Tests at reduced short circuit currents and small DC currents

9.12.11.2.1 Tests at reduced DC short-circuit currents

At direct currents, the test circuit is adjusted so as to obtain a current of 500 A or 10 $\times I_n$ *whichever is the higher, at a time constant corresponding to the assigned time constant.*

Each of the protected poles of the circuit-breaker is subjected separately to a test in a circuit, of which the connections are shown in Figure 3.

The circuit-breaker is caused to open automatically three times, the circuit being closed once by the auxiliary switch A and twice by the circuit-breaker itself.

The sequence of operations shall be:

$$O – t – CO – t – CO$$

9.12.11.2.2 Short-circuit test on circuit-breakers for verifying their suitability for use in IT systems

Single-pole circuit-breakers and each protected pole of multi-pole circuit-breakers are subjected individually to a test in a circuit the connections of which are shown in Figure 3, where the connection M shall be replaced by a connection to a phase. For circuit-breakers with the marking of polarity, it is connected according to the specified polarity. The sequence *of operations shall be O – t – CO. For the O breaking operation, the auxiliary switch A is closed once the voltage is applied.*

The additional impedances Z_1 (see 9.12.7) are adjusted so as to obtain a current of 500 A or 1,2 times the upper limit of the standard range of instantaneous tripping given in Table 2, whichever is the higher, but not exceeding 1 250 A.

If the manufacturer specifies a higher line to line voltage for application in IT-systems according to Clause 6, item d) than provided in Table 1, then 105 % (±5 %) of that line to line voltage shall be applied. In all other cases 105 % (±5 %) of the 200 V according to Table 1 shall be applied.

Furthermore, the test according to 9.12.11.2.3 is performed on single pole circuit-breakers with a rated voltage of 200 V and separately on each pole of a two-pole or three-pole circuit-breaker at a test voltage of 105 % (±5 %) of the line to line voltage for application in IT-systems, as specified by the manufacturer according to Clause 6, item d).

9.12.11.2.3 Verification of small DC currents

The general test conditions shall be as specified in 9.11.1, except the currents, which shall be consecutively adjusted to

1 A, 2 A, 4 A, 8 A, 16 A, 32 A, 63 A and 150 A.

The circuit-breaker is closed three times for each of the test currents listed above. During the test, the operating means is operated as in normal use. If the circuit-breaker does not open, it will be opened manually.

The time interval between the individual operating cycles CO shall be at least 10 s, the closing time shall not exceed 2 s. The time interval between the tests for different currents shall be at least 2 min.

During the test, the time required for the arc to be extinguished shall not exceed 1 s.

9.12.11.3 Test at 1 500 A

For circuit-breakers having a rated short-circuit capacity of 1 500 A or above, the test circuit is calibrated according to 9.12.7 to obtain a current of 1 500 A.

The sequence of operation shall be as specified in 9.12.11.2.1

The circuit breakers are tested in a circuit according to Figure 3, 4 or 5.

9.12.11.4 Test above 1 500 A

9.12.11.4.1 Ratio k between service short-circuit capacity and rated short-circuit capacity

The ratio k between the service short-circuit capacity and the rated short-circuit capacity shall be in accordance with Table 16.

Table 16 – Ratio k between service short-circuit capacity (I_{cs}) and rated short-circuit capacity (I_{cn})

I_{cn}	k
$I_{cn} \leq 6\,000$ A	1
$I_{cn} > 6\,000$ A	0,75 [a]

[a] Minimum value of I_{cs}: 6 000 A.

9.12.11.4.2 Test at service short-circuit capacity (I_{cs})

a) The test circuit is adjusted at DC voltage with a time constant as specified in 9.12.5. Three samples are tested in the same circuit as specified in 9.12.11.3.

When the supply and load terminals of the circuit-breaker under test are not marked, two of the samples are connected in one direction and the third sample in the reverse direction.

b) The sequence of operations is:

O – t – CO – t – CO

One-pole circuit-breakers with a rated voltage of 200 V are tested in a test circuit as shown in Figure 3.

Two-pole circuit-breakers with a rated voltage of 200 V and 400 V are tested in a test circuit as shown in Figure 4.

Three-pole circuit-breakers with a rated voltage of 400 V are tested in a test circuit as shown in Figure 5 but with the M breaker-terminal connected to M-supply.

9.12.11.4.3 Test at rated short-circuit capacity (I_{cn})

For a factor k = 1, this test is omitted.

a) The test circuit is adjusted at DC voltage to a time constant as specified in 9.12.5. Three samples are tested in the same circuit as specified in 9.12.11.3.

When the supply and load terminals of the circuit-breaker under test are not marked, two of the samples are connected in one direction and the third sample in the reverse direction.

b) The sequence of operations is:

O – t – CO

One-pole circuit-breakers with a rated voltage of 200 V are tested in a test circuit as shown in Figure 3.

Two-pole circuit-breakers with a rated voltage of 200 V and 400 V are tested in a test circuit as shown in Figure 4.

Three-pole circuit-breakers with a rated voltage of 400 V are tested in a test circuit as shown in Figure 5 but with the M pole terminal connected to M-supply.

9.12.11.4.4 Test of the one-pole making and breaking capacity (I_{cn1}) of multipole circuit-breakers

The test circuit is adjusted corresponding to 9.12.7 for DC current with a time constant as specified in 9.12.5.

The test is made on each protected pole in accordance with the wiring diagram shown in Figure 3 for a DC voltage of 200 V between line and M.

In addition to that, poles that do not carry the short-circuit current during this test are connected to the other polarity of the supply voltage by means of the corresponding terminals.

The sequence of operations is:

O – t – CO

9.12.12 Verification of the circuit breaker after short circuit tests

9.12.12.1 Verifications after the tests at reduced short-circuit currents, at 1 500 A and at service short-circuit capacity

After the tests according to 9.12.11.2, 9.12.11.3 or 9.12.11.4.2, the circuit-breakers shall show no damage impairing their further use and shall, without maintenance, withstand the following tests.

a) *Leakage current across open contacts, according to 9.7.5.3.*
b) *Dielectric strength tests according to 9.7.3, carried out between 2 h and 24 h after the short-circuit tests at a voltage of 500 V AC or 707 V DC less than the value specified in 9.7.3 and without previous humidity treatment.*

   After the test carried out under the conditions specified in item a) of 9.7.2, it shall be verified that the indicating means show the open position.

   During the test carried out under the conditions specified in item b) of 9.7.2, the indicating means shall show the closed position.
c) *Moreover, after the test of 9.12.11.3 or 9.12.11.4.2, the circuit-breakers shall not trip when a current equal to 0,85 times the conventional non-tripping current is passed through all poles for the conventional time, starting from cold.*

   At the end of this verification, the current is steadily increased, within 5 s, to 1,1 times the conventional tripping current.

   The circuit-breakers shall trip within the conventional time.

9.12.12.2 Verifications after the short-circuit test at rated short-circuit capacity

After the tests according to 9.12.11.4.3 and 9.12.11.4.4, the polyethylene foil shall show no holes visible with normal or corrected vision without additional magnification and the circuit-breakers shall show no damage impairing their further use and shall, without maintenance, withstand the following tests:

a) *Leakage current across open contacts, according to 9.7.5.3.*
b) *Dielectric strength tests according to 9.7.3, carried out between 2 h and 24 h after the short-circuit tests at a voltage of 900 V AC or 1 273 V DC and without previous humidity treatment.*

   After the test carried out under the conditions specified in item a) of 9.7.2, it shall be verified that the indicating means show the open position.

   During the test carried out under the conditions specified in item b) of 9.7.2, the indicating means shall show the closed position.
c) *Moreover, the circuit-breakers shall trip within the time corresponding to the test c of Table 6 when a current equal to 2,8 I_n is passed through all poles, the lower time limit being 0,1 s instead of 1 s.*

9.13 Mechanical stresses

9.13.1 Mechanical shock

9.13.1.1 Test device

The circuit-breaker is subjected to mechanical shocks using an apparatus as shown Figure 7.

A wooden base A is fixed to a concrete block and a wooden platform B is hinged to base A. This platform carries a wooden board C, which can be fixed at various distances from the hinge and in two vertical positions.

The end of board B bears a metal stop-plate D which rests on a coiled spring having a constant of 25 N/mm.

The circuit-breaker is secured to the vertical board in such a way that the distance of the horizontal axis of the sample is 180 mm from the platform, the vertical board being in turn so fixed that the distance of the mounting surface is 200 mm from the hinge, as shown in Figure 7.

On the surface C, opposite the mounting surface of the circuit-breaker, a supplementary mass is fixed so that the static force on the metal stop-plate is 25 N in order to ensure that the moment of inertia of the complete system is substantially constant.

9.13.1.2 Test procedure

With the circuit-breaker in the closed position, but not connected to any electrical source, the platform is lifted at its free end and then allowed to fall 50 times from a height of 40 mm, the interval between consecutive falls being such that the sample is allowed to come to rest.

The circuit-breaker is then secured to the opposite side of the vertical board C and the platform is allowed to fall 50 times as before.

After this test, the vertical board is turned through 90° about its vertical axis and, if necessary, repositioned so that the vertical axis of symmetry of the circuit-breaker is 200 mm from the hinge.

The platform is then allowed to fall 50 times as before, with the circuit-breaker on one side of the vertical board, and 50 times with the circuit-breaker on the opposite side.

Before each change of position, the circuit-breaker is manually opened and closed.

During the tests, the circuit-breaker shall not open.

9.13.2 Resistance to mechanical stresses and impact

9.13.2.1 *Compliance is checked on those exposed parts of the circuit-breaker mounted as for normal use (see note to 8.1.6), which may be subjected to mechanical impact in normal use, by the test of 9.13.2.1 for all types of circuit-breakers and, in addition, by the tests specified in*:

– *9.13.2.3 for screw-in type circuit-breakers;*

– *9.13.2.4 for circuit-breakers intended to be mounted on a rail and for all types of plug-in circuit-breakers designed for surface mounting;*

– *9.13.2.5 for plug-in type circuit-breakers, the holding in position of which depends solely on their connections.*

Circuit-breakers only intended to be totally enclosed are not submitted to this test.

9.13.2.2 *The samples are subjected to blows by means of an impact-test apparatus as shown in Figure 9 to Figure 13.*

The head of the striking element has a hemispherical face of radius 10 mm and is of polyamide having a Rockwell hardness of HR 100.

The striking element has a mass of (150 ± 1) g and is rigidly fixed to the lower end of a steel tube with an external diameter of 9 mm and a wall thickness of 0,5 mm, which is pivoted at its upper end in such a way that it swings only in a vertical plane.

The axis of the pivot is (1 000 ± 1) mm above the axis of the striking element.

For determining the Rockwell hardness of the polyamide of the head of the striking element, the following conditions apply:

– *diameter of the ball: (12,7 ± 0,002 5) mm;*
– *initial load: (100 ± 2) N;*
– *overload: (500 ± 2,5) N.*

NOTE 1 Additional information concerning the determination of the Rockwell hardness of plastics is given in ISO 2039-2.

The design of the test apparatus is such that a force of between 1,9 N and 2,0 N has to be applied to the face of the striking element to maintain the tube in the horizontal position.

Surface-type circuit-breakers are mounted on a sheet of plywood, 8 mm thick and 175 mm square, secured at its top and bottom edges to a rigid bracket, which is part of the mounting support, as shown in Figure 11.

The mounting support shall have a mass of (10 ± 1) kg and shall be mounted on a rigid frame by means of pivots.

The frame is fixed to a solid wall.

Flush-type circuit-breakers are mounted in a device as shown in Figure 12, which in turn is fixed to the mounting support shown in Figure 11.

Panel board type circuit-breakers are mounted in a device as shown in Figure 13, which in turn is fixed to the mounting support shown in Figure 11.

Plug-in type circuit-breakers are mounted complete with the appropriate means for the plug-in connection, which means are fixed on the sheet of plywood for the surface-type, or in the device according to Figure 12 for the flush-type or Figure 13 for the panel-board-type, as applicable.

Screw-in type circuit-breakers are mounted in their appropriate base which is fixed to a mounting plate made of a plywood sheet, 8 mm thick and 175 mm square.

Circuit-breakers for screw fixing are fixed by means of screws.

Circuit-breakers for rail mounting are mounted on their appropriate rail.

Circuit-breakers intended both for screw fixing and for rail mounting shall be fixed with screws for the tests.

The design of the test apparatus is such that

– *the sample can be moved horizontally and turned about an axis perpendicular to the surface of the plywood;*
– *the plywood can be turned about a vertical axis.*

The circuit-breaker is mounted on the plywood or on the appropriate device as for normal use, with covers, if any, so that the point of impact lies in the vertical plane through the axis of the pivot of the pendulum.

Cable entries which are not provided with knock-outs are left open. If they are provided with knock-outs, two of them are opened.

Before applying the blows, fixing screws of bases, covers and the like are tightened with a torque equal to two-thirds of that specified in Table 10.

The striking element is allowed to fall from a height of 10 cm onto surfaces which are exposed when the circuit-breaker is mounted as for normal use.

The height of fall is the vertical distance between the position of a checking point when the pendulum is released and the position of that point at the moment of impact.

The checking point is marked on the surface of the striking element where the line through the point of intersection of the axis of the steel tube of the pendulum and that of the striking element, and perpendicular to the plane through both axes, meets the surface.

NOTE 2 Theoretically, the centre of gravity of the striking element is the checking point. As the centre of gravity is difficult to determine, the checking point is chosen as specified above.

Each circuit-breaker is subjected to ten blows, two of them being applied to the operating means and the remainder being evenly distributed over the parts of the sample likely to be subjected to impacts.

The blows are not applied to knock-out areas or to any openings covered by transparent material.

In general, one blow is applied on each lateral side of the sample after it has been turned as far as possible, but not through more than 60°, about a vertical axis, and two blows are applied, each approximately midway between the blows on a lateral side and the blows on the operating means.

The remaining blows are then applied in the same way, after the sample has been turned through 90° about that of its axes which is perpendicular to the plywood.

If cable entries or knock-outs are provided, the sample is so mounted that the two lines of blows are as nearly as possible equidistant from these entries.

Two blows shall be applied on the operating means as follows: one when the operating means is in the closed position and the other when it is in the open position.

After the test, the samples shall show no damage within the meaning of this document. In particular covers which, when broken, make live parts accessible or impair the further use of the circuit-breaker, operating means, linings and barriers of insulating material and the like, shall not show such damage.

In case of doubt, it shall be verified that removal and replacement of external parts, such as enclosures and covers, is possible without these parts or their lining being damaged.

NOTE 3 Damage to the appearance, small dents which do not reduce the creepage distances or clearances below the values specified in 8.1.3 and small chips which do not adversely affect the protection against electric shock are neglected.

9.13.2.3 *Screw-in type circuit-breakers are screwed home in an appropriate base, a torque of 2,5 Nm being applied for 1 min.*

After the test, the sample shall show no damage impairing its further use.

9.13.2.4 *Circuit-breakers designed to be mounted on a rail are mounted as for normal use, but without cables being connected and without any cover or coverplate, on a rail rigidly fixed on a vertical rigid wall.*

Plug-in circuit-breakers designed for surface mounting are mounted complete with the appropriate means for the plug-in connection but without cables being connected and without any cover-plate.

