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Interested committees:

Title: BS EN 60947-10 Low-voltage switchgear and controlgear Part 10: Semiconductor Circuit-Breakers

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

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UK Vote

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Submission of Comments

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



121A/489/CD

COMMITTEE DRAFT (CD)

PROJECT NUMBER: IEC 60947-10 ED1	
DATE OF CIRCULATION: 2022-04-15	CLOSING DATE FOR COMMENTS: 2022-08-05
SUPERSEDES DOCUMENTS: 121A/381/NP, 121A/401B/RVN	

IEC SC 121A : LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR	
SECRETARIAT: France	SECRETARY: Mr Michaël LAHEURTE
OF INTEREST TO THE FOLLOWING COMMITTEES: TC 23, SC 23E, TC 64, TC 69	PROPOSED HORIZONTAL STANDARD: ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.
FUNCTIONS CONCERNED: ☒ EMC ☐ ENVIRONMENT ☐ QUALITY ASSURANCE ☒ SAFETY	

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TITLE: Low-voltage switchgear and controlgear – Part 10: Semiconductor Circuit-Breakers

NOTE FROM TC/SC OFFICERS: SC121A Officers support circulation of CD1 for project IEC 60947-10 ED1. Secretary Note1: NC experts are kindly requested to refer their comments to line number. Secretary Note2: - text highlighted in yellow means that PT 60947-10 is waiting for NC inputs and proposals on a specific item or topic, - text highlighted in purple is related to missing cross references as this is a first draft and PT 60947-10 does not expect comments from NCs on this.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –
Part 10: Semiconductor circuit-breakers**

FOREWORD

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International Standard IEC 60947-10 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low-voltage.

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

FDIS	Report on voting
121A/XX/FDIS	121A/XX/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.

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

- 356 • reconfirmed,
- 357 • withdrawn,
- 358 • replaced by a revised edition, or
- 359 • amended.

360

361 The National Committees are requested to note that for this document the stability date
362 is 20XX....

363 THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED
364 AT THE PUBLICATION STAGE.

365

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 10: Semiconductor circuit-breakers

1 Scope

This part of IEC 60947 series applies to semiconductor circuit-breakers for protection, isolation and switching intended to be connected to circuits, the rated voltage of which does not exceed 1 000 V AC or 1 500 V DC.

This standard covers the following different types:

- Semiconductor Circuit-Breakers (SCCBs) have semiconductor switching elements and, for isolation function mechanical switching elements connected in series.
- Semiconductor Hybrid Circuit-Breakers (SCHCBs) have semiconductor switching elements and, for isolation function mechanical switching elements connected in series and have mechanical switching elements in parallel to the semiconductor to reduce functional power.

This applies whatever the rated voltage, currents, the method of construction or the proposed applications of the semiconductor circuit-breakers may be.

The document includes the requirements and test methods for:

- Protection;
- Isolation;
- the conditions with which semiconductor switching, protection and isolation devices shall comply with reference to:
 - operation and behaviour in normal service;
 - operation and behaviour in case of overload and operation and behaviour in case of short-circuit;
- dielectric properties;
- remote control;
- indication;
- electromagnetic compatibility;
- security;
- lifetime;
- the characteristics of semiconductor circuit breakers;
- tests intended for confirming that these conditions have been met and the methods to be adopted for these tests;
- information to be marked on or given with the apparatus.