A downward vertical force of 50 N is applied without jerks for 1 min on the forward surface of the circuit-breaker, immediately followed by an upward vertical force of 50 N for 1 min (see Figure 14).

During this test, the circuit-breaker shall not become loose and after the test, the circuit-breaker shall show no damage impairing its further use.

9.13.2.5 *Plug-in type circuit-breakers, the holding in position of which depends solely on their connections, are mounted, complete with the appropriate plug-in base but without cables being connected and without any cover-plate, on a vertical rigid wall.*

A force of 20 N is applied to the circuit-breaker portion at a point equidistant between the plug-in connections, without jerks for 1 min (see Figure 16).

During this test, the circuit-breaker portion shall not become loose and shall not move from the base portion and after the test both portions shall show no damage impairing their further use.

9.14 Test of resistance to heat

9.14.1 *The samples, without removable covers, if any, are kept for 1 h in a heating cabinet at a temperature of (100 ± 2) °C; removable covers, if any, are kept for 1 h in the heating cabinet at a temperature of (70 ± 2) °C.*

During the test, the samples shall not undergo any change impairing their further use and sealing compound, if any, shall not flow to such an extent that live parts are exposed.

After the test and after the samples have been allowed to cool down to approximately room temperature, there shall be no access to live parts which are normally not accessible when the samples are mounted as for normal use, even if the standard test finger is applied with a force not exceeding 5 N.

After the test, markings shall still be legible.

Discoloration, blisters or a slight displacement of the sealing compound are disregarded, provided that safety is not impaired within the meaning of this document.

9.14.2 *External circuit-breaker parts made of insulating material necessary to retain in position current-carrying parts and parts of the protective circuit are subjected to a ball-pressure test by means of the apparatus shown in Figure 15 except that, where applicable,* *the insulating parts necessary to retain in position the terminals for protective conductors in a box shall be tested as specified in 9.14.3.*

The part to be tested is placed on a steel support with the appropriate surface in the horizontal position and a steel ball of 5 mm diameter is pressed against this surface with a force of 20 N.

The test is made in a heating cabinet at a temperature of (125 ± 2) °C.

After 1 h, the ball is removed from the sample which is then cooled down within 10 s to approximately room temperature by immersion in cold water.

The diameter of the impression caused by the ball is measured and shall not exceed 2 mm.

9.14.3 *External circuit-breaker parts made of insulating material not necessary to retain in position current-carrying parts and parts of the protective circuit, even though they are in contact with them, are subjected to a ball-pressure test in accordance with 9.14.2, but the test is made at a temperature of (70 ± 2) °C, or (40 ± 2) °C plus the highest temperature rise, determined for the relevant part during the test of 9.8, whichever is the higher.*

NOTE 1 For the purpose of the tests of 9.14.2 and 9.14.3, bases of surface-type circuit-breakers are considered as external parts.

NOTE 2 The tests of 9.14.2 and 9.14.3 are not made on parts of ceramic material.

NOTE 3 If two or more of the insulating parts referred to in 9.14.2 and 9.14.3 are made of the same material, the test according to 9.14.2 or 9.14.3, as applicable, is carried out on only one of these parts.

9.15 Resistance to abnormal heat and to fire

The glow-wire test is performed on a complete circuit breaker in accordance with IEC 60695-2-10 under the following conditions:

- *for external parts of circuit-breakers made of insulating material necessary to retain in position current-carrying parts and parts of the protective circuit, by the test made at a temperature of (960 ± 15) °C;*
- *for all other external parts made of insulating material, by the test made at a temperature of (650 ± 10) °C.*

NOTE For the purpose of this test, bases of surface-type circuit-breakers are considered as external parts.

Small parts, where each surface lies completely within a circle of 15 mm diameter, or where any part of the surface lies outside a 15 mm diameter circle and it is not possible to fit a circle of 8 mm diameter on any of the surfaces, are not subjected to the test of 9.15 (see Figure 17 for diagrammatic representation).

If a number of insulating parts is made of the same material, the test is carried out only on one of these parts, according to the appropriate glow-wire test temperature.

The test is not made on parts of ceramic material.

The glow-wire test is applied to ensure that an electrically heated test wire under defined test conditions does not cause ignition of insulating parts, or to ensure that a part of insulating material, which might be ignited by the heated test wire under defined conditions, has a limited time to burn without spreading fire by flame or burning parts or droplets falling down from the tested part. The test is made on three samples, points of application of the glow wire test being different from one sample to another one.

The glow wire cannot be applied directly to terminals area or arc chamber or magnetic tripping device area, where the glow-wire cannot protrude far through the outer surface before *touching either relatively big metal parts or even ceramics, which will cool down the glow-wire quickly and in addition limit the amount of insulating material ever getting in touch with the glow-wire. In this situation the parts ensure minimum severity of the test by cooling down the glow-wire and limiting access to the insulating material under test.*

The sample shall be positioned during the test in the most unfavourable position of its intended use (with the surface tested in a vertical position).

If an internal part of insulation material influences the test with a negative result, it is allowed to remove the relevant identified internal part(s) of insulation material from a new sample. Then, the glow wire test shall be repeated at the same place on this new sample.

In accordance with the manufacturer, it is acceptable as an alternative method to remove the part under examination in its entirety and test it separately (see IEC 60695-2-11:2014, Clause 4).

The sample is regarded as having passed the glow-wire test if

– *either there is no visible flame and no sustained glowing,*
– *or flames and glowing on the sample extinguish themselves within 30 s after the removal of the glow-wire.*

There shall be no ignition of the tissue paper or scorching of the pinewood board.

9.16 Test of resistance to rusting

All grease is removed from the parts to be tested by immersion in a cold chemical degreaser such as methyl-chloroform or refined petrol, for 10 min. The parts are then immersed for 10 min in a 10 % solution of ammonium chloride in water at a temperature of (20 ± 5) °C.

Without drying, but after shaking off any drops, the parts are placed for 10 min in a box containing air saturated with moisture at a temperature of (20 ± 5) °C.

After the parts have been dried for 10 min in a heating cabinet at a temperature of (100 ± 5) °C, their surfaces shall show no signs of rust.

NOTE 1 Traces of rust on sharp edges and any yellowish film removable by rubbing are ignored.

For small springs and the like and for inaccessible parts exposed to abrasion, a layer of grease may provide sufficient protection against rusting. Such parts are only subjected to the test if there is a doubt as to the effectiveness of the grease film, and in such a case the test is made without previous removal of the grease. When using the liquid specified for the test, adequate precautions should be taken to prevent inhalation of the vapour.

9.17 Verification of the behaviour in case of making inrush current

9.17.1 General

Circuit-breakers are subjected to the test for making currents generated by input capacitors in the down-stream load circuit.

9.17.2 Values of the test quantities

All tests regarding the verification of the withstand capacity against making currents shall be carried out using the values stated by the manufacturer in accordance with the relevant requirements of this document.

The value of the voltage applied is the value required to generate the specified recovery voltage.

The value of the recovery voltage (see 3.5.8.1) shall equal 105 % of the rated voltage of the circuit-breaker under test.

9.17.3 Limit deviations of the test quantities

The tests are deemed to be valid if the values of the required characteristics recorded in the test protocol are within the following limit deviations:

- *current* $^{+10}_{\ 0}$ %;
- *voltage (including the recovery voltage):* $^{\ 0}_{-5}$ %.

9.17.4 Test circuit for the determination of the withstand capacity against making currents

Figures 3, 4 and 5 show the wiring diagrams of the circuits used for the respective tests:

- *for single-pole circuit-breakers (Figure 3);*
- *for two-pole circuit-breakers (Figure 4);*
- *three-pole circuit-breaker with two protected poles and non-polarized protected M pole (Figure 5).*

There shall be one and only one point of the test circuit which is earthed; this may be the short-circuit link or the mid-point of the supply or any other convenient point. In any case, the earthing method shall be stated in the test report.

In each test circuit for testing the withstand capacity against making currents, the impedances Z_1 *are inserted on the load side of the circuit-breakers under test.*

For the tests of the withstand capacity against making currents, the circuit-breaker is connected with cables having a length of 0,75 m per pole and the maximum cross-section corresponding to the rated current according to Table 4. It is recommended that a line with a length of 0,5 m be connected on the supply side and of 0,25 m on the load side of the circuit-breaker under test.

A resistor R2 of about 0,5 Ω is connected in series with a copper wire F as follows:

- *for the circuit in Figure 3, between the metal support and the selector switch P. This switch is in one of its two positions for approximately half the number of operations of the circuit-breaker, and in the other position for the remaining operations;*
- *for the circuits in Figures 4 and 5, between the metal support and the mid-point of the supply.*

The copper wire F shall be at least 50 mm in length and

- *0,1 mm in diameter for circuit-breakers to be tested in free air, mounted on a metal support; and*
- *0,3 mm in diameter for circuit-breakers to be tested in the smallest individual enclosure specified by the manufacturer.*

Resistors R_1 *drawing a current of 10 A per phase are connected on the supply side of the circuit-breaker, between the impedances Z for adjusting the peak current value.*

9.17.5 Testing for determination of the withstand capacity against making currents

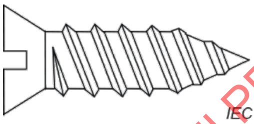
The impedances Z_1, Z (see 9.12.7) are adjusted, as described in Figure 18, so that a current with a peak value of the prospective current shall be adjusted to 350 A $^{0}_{+10}$ % and a load current in the steady state shall not exceed the rated current of the circuit-breaker.

One randomly selected pole of the circuit-breaker shall be subjected to 10 current impulses. The polarity of the impulse current wave shall be reversed after every two current impulses. For polarized poles, the load current shall depend on the polarity and not be reversed. The time interval between two consecutive current impulses shall be approximately 30 s taking care to switch off the current impulses after a making time of 15 s.

The switching sequence is initiated via the auxiliary switch A (see Figures 3, 4, 5):

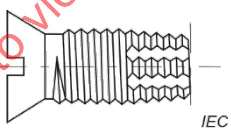
– *5 times by closing the auxiliary switch with the circuit-breaker closed, and*
– *5 times by closing the circuit-breaker with the auxiliary switch closed.*

During the tests, the circuit-breaker shall not trip. After this test, the proper tripping of the circuit-breaker is verified by the test of 9.10.2.



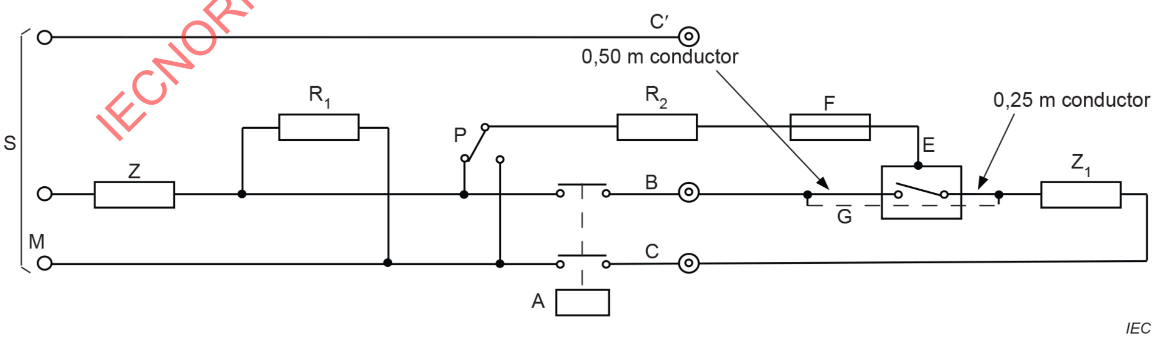
NOTE See 3.3.11.1

Figure 1 – Thread forming tapping screw



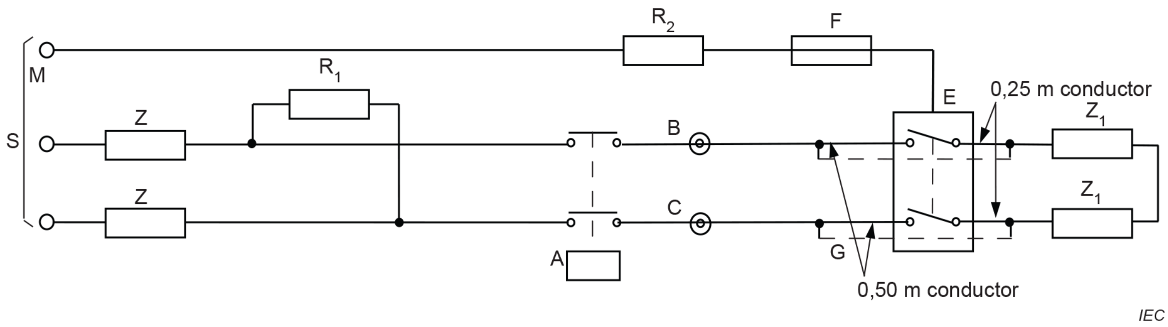
NOTE See 3.3.11.2

Figure 2 – Thread cutting tapping screw



NOTE For an explanation of letter symbols, see the key after Figure 5.

Figure 3 – Single-pole circuit-breaker or pole of multiple circuit breaker



NOTE For an explanation of letter symbols, see the key after Figure 5.

Figure 4 – Two-pole circuit-breaker with two protected poles

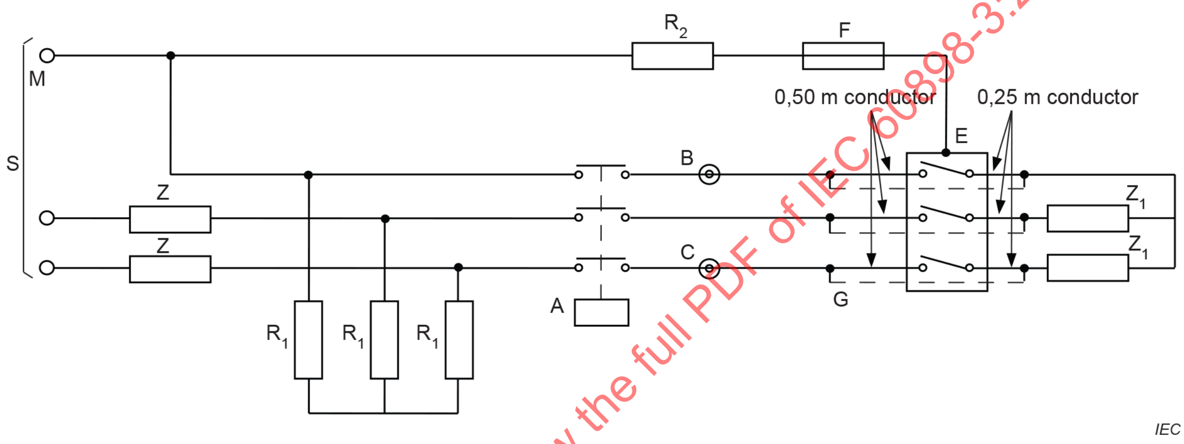


Figure 5 – Three-pole circuit-breaker with two protected poles and non-polarized protected M-pole

Key to Figure 3, Figure 4 and Figure 5

S Supply source

M Mid-point

Z Impedances for adjusting the current to the rated short-circuit capacity

Z_1 Impedances for adjusting the current to values lower than the rated short-circuit capacity

R_1 Resistors

E Enclosure or support

A Making switch for the short-circuit

NOTE In Figure 3 and Figure 4, A can also be a single pole switch.

G Negligible impedance connection for circuit adjustment

R_2 Resistor 0,5 Ω

F Copper wire

P Selector switch

B, C and C’: Points of connection of the grid(s) shown in Annex F (see 9.12.9.2)

Length of cables according to 9.12.4

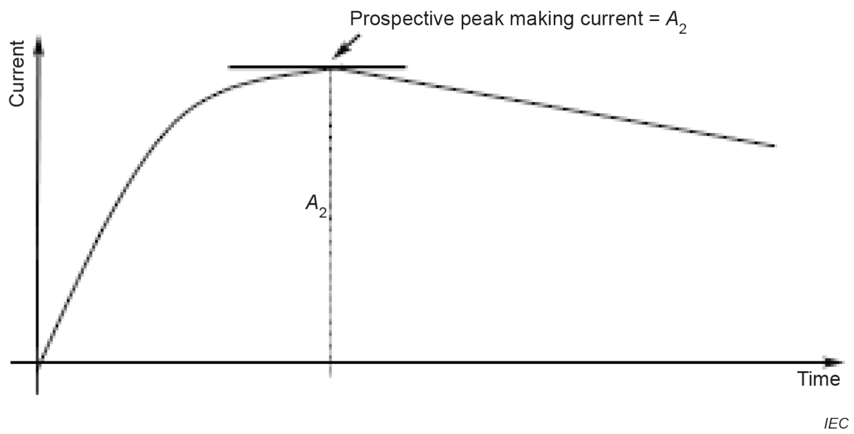
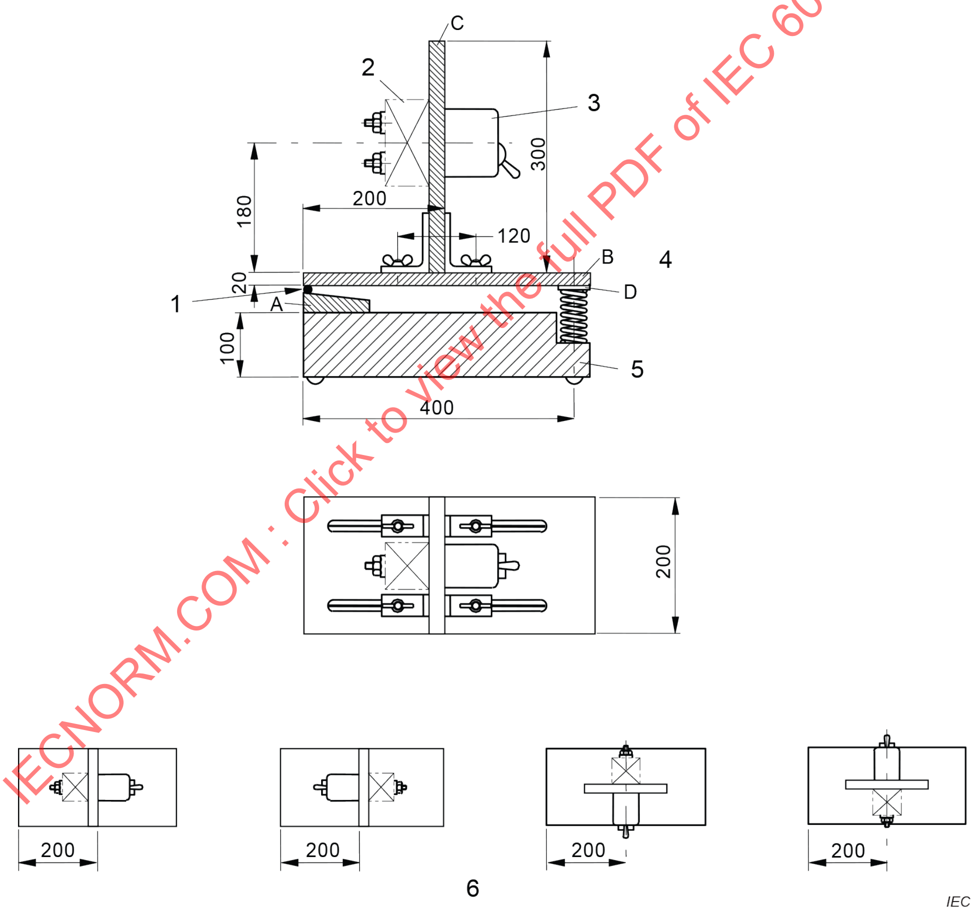


Figure 6 – Calibration of the test circuit in case of direct currents

Dimensions in millimetres



Key

1 Hinge

2 Additional mass

3 Sample

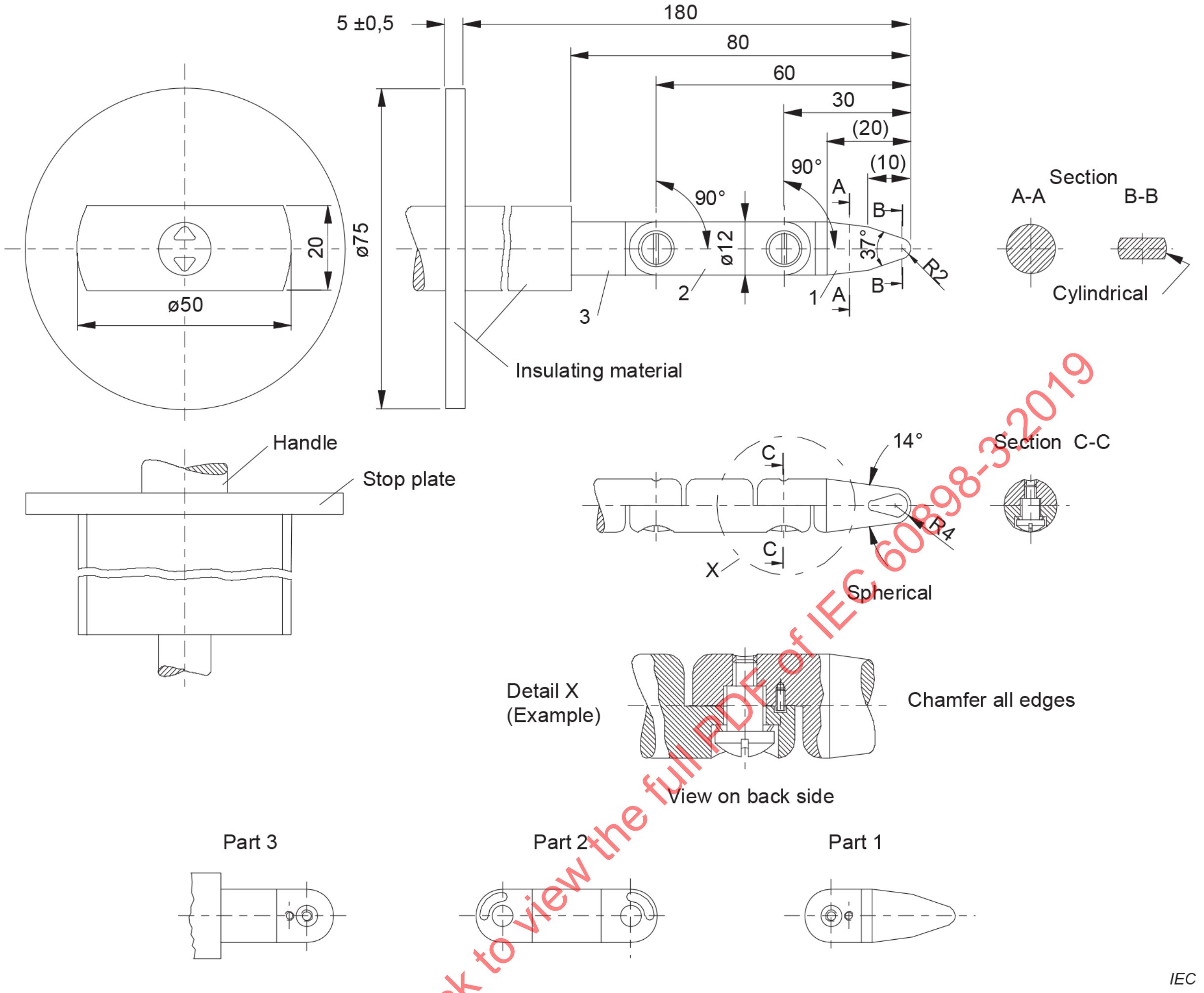
4 Metal stop plate

5 Concrete block

6 Consecutive test positions

Figure 7 –Mechanical shock test apparatus (see 9.13.1)

Dimensions in millimetres



Tolerances on dimensions without specific tolerance

on angles $^{0}_{-10'}$

on linear dimensions:

up to 25 mm $^{0}_{-0,05}$

over 25 mm: ±0,2

Material of finger: e.g. heat-treated steel

Both joints of this finger may be bent through an angle of $90°^{+10°}_{0}$, but in the one and same direction only.

Using the pin and groove solution is only one of the possible approaches in order to limit the bending angle to 90°. For this reason, dimensions and tolerances of these details are not given in the drawing. The actual design shall ensure a 90° bending angle with a 0° to +10° tolerance.

Figure 8 – Standard test finger (see 9.6)

Dimensions in millimetres

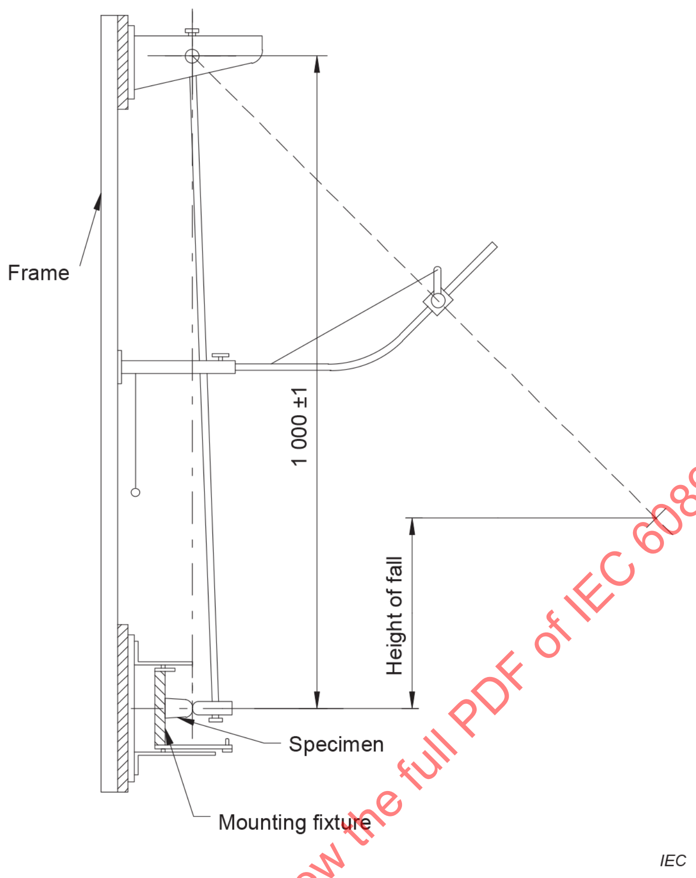
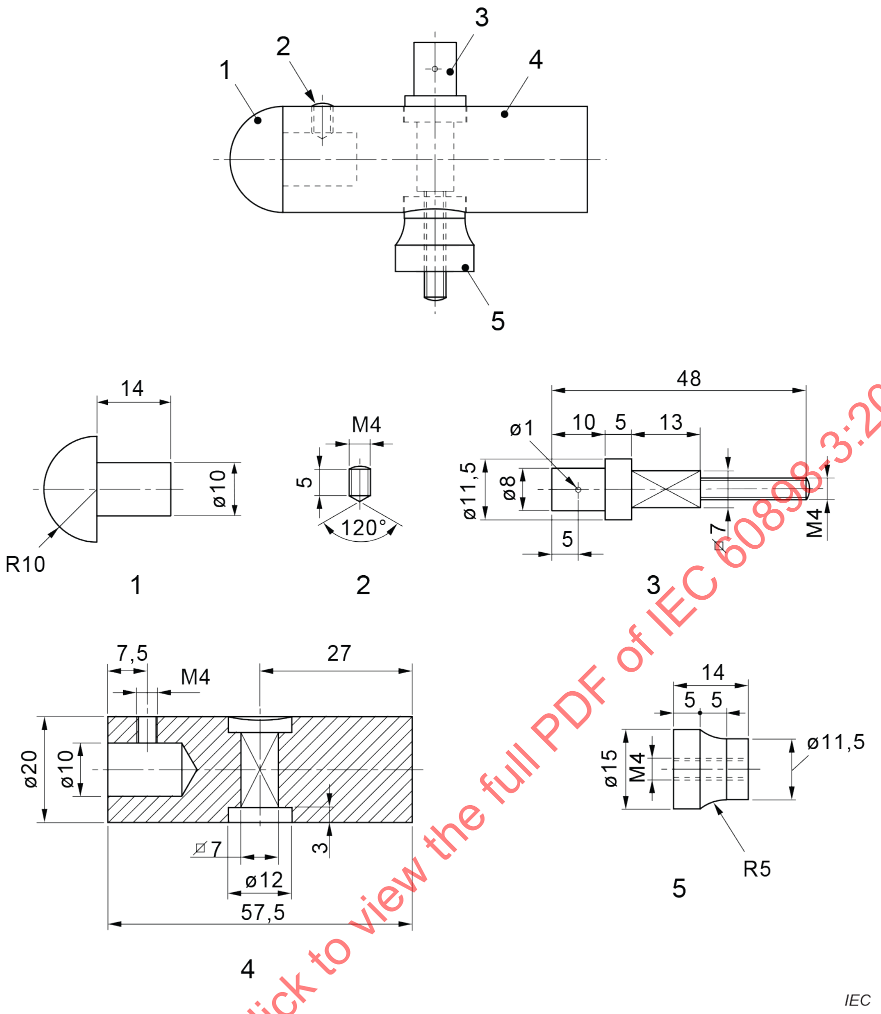


Figure 9 – Mechanical impact test apparatus (see 9.13.2)

Dimensions in millimetres



Material of the parts:

1 polyamide

2,3,4,5 steel Fe 360

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

Dimensions in millimetres

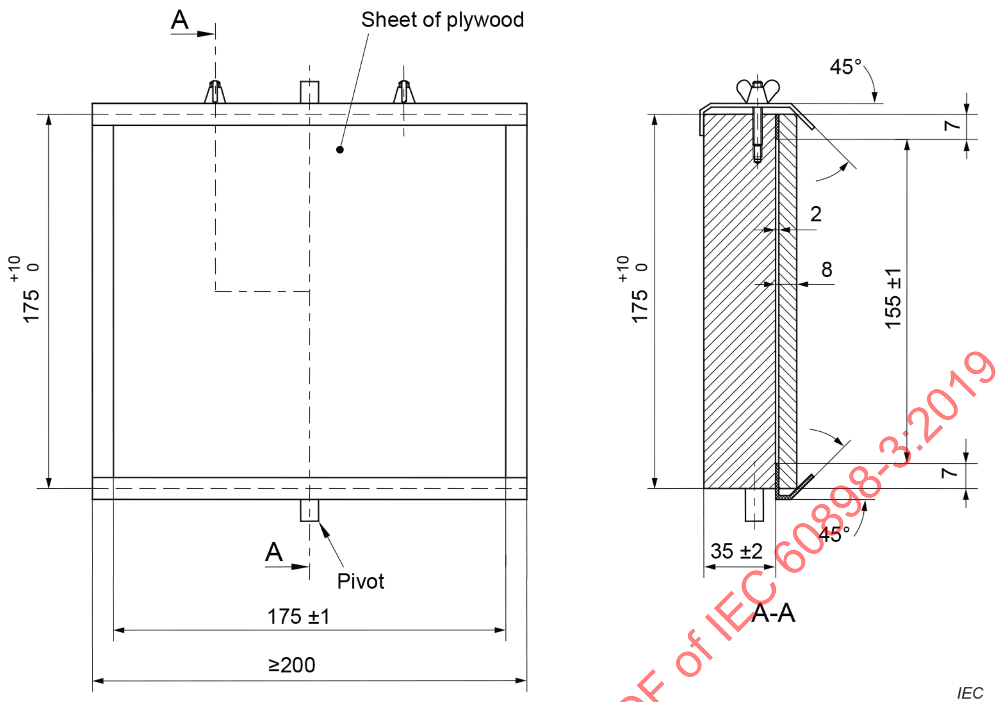
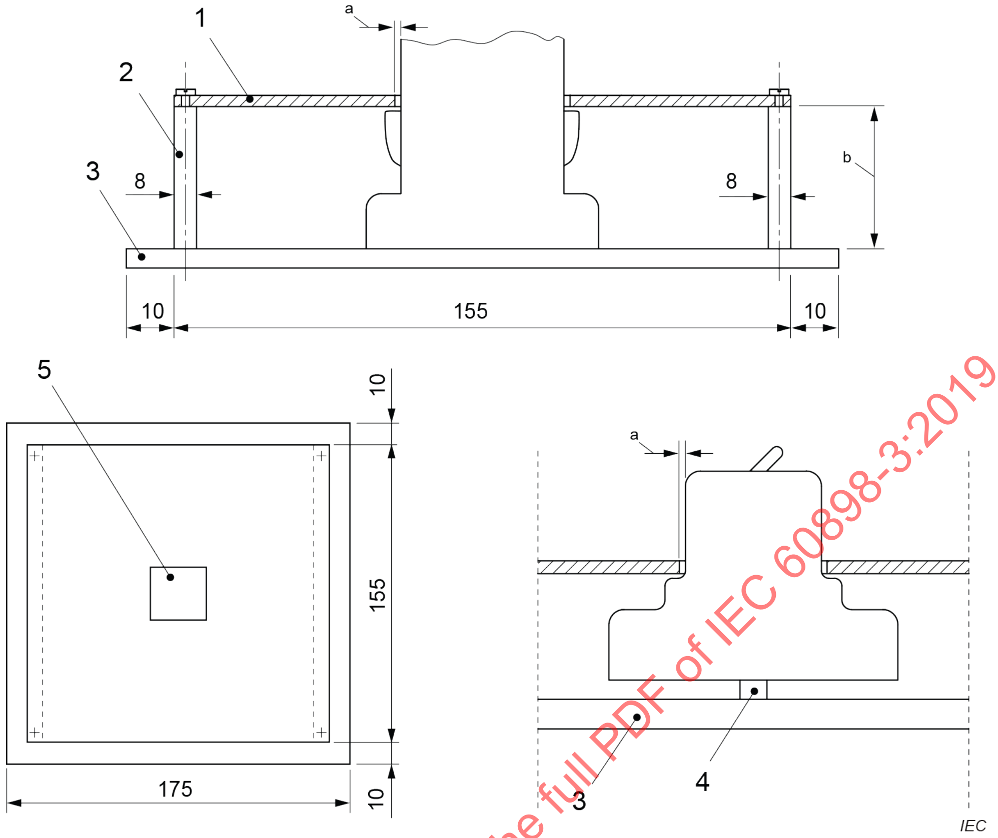


Figure 11 – Mounting support for mechanical impact test (see 9.13.2)

Dimensions in millimetres



Key

1 Interchangeable steel plate with a thickness of 1 mm

2 Aluminium plates with a thickness of 8 mm

3 Mounting plate

4 Rail for circuit-breakers designed for rail mounting

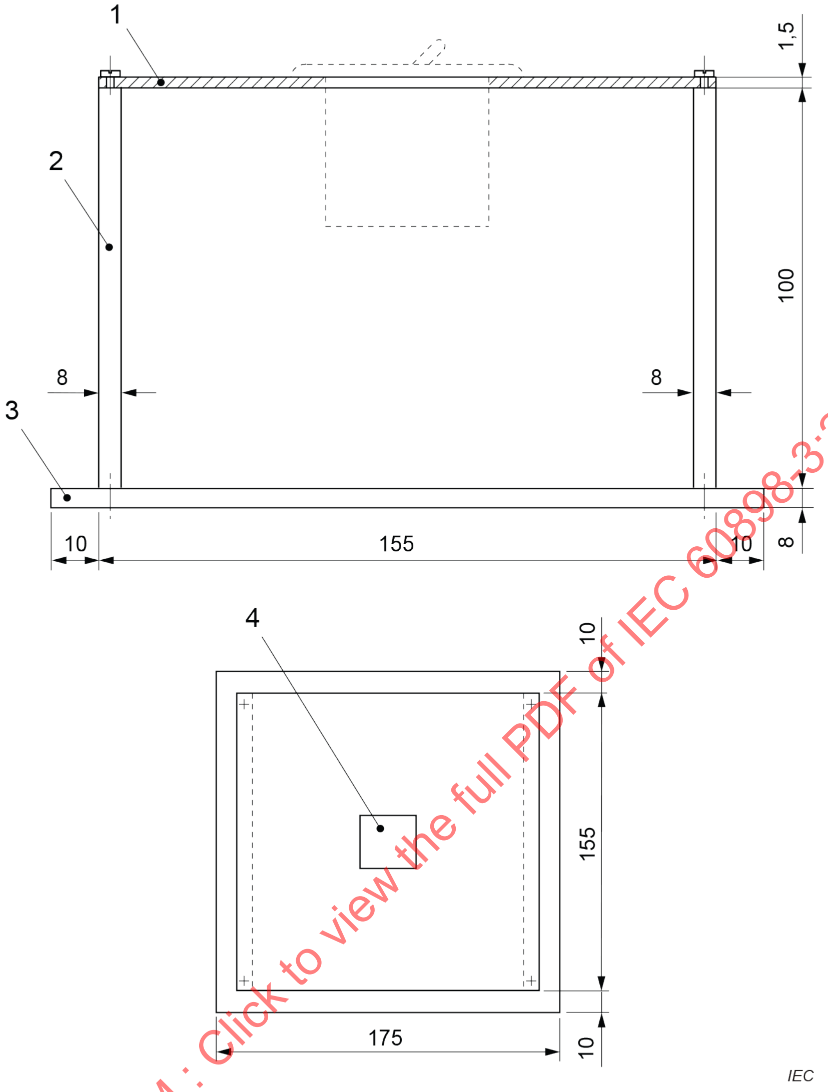
5 Cut-out for the circuit-breaker in the steel plate

a) The distance between the edges of the cut-out and the faces of the circuit-breaker shall be between 1 mm and 2 mm.

b) The height of the aluminium plates shall be such that the steel plate rests on the supports of the circuit-breaker or, if the circuit-breaker has no such support, the distance from live parts, which are to be protected by an additional cover plate, to be on the underside of the steel, is 8 mm.

Figure 12 – Example of mounting for a rear fixed circuit-breaker for mechanical impact test (see 9.13.2)

Dimensions in millimetres



Key

1 Interchangeable steel plate with a thickness of 1,5 mm

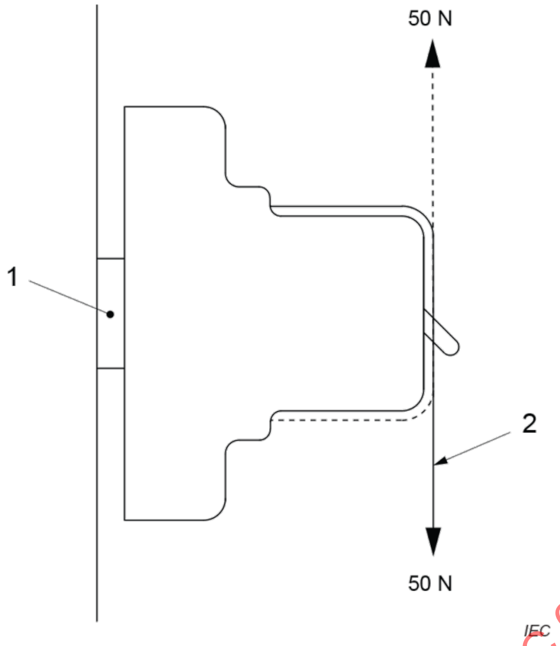
2 Aluminium plates with a thickness of 8 mm

3 Mounting plate

4 Cut-out for the circuit-breaker in the steel plate

NOTE In particular cases, the dimensions can be increased.

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



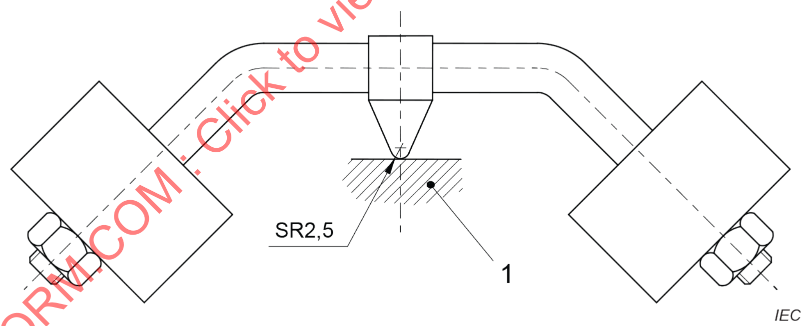
Key

1 Rail

2 Cord

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

Dimensions in millimetres



Key

1 Sample

Figure 15 – Ball-pressure test apparatus

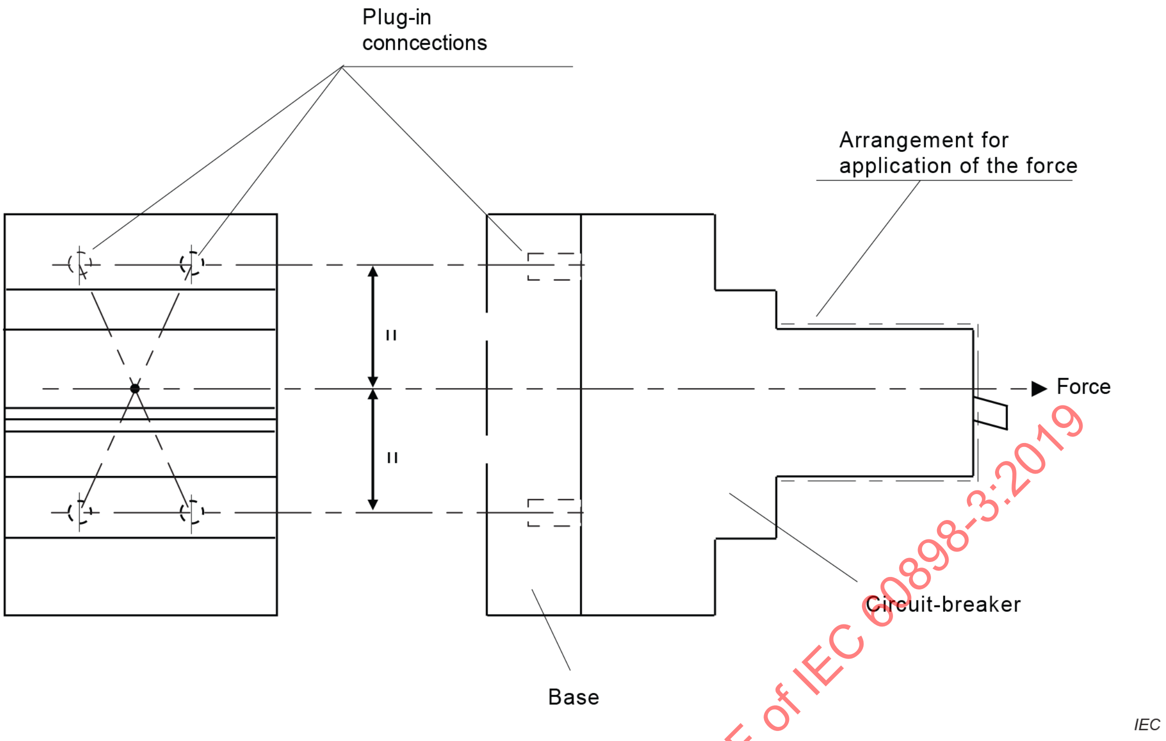


Figure 16 – Example of application of force for mechanical test on two-pole plug-in circuit-breaker, the holding in position of which depends solely on the plug-in connections (see 9.13.2.5)

Dimensions in millimetres

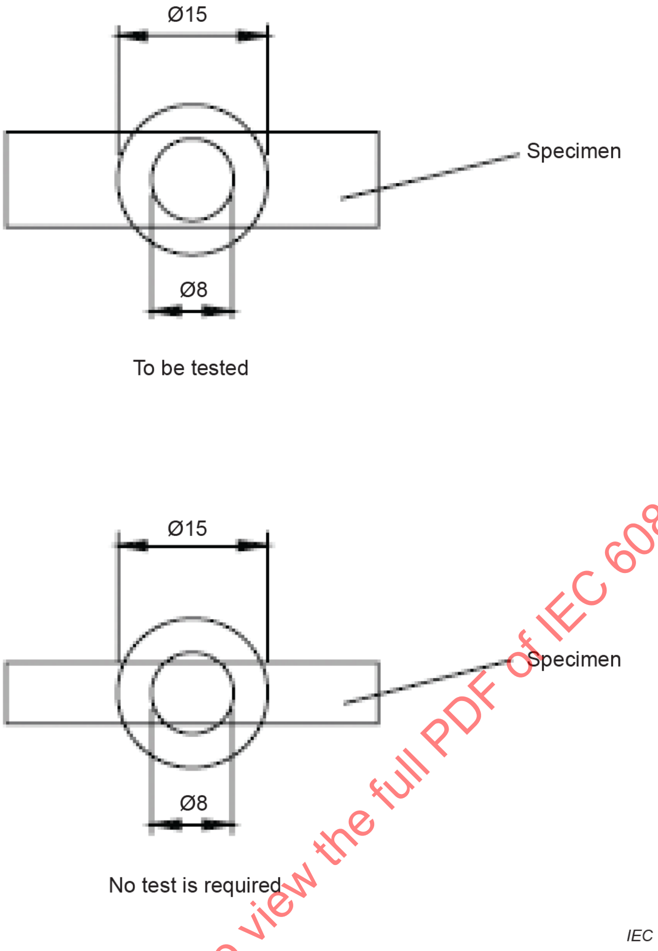
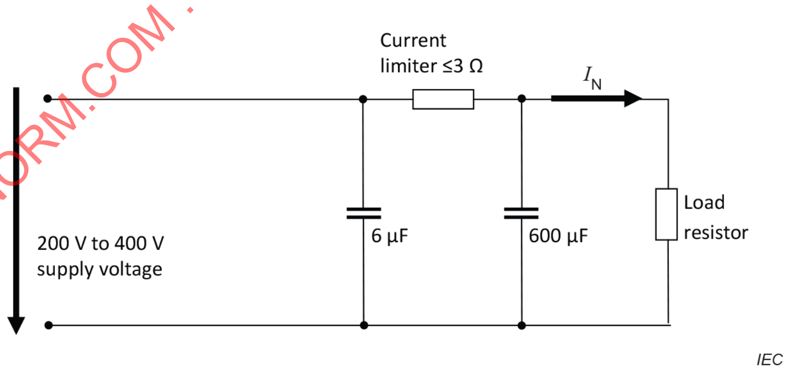


Figure 17 – Diagrammatic representation (see 9.15)



NOTE The capacitors 6µF ±10 % and 600µF ±10 % can also be obtained by capacitors connected in parallel.