2 Normative references

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

AEC - Q101: *Failure mechanism based stress test qualification for discrete semiconductors in automotive applications*

- 407 IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*
- 408 IEC 60068-2-30, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h +*
409 *12 h cycle)*
- 410 IEC 60269-1:2006, *Low-voltage fuses – Part 1: General requirements*
411 IEC 60269-1:2006/AMD1:2009
412 IEC 60269-1:2006/AMD2:2014
- 413 IEC 60364 (all parts), *Low-voltage electrical installations*
- 414 IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage systems – Part 1:*
415 *Principles, requirements and tests*
- 416 IEC 60947-1:2020, *Low-voltage switchgear and controlgear – Part 1: General rules*
- 417 IEC 60947-4-1, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-*
418 *starters – Electromechanical contactors and motor-starters*
- 419 IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic*
420 *current emissions (equipment input current ≤ 16 A per phase)*
- 421 IEC 61000-3-3, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage*
422 *changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment*
423 *with rated current ≤ 16 A per phase and not subject to conditional connection*
- 424 IEC 61000-4-2:2008 *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement*
425 *techniques – Electrostatic discharge immunity test*
- 426 IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and*
427 *measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
428 IEC 61000-4-3:2006/AMD1:2007
429 IEC 61000-4-3:2006/AMD2:2010
- 430 IEC 61000-4-4:2012, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and*
431 *measurement techniques – Electrical fast transient/burst immunity test*
- 432 IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and*
433 *measurement techniques – Surge immunity test*
434 IEC 61000-4-5:2014/AMD1:2017
- 435 IEC 61000-4-6:2013, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and*
436 *measurement techniques – Immunity to conducted disturbances, induced by radio-frequency*
437 *fields*
- 438 IEC 61000-4-11:2020 *Electromagnetic compatibility (EMC) – Part 4-11: Testing and*
439 *measurement techniques – Voltage dips, short interruptions and voltage variations immunity*
440 *tests*
- 441 IEC 61140:2016 *Protection against electric shock – Common aspects for installation and*
442 *equipment*
- 443 IEC 62475:2010, *High-current test techniques – Definitions and requirements for test currents*
444 *and measuring systems*

445 CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance*
446 *characteristics – Limits and methods of measurement*
447 CISPR 11:2015/AMD1:2016

448 CISPR 32:2015, *Electromagnetic compatibility of multimedia equipment – Emission*
449 *requirements*

450 JEDEC JESD22-A104, *Temperature cycling*

451 JEDEC JESD22-A105, *Power and temperature cycling*

452 JEDEC JESD22-A106, *Thermal shock*

453 JEDEC JESD22-A108, *Temperature, bias, and operating life*

454 JEDEC JESD22-B103, *Vibration, variable frequency*

455 JEDEC JESD47, *Stress-test-driven qualification of integrated circuit*

456 **3 Terms, definitions, symbols and reference clauses**

457 **3.1 General**

458 For the purposes of this document, the terms and definitions given in IEC 60947-1:2020, as
459 well as the following apply.

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

- 462 • ISO Online browsing platform: available at <https://www.iso.org/obp>
- 463 • IEC Electropedia: available at <http://www.electropedia.org/>

464 NOTE Where these definitions are taken unchanged from the *International Electrotechnical Vocabulary (IEV)*,
465 IEC 60050-441, the reference to this publication is given in brackets.

466 **3.2 General terms and definitions**

467 **3.2.1**

468 **Semiconductor circuit-breaker (SCCB)**

469 protective device with semiconductor switching elements and, for isolation function mechanical
470 switching elements connected in series, capable of making, carrying and breaking currents
471 under normal circuit conditions and also making, carrying for a specified time and breaking
472 currents under specified abnormal circuit conditions such as those of short-circuit.

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

474 NOTE to entry: the term “solid state” is often used as a synonymous of “semiconductor”

475 **3.2.2**

476 **Semiconductor hybrid circuit-breaker (SCHCB)**

477 protective device with semiconductor switching elements and, for isolation function mechanical
478 switching elements connected in series and have additionally mechanical switching elements
479 in parallel to the semiconductor switching elements to reduce the functional power capable of
480 making, carrying and breaking currents under normal circuit conditions and also making,
481 carrying for a specified time and breaking currents under specified abnormal circuit conditions
482 such as those of short-circuit.

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

3.2.3

Frame size

a term designating a group of semiconductor circuit-breakers, the external physical dimensions of which are common to a range of current ratings.

NOTE 1 to entry: Frame size is expressed in amperes corresponding to the highest current rating of the group.

NOTE 2 to entry: Within a frame size, the width may vary according to the number of poles.

NOTE 3 to entry: This definition does not imply dimensional standardization.

3.2.4

Construction break

a significant difference in construction between semiconductor circuit-breakers of a given frame size, requiring additional type testing

3.2.5

Plug-in semiconductor circuit-breaker

a device which, in addition, has a set of contacts which enable the semiconductor circuit-breakers to be removed

3.2.6

Withdrawable semiconductor circuit-breaker

device which has a set of isolating contacts which enable the semiconductor circuit-breakers to be withdrawn from the main circuit, and, in the disconnected position, to achieve an isolating distance in accordance with specified requirements

3.2.7

non moulded-case circuit-breaker

CB with components enclosed in a dedicated cabinet or enclosure

3.2.8

Moulded-case semiconductor circuit-breaker

a device having a supporting housing of moulded insulating material

[SOURCE: IEC 60050-441:1984, 441-14-24]

3.2.9

Remote control function

allows a semiconductor circuit-breaker to be controlled other than by hand

3.2.10

Short-circuit release function

an over-current release intended for protection against short circuits.

3.2.11

Closing release function

a release, energized by a source of voltage, which triggers the closing of the circuit-breaker

3.2.12

Short-circuit breaking (or making) capacity

a breaking (or making) capacity for which the prescribed conditions include a short circuit

3.2.13**Ultimate short-circuit breaking capacity**

a breaking capacity for which the prescribed conditions according to a specified test sequence do not include the capability of the circuit-breaker to carry its rated current continuously

3.2.14**Service short-circuit breaking capacity**

a breaking capacity for which the prescribed conditions according to a specified test sequence include the capability of the circuit-breaker to carry its rated current continuously

3.2.15**Break time**

Interval of time between the specified instant of initiation of the breaking operation and the instant when the current is equal or lower than the maximum leakage current in stand-by state.

NOTE 1 to entry:

– in the case of breaking due to overcurrent, the instant of initiation of the breaking operation is the instant of initiation of a current large enough to cause the circuit-breaker to operate;

– in the case of breaking due to any form of external command, the instant of initiation of the breaking operation is the instant of application of the command.

NOTE 2 to entry: at the end of the breaking operation the circuit-breaker is not in OPEN state.

NOTE 3 to entry: for semiconductor Circuit-Breakers (SCCBs), the breaking operation does not involve any mechanical separation of contacts.

3.2.16**Opening time**

Interval of time between the specified instant of initiation of the breaking operation and the instant of initiation of steady decay of the current.

NOTE to entry: the instant of initiation of the breaking operation is the same as for Break time.

3.2.17**Commitment time**

Interval of time between the specified instant of initiation of the breaking operation and the instant of initiation of the turn-off of the power semiconductor.

NOTE to entry: the instant of initiation of the breaking operation is the same as for Break time.

3.2.18**Interrupting time**

Interval of time between the specified instant of the initiation of the turn-off of the power semiconductor and the instant when the current is equal or lower than the maximum leakage current in stand-by state.

3.2.19**Isolation time**

Interval of time between the specified instant of the initiation of the breaking operation and the instant when the circuit-breaker is in open state.

3.2.20**Isolation contacts**

Mechanical contacts ensuring the suitability for isolation of the semiconductor circuit-breaker or the semiconductor hybrid circuit-breaker.

3.2.21**Parallel mechanical contacts**

of a SCHCB mechanical switching elements in parallel to the power semiconductor

3.2.22**Rated instantaneous short-circuit current setting I_i**

rated value of the current causing the operation of a release without any intentional time-delay

3.2.23**Overload current setting I_r**

current setting of an adjustable overload release

NOTE 1 to entry: In case of a non-adjustable overload release, this value is equal to the rated current I_n .