Figure 18 – Impedance Z_1 for test circuit in Figures 3, 4 and 5 for the simulation of making currents

Annex A
(normative)

Determination of clearances and creepage distances

A.1 General

In determining clearances and creepage distances, it is recommended that the following points be considered.

A.2 Orientation and location of a creepage distance

If necessary, the manufacturer shall indicate the intended orientation of the equipment or component in order that creepage distances be not adversely affected by the accumulation of pollution for which they were not designed.

A.3 Creepage distances where more than one material is used

A creepage distance may be split in several portions of different materials and/or have different pollution degrees if one of the creepage distances is dimensioned to withstand the total voltage or if the total distance is dimensioned according to the material having the lowest CTI.

A.4 Creepage distances split by floating conductive part

A creepage distance may be split into several parts, made with insulation material having the same CTI, including or separated by floating conductors as long as the sum of the distances across each individual part is equal or greater than the creepage distance required if the floating part did not exist.

The minimum distance X for each individual part of the creepage distance is given in IEC 60664-1:2007, 6.2 (see also Example 11 in Figure A.1).

A.5 Measurement of creepage distances and clearances

In determining creepage distances according to IEC 60664-1, the dimension X, specified in the following examples, has a minimum value of 1,0 mm for pollution degree 2.

If the associated clearance is less than 3 mm, the minimum dimension X may be reduced to one third of this clearance.

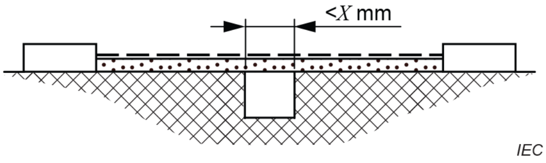
The methods of measuring creepage distances and clearances are indicated in Figure A.1. These cases do not differentiate between gaps and grooves or between types of insulation. The following assumptions are made:

– any recess is assumed to be bridged with an insulating link having a length equal to the specified width X and being placed in the most unfavourable position (see Example 3);

– where the distance across a groove is equal to or larger than the specified width X, the creepage distance is measured along the contours of the groove (see Example 2);

– creepage distances and clearances measured between parts which can assume different positions in relation to each other, are measured when these parts are in their most unfavourable position.

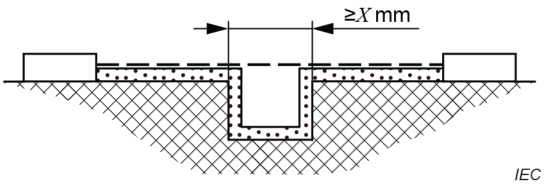
Example 1



Condition: Path under consideration includes a parallel- or converging-sided groove of any depth with a width less than X mm.

Rule: Creepage distance and clearance are measured directly across the groove as shown.

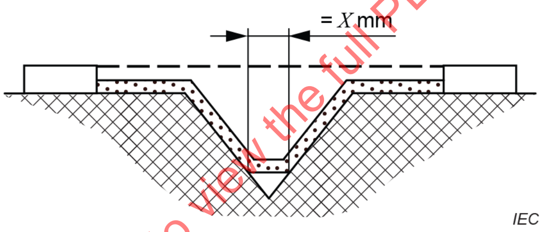
Example 2



Condition: Path under consideration includes a parallel-sided groove of any depth and with a width equal to or more than X mm.

Rule: Clearance is the "line of sight" distance. Creepage path follows the contour of the groove.

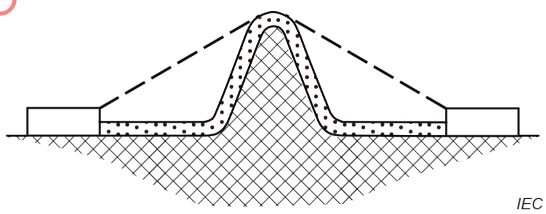
Example 3



Condition: Path under consideration includes a V-shaped groove with a width greater than X mm.

Rule: Clearance is the "line of sight" distance. Creepage path follows the contour of the groove but "short-circuits" the bottom of the groove by X mm link.

Example 4

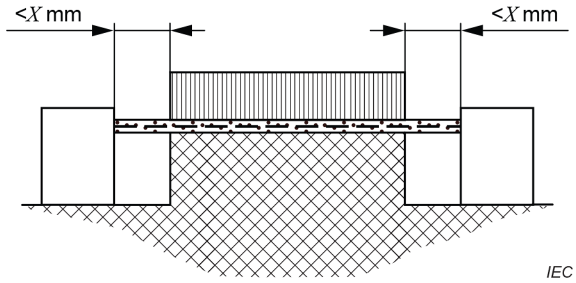


Condition: Path under consideration includes a rib.

Rule: Clearance is the shortest direct air path over the top of the rib. Creepage path follows the contour of the rib.

— — — Clearance   Creepage distance

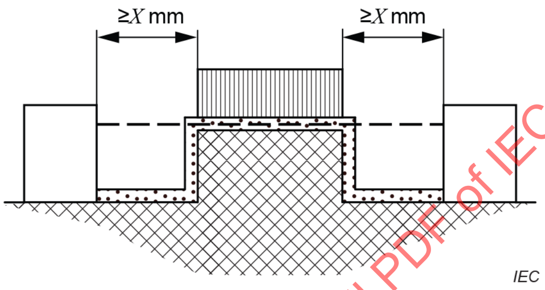
Example 5



Condition: Path under consideration includes an uncemented joint with grooves less than X mm wide on each side.

Rule: Creepage and clearance path is the "line of sight" distance shown.

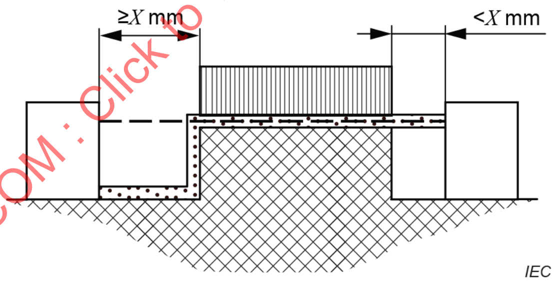
Example 6



Condition: Path under consideration includes an uncemented joint with grooves equal to or more than X mm wide on each side.

Rule: Clearance is the "line of sight" distance. Creepage path follows the contour of the grooves.

Example 7



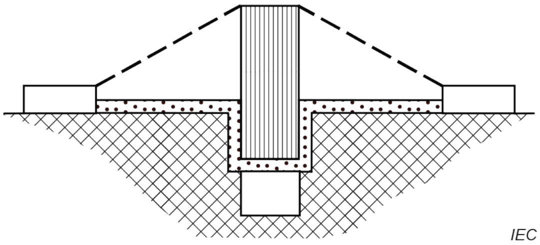
Condition: Path under consideration includes an uncemented joint with a groove on one side less than X mm wide and the groove on the other side equal to or more than X mm wide.

Rule: Clearance and creepage paths area as shown.

— — — Clearance

Creepage distance

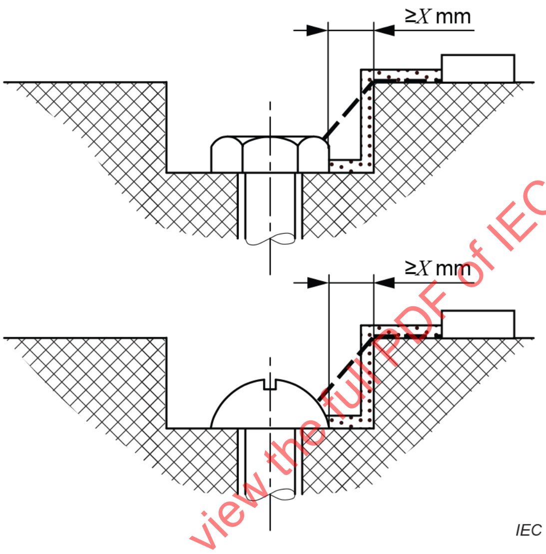
Example 8



Condition: Creepage distance through uncemented joint is less than creepage distance over barrier.

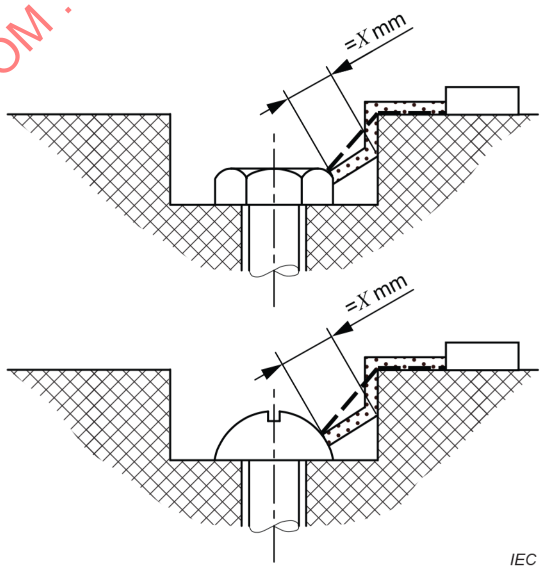
Rule: Clearance is the shortest direct air path over the top of the barrier.

Example 9



Gap between head of screw and wall of recess wide enough to be taken into account.

Example 10

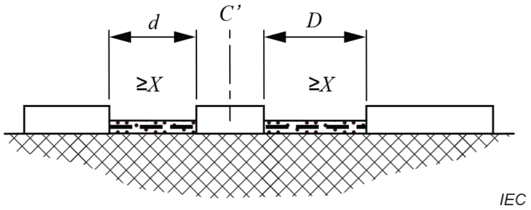


Gap between head of screw and wall of recess too narrow to be taken into account.

Measurement of creepage distance is from screw to wall when the distance is equal to X mm.

— — — Clearance   ▒▒▒ Creepage distance

Example 11



Clearance is the distance = $d + D$

Creepage distance is also = $d + D$

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

Annex B
(normative)

Test sequences and number of samples necessary to prove compliance with this document

B.1 Test sequences

The tests are made according to Table B.1 where the tests in each sequence are carried out in the order indicated.

Table B.1 – Test sequences

Test sequence		Clause or subclause	Test (or inspection)
A_1		6	Marking
		8.1.1	General
		8.1.2	Mechanism
		9.3	Indelibility of marking
		8.1.3	Clearances and creepage distances (external parts only)
		8.1.6	Non-interchangeability
		9.4	Reliability of screws, current-carrying parts and connections
		9.5	Reliability of screw-type terminals for external copper conductors
		9.6	Protection against electric shock
		8.1.3	Clearances and creepage distances (internal parts only)
		9.14	Resistance to heat
		9.16	Resistance to rusting
A_2		9.15	Resistance to abnormal heat and to fire
B		9.7.5.4	Verification of resistance of the insulation of open contacts against an impulse voltage (suitability for isolation)
		9.7.1	Resistance to humidity
		9.7.2	Insulation resistance of the main circuit
		9.7.3	Dielectric strength of the main circuit
		9.7.4	Insulation resistance and dielectric strength of auxiliary circuit
		9.7.5.2	Verification of clearances with the impulse withstand voltage
		9.8	Temperature rise and power loss
		9.9	28-day test
C	C_1	9.11	Mechanical and electrical endurance
		9.12.11.2.1	Test at reduced DC short-circuit currents
		9.12.12	Verification of circuit-breaker after short-circuit tests
	C_2	9.12.11.2.3	Test at small direct currents
		9.12.12	Verification of circuit-breaker after short-circuit tests
	C_3	9.12.11.2.2	Short-circuit test on circuit-breakers for verifying their suitability for use in IT systems
		9.12.12	Verification of circuit-breaker after short-circuit tests

Test sequence		Clause or subclause	Test (or inspection)
D	D_0	9.10	Tripping characteristic
	D_1	9.13 9.17 9.12.11.3 9.12.12	Mechanical stresses Verification of the behaviour in case of making inrush current Short-circuit performance at 1 500 A Verification of circuit-breaker after short-circuit tests
E	E_1	9.12.11.4.2 9.12.12	Service short-circuit capacity (I_{cs}) Verification of circuit-breaker after short-circuit tests
	E_2	9.12.11.4.3 9.12.12	Performance at rated short-circuit capacity (I_{cn}) Verification of circuit-breaker after short-circuit tests
	E_3	9.12.11.4.4 9.12.12	The performance at rated making and breaking capacity (I_{cn1}) on each pole of a multipole circuit-breaker Verification of circuit-breaker after short-circuit tests
With the agreement of the manufacturer, the same samples can be used for more than one sequence.			

B.2 Number of samples to be submitted for full test procedure and acceptance criteria

If only one rating (i.e. one set of rated quantities, see 5.2) of one type (number of poles, instantaneous tripping) of circuit-breaker is submitted for test, the number of samples to be submitted to the different test sequences are those indicated in Table B.2 in which the acceptance criteria are given.

If all the samples submitted according to the second column of Table B.2 pass the tests, compliance with the document is met. If only the minimum number given in the third column passes the tests, additional samples as shown in the fourth column shall be tested and shall satisfactorily complete the test sequence.

For circuit-breakers having more than one rated current, two separate sets of circuit-breakers shall be submitted to each test sequence: one set adjusted at the maximum rated current, the other set at the minimum rated current. In addition, one sample of all other rated currents shall be submitted for test sequence D_0 of Table B.1.

Table B.2 – Number of samples for full test procedure

Test sequence	Number of samples	Minimum number of samples which shall pass the tests[a b]	Number of samples for repeated tests[c]
A_1	1	1	–
A_2	3	2	3
B	3	2	3
C_1	3	2	3
C_2	3	2	3
C_3	3	2	3
D	3	2	3
E_1	3	2	3
E_2	3	2	3
E_3	3	2	3

[a] In total, a maximum of two test sequences may be repeated.

[b] It is assumed that a sample which has not passed a test has not met the requirements due to workmanship or assembly defects which are not representative of the design.

[c] In the case of repeated tests, all results shall be acceptable.

B.3 Number of samples to be submitted for simplified test procedure

B.3.1 This part of the document applies when submitting simultaneously a range of circuit-breakers of the same fundamental design.

B.3.2 For a series of circuit-breakers of the same fundamental design, the number of samples to be tested may be reduced according to B.3.2 and B.3.3.

For subsequent additions (e.g. further values of rated currents, different classification of instantaneous tripping, different number of poles) to such a series of circuit-breakers, the same reductions apply.

NOTE When a series of circuit-breakers presenting minor variations with respect to an already approved series of circuit-breakers is submitted to type tests, a further reduction of the number of samples and tests can be agreed upon.

Circuit-breakers can be considered to be of the same fundamental design if the following conditions are met:

– they have the same basic design;
– they have the same external physical dimensions per pole;
– the materials, finish and dimensions of the internal current carrying parts are identical, other than the variations given in a) below;
– the terminals are of similar design, (see d) below);
– the contact size, material, configuration and method of attachment are identical;
– the manual operating mechanisms (materials and physical characteristics) are identical;
– the moulding and insulating materials are identical;
– the method, materials and construction of the arc extinction device are identical;
– the basic design of the overcurrent tripping device is identical, other than the variations given in b) below;

– the basic design of the instantaneous tripping device is identical, other than the variations given in c) below;
– their voltage rating is intended for the same types of distribution system (see Table 1);
– multipole circuit-breakers are either composed of single-pole circuit-breakers or built up from the same components as the single-pole circuit-breakers, having the same overall dimensions per pole, with the exception of external barriers between poles.

The following variations are permitted:

a) cross-sectional areas of the internal current-carrying connections;
b) dimensions and material of the overcurrent tripping device;
c) number of turns and cross-sectional area of the operating coil of the instantaneous tripping device;
d) dimensions of terminals.

B.3.3 For circuit-breakers having the same instantaneous tripping classification according to 4.7, the number of samples to be tested may be reduced, according to Table B.3.

Table B.3 – Reduction of samples for series of circuit-breakers having different numbers of poles

Test sequence	Number of samples depending on number of poles [a]		
	One pole[b]	Two poles[c]	Three poles [d]
A_1	1 maximum rated current	1 maximum rated current [e, h]	1 maximum rated current [g]
A_2	3 maximum rated current	3 maximum rated current	3 maximum rated current
B	3 maximum rated current	3 maximum rated current [e]	3 maximum rated current
C_1	3 maximum rated current	3 maximum rated current [e]	3 maximum rated current
C_2	3 maximum rated current	3 maximum rated current	3 maximum rated current
$D_0 + D_1$	3 maximum rated current	3 maximum rated current [f]	3 maximum rated current
D_0	1 of all other rated currents		
E_1	3 maximum rated current 3 minimum rated current	3 maximum rated current 3 minimum rated current	3 maximum rated current 3 minimum rated current
E_2	3 maximum rated current 3 minimum rated current	3 maximum rated current 3 minimum rated current	3 maximum rated current 3 minimum rated current
E_3	[i]	3 maximum rated current [h]	3 maximum rated current [h]

[a] If a test is to be repeated according to the acceptance criteria of Clause B.2, a new set of samples is used for the relevant test sequence. In repeated tests, all results shall be satisfactory.

[b] If only multipole circuit-breakers are submitted, this column applies to the set of samples having the smallest number of poles (instead of the relevant column).

[c] Applicable to two-pole circuit-breakers with two protected poles.

[d] Also applicable to three-pole circuit-breaker with two protected poles and non-polarized protected M pole.

[e] This test sequence is omitted when three-pole circuit-breakers have been tested.

[f] This test sequence shall be omitted for two-pole circuit breakers with two protected poles, when three-pole circuit-breakers have been tested.

[g] When multipole circuit-breakers are submitted, a maximum of four screw-type terminals for external conductors are subjected to the tests of 9.5, i.e. two supply and two load terminals.

[h] If each pole of the multipole is identical to the individual pole tested in E_2, this test is omitted. If not, this test is carried out on an individual protected pole, taken at random, of the circuit-breaker with the highest number of poles.

[i] Covered by test sequence E_2.

B.3.4 For an additional series of circuit-breakers of the same fundamental design as described in B.3.1 but of a different instantaneous tripping classification according to 4.7, the test sequences to be applied may be limited to those given in Table B.4, the number of samples being those given in Table B.3.

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

Circuit-breaker type-tested first	Subsequent test sequences for circuit-breakers of	
	B-type	C-type
B-type	–	$(D_0 + D_1) + E$
C-type	D_0 [a] + B [a]	

[a] For these test sequences, only the tests of 9.8 and 9.10.2 are required.

Annex C
(informative)

Co-ordination under short-circuit conditions between a circuit-breaker and another short-circuit protective device (SCPD) associated in the same circuit

C.1 General

To ensure co-ordination under short-circuit conditions between a circuit-breaker (C_1) and another short-circuit protective device (SCPD) associated with it in the same circuit, it is necessary to consider the characteristics of each of the two devices as well as their behaviour as an association.

NOTE An SCPD can incorporate additional protective means, for example overload releases.

The SCPD may consist of a fuse (or a set of fuses) – see Figure C.1 – or another circuit-breaker (C_2) (see Figures C.2 and C.3).

The comparison of the individual operating characteristics of each of the two associated devices may not be sufficient, when reference has to be made to the behaviour of these two devices operating in series, since the impedance of the devices is not always negligible. It is recommended that this be taken into account. For short-circuit currents, it is recommended that reference be made to I^2t instead of time.

C_1 is frequently connected in series with another SCPD for reasons such as the method of power distribution adopted for the installation or because the short-circuit capacity of C_1 alone may be insufficient for the proposed application. In such instances, the SCPD may be mounted in locations remote from C_1. The SCPD may be protecting a main feeder supplying a number of circuit-breakers C_1 or just an individual circuit-breaker.

For such applications, the user or specifying authority may have to decide, on the basis of a desk study alone, how the optimum level of co-ordination may best be achieved. Annex C is intended to give guidance for this decision, and also on the type of information which the circuit-breaker manufacturer should make available to the prospective user.

Guidance is also given on test requirements, where such tests are deemed necessary for the proposed application.

The term "co-ordination" includes consideration of selectivity (see 3.5.15.2 and also 3.5.15.4 and 3.5.15.5) as well as consideration of back-up protection (see 3.5.15.3).

Consideration of selectivity can in general be carried out by desk study (see Clause C.5) whereas the verification of back-up protection normally requires the use of tests (see Clause C.6).

When considering short-circuit breaking capacity, reference is made to the rated short-circuit capacity (I_{cn}) of C_1 and C_2 when both are circuit-breakers according to IEC 60898-3, and to the ultimate short-circuit breaking capacity (I_{cu}) of C_2, when C_2 is a circuit-breaker according to IEC 60947-2.

C.2 Purpose

This annex gives guidance on and requirements for the co-ordination of a circuit-breaker with other SCPDs associated in the same circuit, as regards selectivity as well as back-up protection.

The object of this annex is to state

– the general requirements for the co-ordination of a circuit-breaker with another SCPD;
– the methods and the tests (if deemed necessary) intended to verify that the conditions for co-ordination have been met.

C.3 General requirements for the co-ordination of a circuit-breaker with another SCPD

C.3.1 General consideration

Ideally, the co-ordination should be such that a circuit-breaker (C_1) alone will operate at all values of overcurrent up to the limit of its rated short-circuit capacity I_{cn}.

NOTE If the value of the prospective fault current at the point of installation is less than the rated short-circuit capacity of C_1, it can be assumed that the SCPD is only in the circuit for considerations other than that of back-up protection.

In practice, the following considerations apply:

a) if the value of the selectivity limit current I_s (see 3.5.15.6) is too low, there is a risk of unnecessary loss of selectivity;
b) if the value of the prospective fault current at the point of installation exceeds the rated short-circuit capacity of C_1, the SCPD shall be so selected that the behaviour of C_1 is in accordance with C.3.3 and the take-over current I_B (see 3.5.15.7), if any, complies with the requirements of C.3.2.

   Whenever possible, the SCPD shall be located on the supply side of C_1. If the SCPD is located on the load side, it is essential that the connection between C_1 and the SCPD be so arranged as to minimize any risk of short-circuit.

C.3.2 Take-over current

For the purpose of back-up protection the take-over current I_B shall not exceed the rated short-circuit capacity I_{cn} of C_1 alone (see Figure C.3 a)).

C.3.3 Behaviour of C_1 in association with another SCPD

For all values of overcurrent up to and including the short-circuit capacity of the association, C_1 and the association shall comply with the requirements of 8.8.

C.4 Type and characteristics of the associated SCPD

On request, the manufacturer of the circuit-breaker shall provide information on the type and the characteristics of the SCPD to be used with C_1, and on the maximum prospective short-circuit current for which the association is suitable at the stated operational voltage.

Details of the SCPD used for any tests made in accordance with this annex, i.e. manufacturer’s name, type designation, rated voltage, rated current and short-circuit breaking capacity, shall be given in the test report.

The maximum conditional short-circuit current I_{nc} (see 3.5.15.9) shall not exceed

– the rated ultimate breaking capacity of the SCPD, if this is a circuit-breaker according to IEC 60947-2;
– the rated short-circuit capacity, if the SCPD is a circuit-breaker according to this document;
– the rated short-circuit breaking capacity, if the SCPD is a fuse.

If the associated SCPD is a circuit-breaker, it shall meet the requirements of this document, or any other relevant standard.

If the associated SCPD is a fuse, it shall be in accordance with IEC 60269 (all parts) or with any other fuse standard.

C.5 Verification of selectivity

Selectivity can normally be considered by desk study alone, i.e. by a comparison of the operating characteristics of C_1 and the associated SCPD, for example when the associated SCPD is a circuit-breaker (C_2) provided with an intentional time-delay.

The manufacturers of both C_1 and the SCPD shall provide adequate data concerning the relevant operating characteristics as to permit I_s to be determined for each individual association.

In certain cases, tests at I_s are necessary on the association, for example:

– when C_1 is of the current limiting type and C_2 is not provided with an intentional time-delay;
– when the opening time of the SCPD is less than that corresponding to one half-cycle.

To obtain the desired selectivity when the associated SCPD is a circuit-breaker, an intentional short-time delay may be necessary for C_2.

Selectivity may be partial (see Figure C.3 a)) or total up to the rated short-circuit capacity I_{cn} of C_1. For total selectivity, the non-tripping characteristic of C_2 or the pre-arcing characteristic of the fuse shall lie above the tripping (break time) characteristic of C_1.

Two illustrations of total selectivity are given in Figures C.2 a) and C.2 b).

C.6 Verification of back-up protection

C.6.1 Determination of the take-over current

Compliance with the requirements of C.3.2 can be checked by comparing the operating characteristics of C_1 with those of the associated SCPD for all settings (if any) of C_2.

C.6.2 Verification of back-up protection

C.6.2.1 Verification by tests

Compliance with the requirements of C.3.3 is normally verified by tests in accordance with C.6.3. In this case, all conditions for the tests shall be as specified in 9.12.11.4.3 with the adjustable resistors and inductors for the short-circuit tests on the supply side of the association.

NOTE An example of a test circuit is shown in Figure 3.

C.6.2.2 Verification by comparison of characteristics

In some practical cases and where the SCPD is a circuit-breaker (see Figures C.3 a) and C.3 b)), it may be possible to compare the operating characteristics of C_1 and of the associated SCPD, special attention being paid to the following:

– the Joule integral value of C_1 at its I_{cn} and that of the SCPD at the prospective current of the association;

– the effects on C_1 (e.g. by arc energy, maximum peak current, cut-off current) at the peak operating current of the SCPD.

The suitability of the association may be evaluated by considering the maximum operating I^2t characteristic of the SCPD, over the range from the rated short-circuit capacity I_{cn} of C_1 up to the prospective short-circuit current of the application, but not exceeding the maximum let-through I^2t of C_1 at its rated short-circuit capacity or other lower limiting value stated by the manufacturer.

NOTE Where the associated SCPD is a fuse, the validity of the desk study is limited to I_{cn} of C_1.

C.6.3 Tests for verification of back-up protection

If the associated SCPD is a circuit-breaker (C_2) fitted with adjustable overcurrent opening releases, the operating characteristics to be used shall be those corresponding to the maximum time and maximum current settings.

If the associated SCPD consists of a set of fuses, each test shall be made using a new set of fuses, even if some of the fuses used during a previous test have not blown.

Where applicable, the connecting cables shall be included as specified in 9.12.4 except that, if the associated SCPD is a circuit-breaker (C_2), the full length of cable (75 cm) associated with this circuit-breaker may be on the supply side.

Each test shall consist of a O – t – CO sequence of operation made in accordance with 9.12.11.4.3 at I_{cn}, the CO operation being made on C_1.

A test is made with the maximum prospective current for the proposed application. This shall not exceed the rated conditional short-circuit current (see 3.5.15.9).

A further test shall be made at a value of prospective current equal to the rated short-circuit breaking capacity I_{cn} of C_1, for which test a new sample C_1 may be used, and also, if the associated SCPD is a circuit-breaker, a new sample C_2.

During each operation

a) if the associated SCPD is a circuit-breaker (C_2):
   - either both C_1 and C_2 shall trip at both test currents, no further tests then being required.

     This is the general case in which back-up protection only is provided;
   - or C_1 shall trip and C_2 shall be in the closed position at the end of each operation, at both test currents, no further tests then being required.

     This requires that the contacts of C_2 separate momentarily during each operation. In this case restoration of the supply is provided, in addition to back-up protection (see note 1 to Figure C.3 a)). The duration of interruption of supply, if any, shall be recorded during these tests;
   - or C_1 shall trip at the lower test current, and both C_1 and C_2 shall trip at the higher test current.

   This requires that the contacts of C_2 separate momentarily at the lower test current. Additional tests shall be made at intermediate currents to determine the lowest current at which both C_1 and C_2 trip, up to which current restoration of supply is provided. The duration of interruption of supply, if any, shall be recorded during these tests.

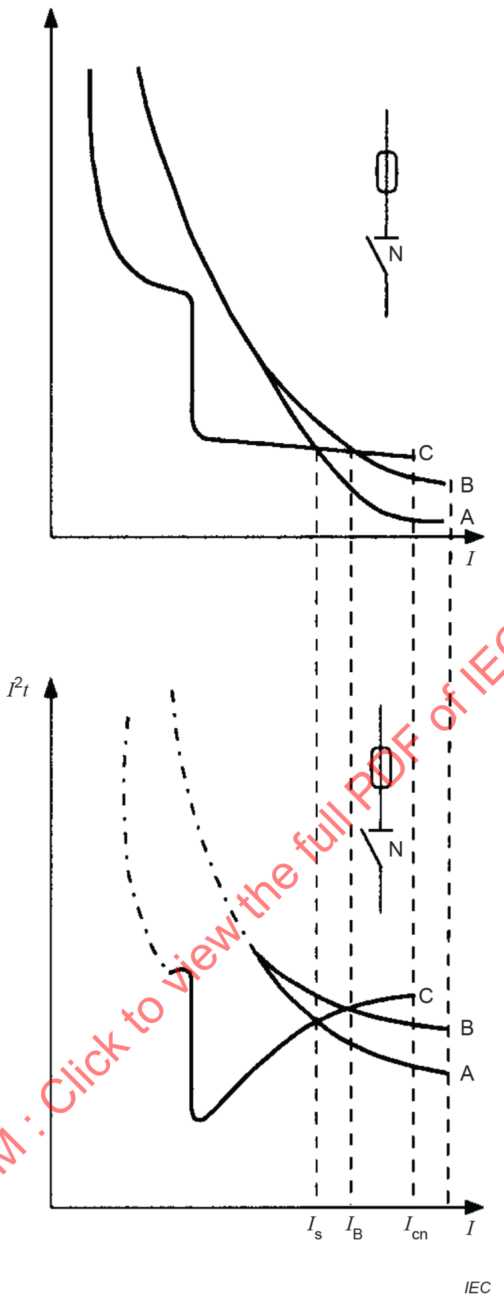
b) if the associated SCPD is a fuse (or a set of fuses) as declared by the manufacturer:
   - for the test at the rated conditional short-circuit current;
     - in case of a single-phase circuit at least one fuse shall blow;

  - in case of a multi-phase circuit either two or more fuses shall blow, or one fuse shall blow and C_1 shall trip;
- for the test at the rated short-circuit breaking capacity C_1 shall trip and at least one fuse shall blow.

C.6.4 Results to be obtained

Following the tests, C_1 shall comply with 9.12.12.2.

In addition, if the associated SCPD is a circuit-breaker (C_2), it shall be verified, by manual operation or other appropriate means, that the contacts of C_2 have not welded.



Key

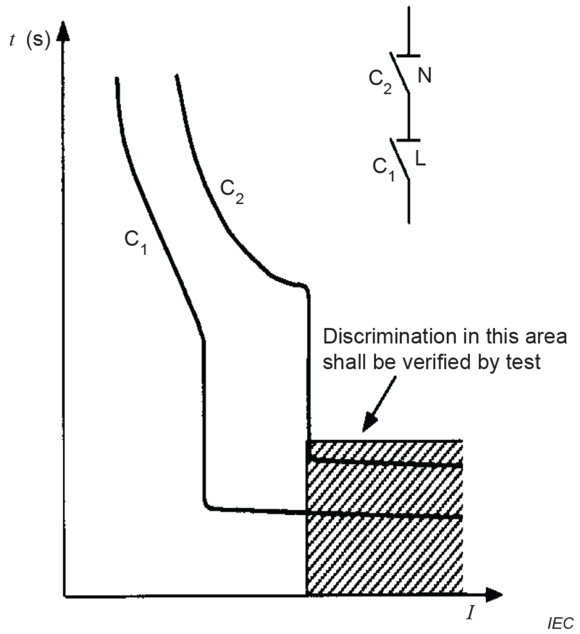
I	Prospective short-circuit current
I_{cn}	Rated short-circuit capacity (5.2.4)
I_s	Selectivity limit current (3.5.15.6)
I_B	Take-over current (3.5.15.7)
A	Pre-arcing characteristic of the fuse
B	Operating characteristic of the fuse
C	Operating characteristic of the circuit-breaker, non-current-limiting (N) (break-time/current and I^2t /current)

NOTE 1 A is deemed to be the lower limit; B and C are deemed to be the upper limits.

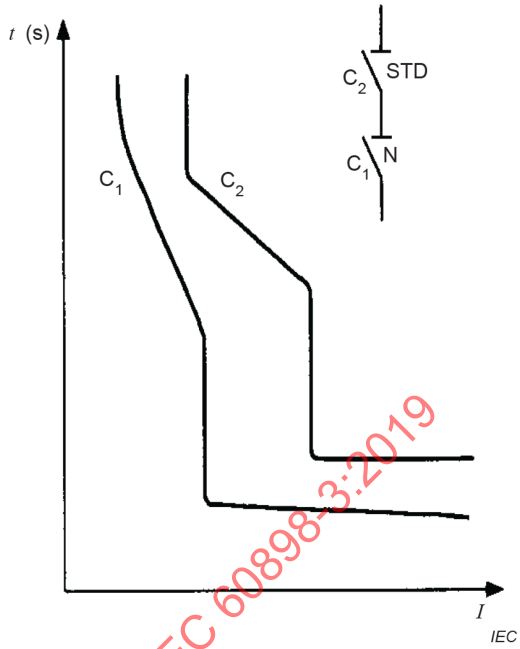
NOTE 2 Non-adiabatic zone for I^2t shown chain-dotted.

NOTE 3 Reproduced from IEC 60947-2: 2016, Figure A.1.

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



a)



b)

Key

C_1 = Current-limiting circuit-breaker (L) (break-time characteristic)

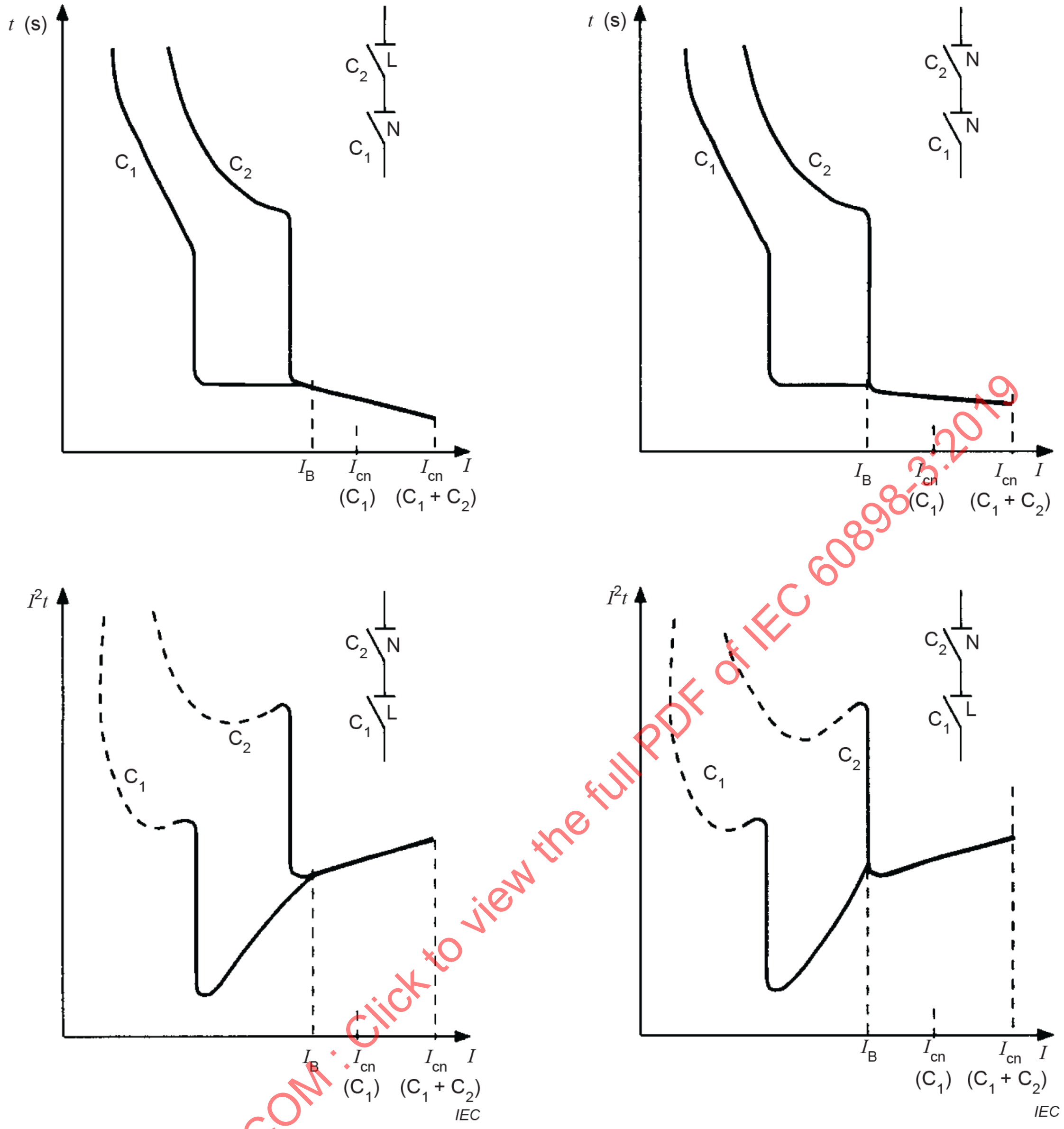
C_2 = Non-current-limiting circuit breaker (N) (tripping characteristic)

C_1 = Non-current-limiting circuit-breaker (N) (break-time characteristic)

C_2 = Circuit-breaker with intentional short-time delay (STD) (tripping characteristic)

NOTE Values of I_{cn} are not shown.

Figure C.2 – Total selectivity between two circuit-breakers



a) b)

Key

C_1 = Non current-limiting circuit-breaker (N)

C_2 = Current-limiting circuit breaker (L)

I_B = Take-over current

C_1, C_2 = Non current-limiting circuit-breaker (N)

NOTE 1 Where applicable, restoration of supply by C_2 occurs.

NOTE 2 I_{cn} $(C_1 + C_2) \leq I_{cn}$ (C_2).

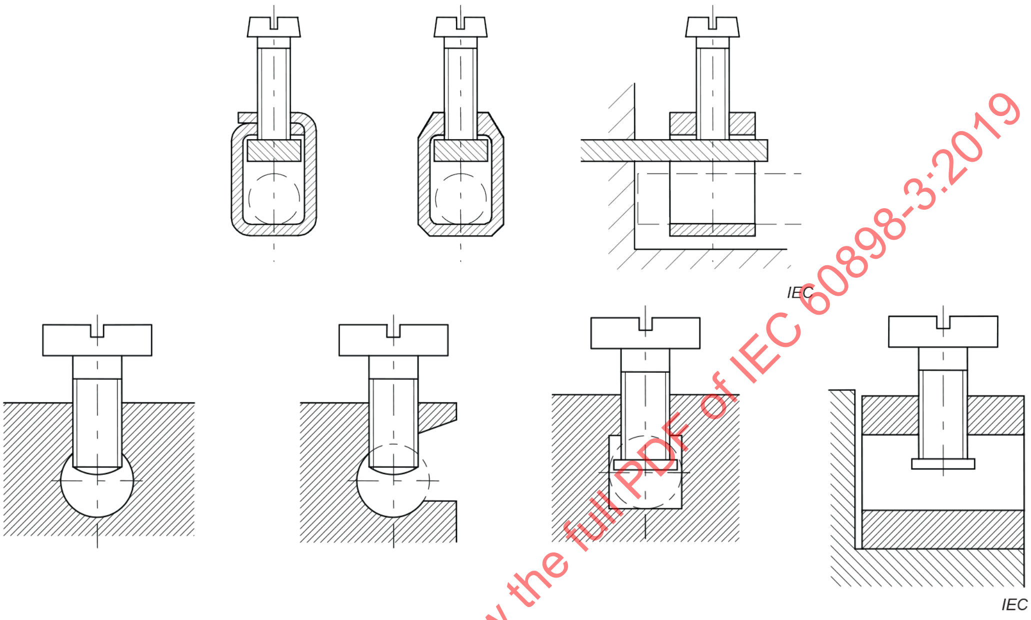
NOTE 3 For values of $I > I_B$, the curve is that of the association (shown in bold) for which data are obtained by tests.

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

Annex D
(informative)

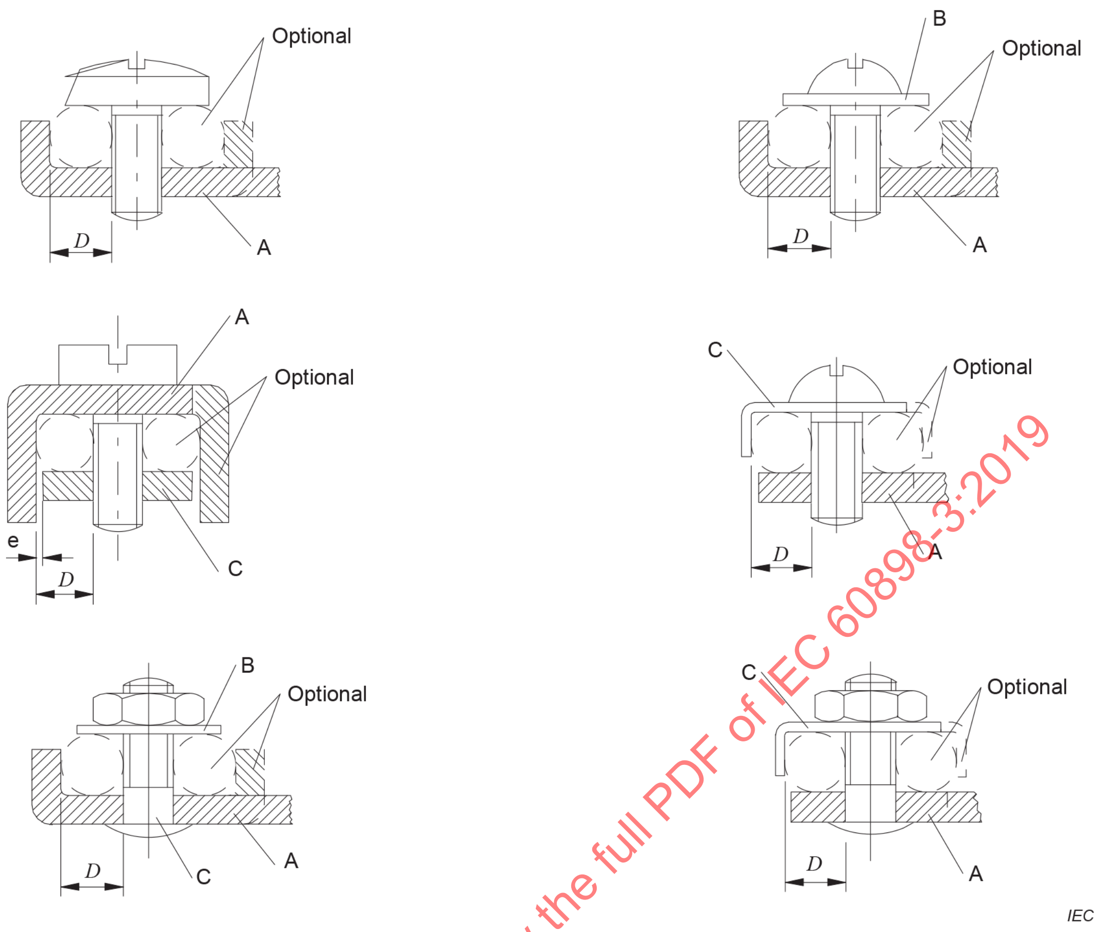
Examples of terminals

In Figures D.1 to D.4, examples of designs of terminals are given. The conductor location shall have a diameter suitable for accepting solid rigid conductors and a cross-sectional area suitable for accepting rigid stranded conductors (see 8.1.5).



The part of the terminal containing the threaded hole and the part of the terminal against which the conductor is clamped by the screw may be two separate parts, as in the case of a terminal provided with a stirrup.

Figure D.1 – Examples of pillar terminals



Key

A Fixed part

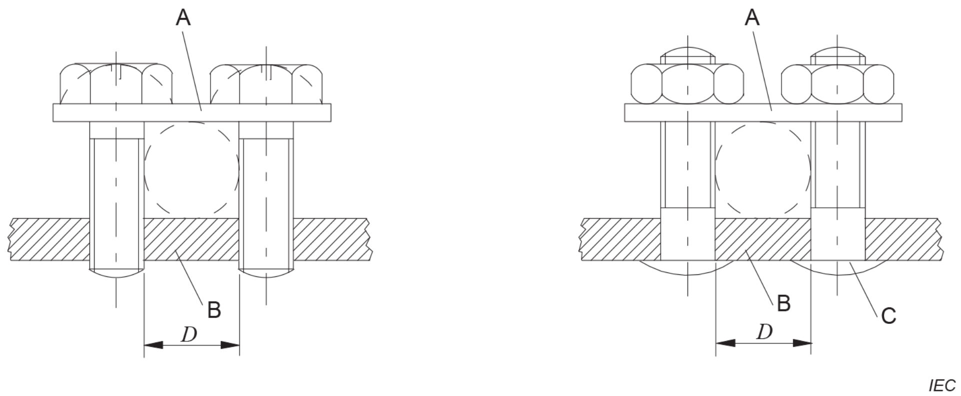
B Washed or clamping plate

C Anti-spread device

D Conductor space

The part which retains the conductor in position may be of insulating material, provided the pressure necessary to clamp the conductor is not transmitted through the insulating material.

Figure D.2 – Examples of screw terminals and stud terminals



Key

A Saddle

B Fixed part

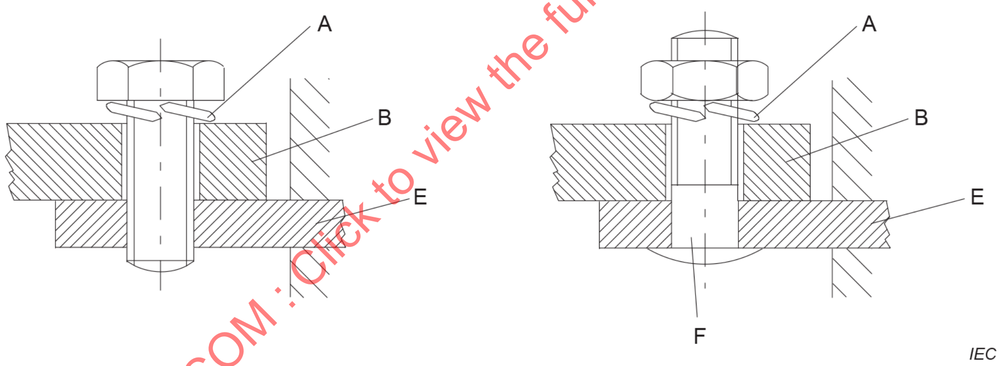
C Stud

D Conductor space

The two faces of the saddle may be of different shapes to accommodate conductors of either small or large cross-sectional area, by inverting the saddle.

The terminals may have more than two clamping screws or studs.

Figure D.3 – Examples of saddle terminals



Key

A Locking means

B Cable lug or bar

E Fixed part

F Stud

For this type of terminal, a spring washer or equally effective locking means shall be provided and the surface within the clamping area shall be smooth.

For certain types of equipment, the use of lug terminals of sizes smaller than that required is allowed.

Figure D.4 – Examples of lug terminals

Annex E
(informative)

Correspondence between IEC and AWG copper conductors

IEC size mm²	AWG	
	Size	Cross-section mm²
1,0	18	0,82
1,5	16	1,3
2,5	14	2,1
4,0	12	3,3
6,0	10	5,3
10,0	8	8,4
16,0	6	13,3
25,0	3	26,7
35,0	2	33,6
50,0	0	53,5
In general IEC sizes apply. Upon request of the manufacturer, AWG sizes can be used.		

Annex F
(normative)

Arrangement for short-circuit test

The device under test is mounted as shown in Figure F.1 which may require adapting to the specific design of the device, and in accordance with the manufacturer's instruction.

When required (i.e. during O operations), a clear polyethylene foil (0,05 ± 0,01) mm, of a size at least 50 mm larger in each direction than the overall dimensions of the front face of the device, but not less than 200 mm × 200 mm, is fixed and reasonably stretched in a frame, placed at a distance of 10 mm from

– either the maximum projection of the operating means of a device without recess for the operating means;
– or the rim of a recess for the operating means of a device with recess for the operating means.

The foil should have the following physical properties:

– density at 23 °C: (0,92 ± 0,05) g/cm^3;
– melting point: (110 to 120) °C.

When required, a barrier of insulating material, at least 2 mm thick, is placed, as shown in Figure F.1, between the arc vent and the polyethylene foil to prevent damage of the foil due to hot particles emitted from the arc vent.

When required, a grid, (or grids) according to Figure F.2 is (are) placed at a distance of "a" (mm) form each arc vent of the device.

The grid circuit (see Figure F.3) shall be connected to the points B or C or C', as applicable (see Figure 3 to Figure 5).

The parameters for the grid circuit(s) are as follows:

– resistor R′: 1,5 Ω;
– copper wire F′: length 50 mm and diameter as specified in 9.12.9.2.

Dimension in millimetres

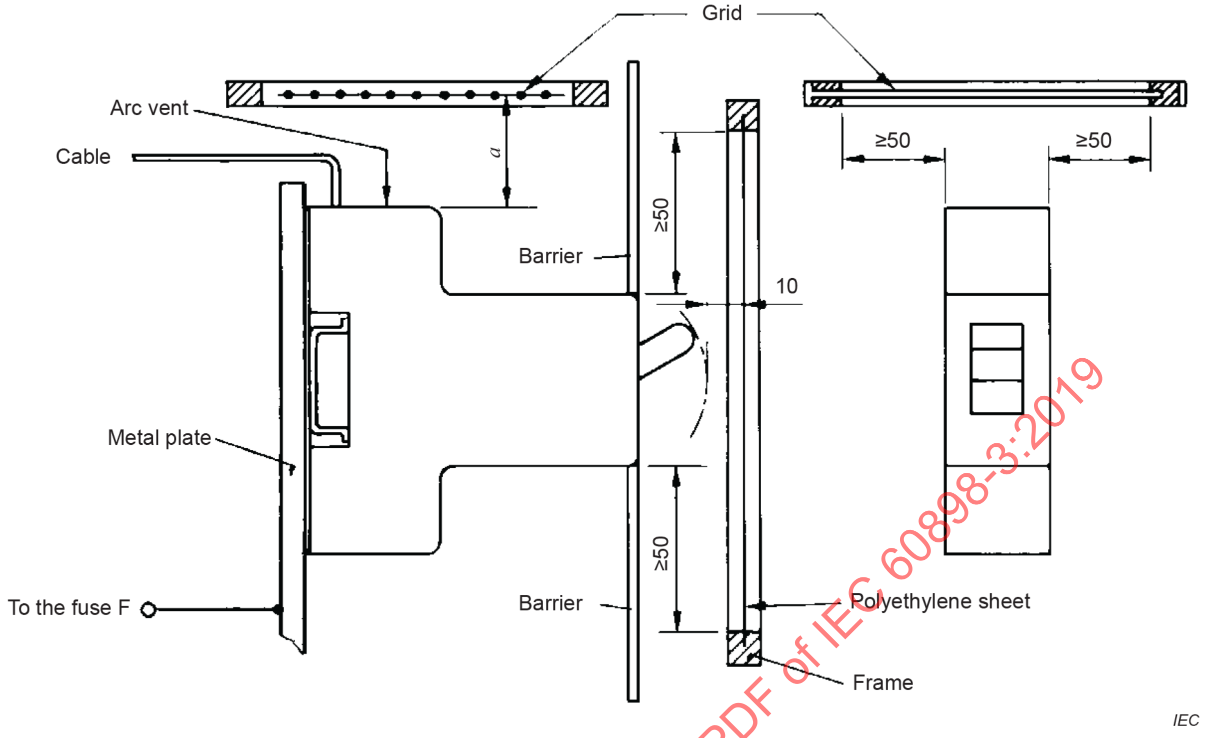


Figure F.1 – Test arrangement

Dimensions in millimetres

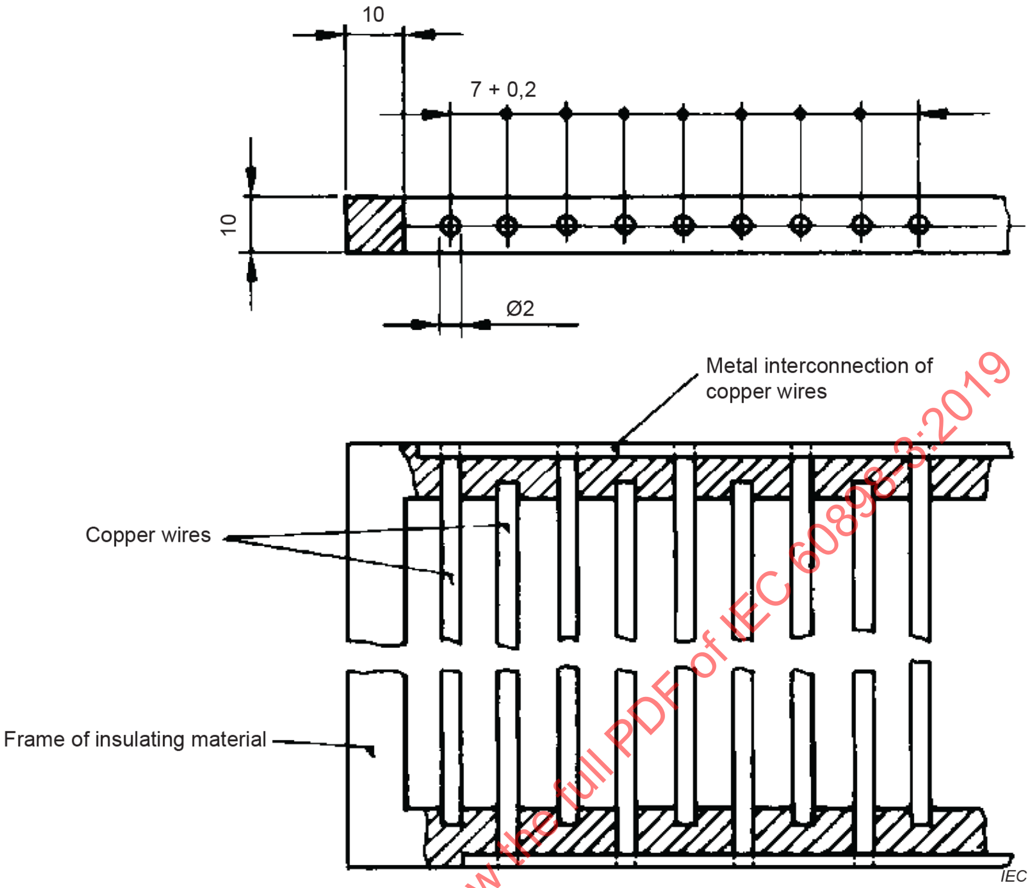


Figure F.2 – Grid circuit

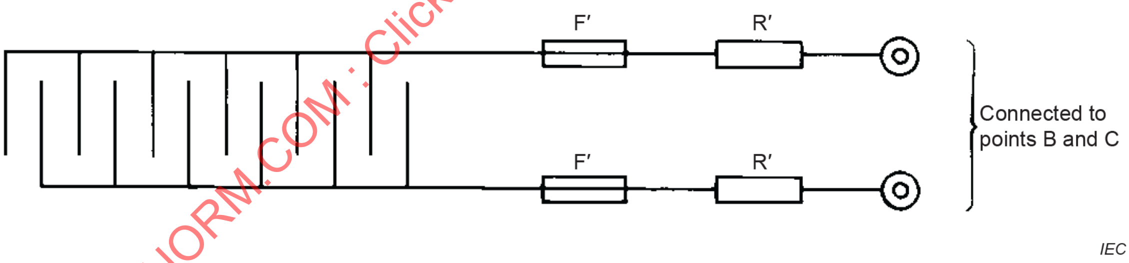


Figure F.3 – Grid circuit

Annex G
(normative)

Routine tests

G.1 General

The tests specified in Annex G are intended to reveal, as far as safety is concerned, unacceptable variations in material or manufacture.

Further tests may have to be made, according to the experience gained by the manufacturer, to ensure that every circuit-breaker is in conformity with the samples which passed the tests of this document.

G.2 Tripping tests

Tripping tests shall be verified according to a) and b).

a) *Verification of the time-current characteristic*

An alternating or direct current of any convenient value between the conventional tripping current and the lower value of the range of instantaneous tripping of Table 2 (according to the tripping characteristic of the circuit-breaker: B or C) is passed separately through each protected pole starting from cold.

The circuit-breaker shall trip within a time corresponding to a point, selected by the manufacturer, situated between the limiting times of the tripping characteristic.

b) *Verification of the instantaneous tripping*

The test is carried out at any convenient voltage without blocking the operating mean in the closed position. The test may be carried out on each protected pole separately.

The test can be done with alternating current by applying corrections factors.

G.3 Verification of clearances between open contacts

With the circuit-breaker in the open position a voltage of substantially sine-wave form of 1 500 V, having a frequency of 50 Hz or 60 Hz or a DC voltage of 2 120 V, is applied for 1 s between the terminals which are electrically connected together when the circuit-breaker is in the closed position.

No flashover or breakdown shall occur.

Alternatively, any convenient method of verification of the clearances between open contacts (e.g. X-ray verification) may be used.

Annex H
(normative)

Particular requirements for circuit-breakers with screwless type terminals for external copper conductors

NOTE Annex H supplements or modifies the corresponding clauses in this document. Where this annex states "addition", "modification" or "replacement", the relevant requirements, test specifications or explanatory matter in this document are adapted accordingly.

H.1 Scope

Annex H applies to circuit-breakers within the scope of this document, equipped with screwless terminals, for current not exceeding 20 A primarily suitable for connecting unprepared (see J.3.6) copper conductors of cross-section up to 4 mm^2.

NOTE In CZ, DK, NL, NO and CH, the upper limit of current for use of screwless terminals is 16 A.

In this annex, screwless terminals are referred to as terminals and copper conductors are referred to as conductors.

H.2 Normative references

Clause 2 applies.

H.3 Terms and definitions

Clause 3 applies with the following exceptions:

Additional terms and definitions:

H.3.1
clamping units
parts of the terminal necessary for mechanical clamping and the electrical connection of the conductors including the parts which are necessary to ensure correct contact pressure

H.3.2
screwless-type terminal
terminal for the connection and subsequent disconnection obtained directly or indirectly by means of springs, wedges or the like

Note 1 to entry: Examples are given in Figure H.2.

H.3.3
universal terminal
terminal for the connection and disconnection of all types of conductors (rigid and flexible)

Note 1 to entry: In the following countries, only universal screwless type terminals are accepted: AT, BE, CN, DK, DE, ES, FR, IT, PT and SE.

H.3.4
non-universal terminal
terminal for the connection and disconnection of a certain kind of conductor only (e.g. rigid-solid conductors only or rigid-[solid or stranded] conductors only)