3.2.24 void**3.2.25****Open state**

position (or state) in which the predetermined dielectric withstand voltage requirements are satisfied between open contacts in the main circuit of the device

NOTE to entry: in the case of a semiconductor hybrid circuit-breaker, the contacts in the main circuit of the device are the isolation contacts

3.2.26**Closed position**

Position in which the predetermined continuity of the main circuit of the circuit breaker is secured by having closed mechanical contacts and having the semiconductor in a conduction position (low-resistance condition).

In this position the operating means and / or the indicator (if present) show the closed position with "I"

3.2.27**Stand-by position**

Position (or state) in which:

- The isolation contacts are in closed position.
- The power semiconductor is switched off, and the parallel mechanical contacts opened for SCHCBs

3.2.28**Power semiconductor**

Semiconductor component used to conduct and interrupt the current in the main circuit in a SCCB, and to interrupt the current in the main circuit in a SCHCB.

3.2.29**Leakage current**

<of a SCCB or a SCHCB in stand-by state>

electric current through each pole in stand-by state under a defined voltage and testing conditions

4 Classification**4.1 According to type**

- Semiconductor circuit-breaker (SCCB), see 3.2.1

- Semiconductor hybrid circuit-breaker (SCHCB), see 3.2.2

4.2 According to their selectivity category

Sec Note: to be further discussed

4.3 According to the method of controlling the operating mechanism:

Sec Note: NCs are invited to make a proposal in regards of this classification

4.4 According to operation on fault conditions

- Following a fault, going into the open position
- Following a fault, going into stand-by

4.5 According to the design

- Moulded case,
- Panel dependant design (**to be defined**)

4.6 According to the method of controlling the operation

- with remote operation
- without remote operation.

4.7 According to the provision for maintenance:

- maintainable;
- non-maintainable.

4.8 According to the provision for software upgrade of embedded software

- on site
- remotely
- none

4.9 According to the method of installation

- fixed;
- plug-in;
- withdrawable.

4.10 According to communication method and security (*to be defined*)

- no communication;
- with communication (e.g. for parametrization, operating actions, measuring...)

4.11 According to the lifetime in service

Sec Note: To be further discussed. Need to identify the relevant test methods to be applied to the components of the SCCBs.

4.12 According to the functional supply

- Self powered by the current (functionally independent of an external supply or of the line voltage)
- Self powered by the voltage
- Powered by an external supply

4.13 According to the degree of protection provided by the enclosure (see 8.1.12 of IEC 60947-1:2020)

4.14 According to the direction of current flow and protection

4.14.1 Circuit-breakers protecting only in one direction of current, and enabling the current only in that direction

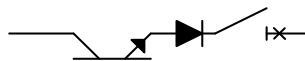


Figure 1 – Unidirectional protection, unidirectional current flow

4.14.2 Circuit-breakers protecting only in one direction of current, and enabling the current in both directions

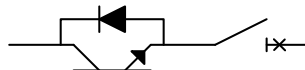


Figure 2 – Unidirectional protection, bidirectional current flow

4.14.3 Circuit-breakers protecting in both directions of current, and enabling the current in both directions

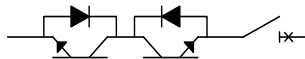


Figure 3 – Bidirectional protection, bidirectional current flow

4.15 According to the existence of a stand-by state

- With a stand-by state
- Without stand-by state

5 Characteristics of semiconductor circuit-breaker

5.1 Summary of characteristics

The characteristics of a semiconductor circuit-breaker shall be stated in terms of the following, as applicable:

- type of circuit-breaker (5.2);
- rated and limiting values of the main circuit (5.3);
- selectivity categories (5.4);
- control circuits (5.5);
- auxiliary circuits (5.6);
- releases (5.7);
- integral fuses (integrally fused circuit-breakers) (X.X).

5.2 Type of circuit-breaker

The following shall be stated:

- type of semiconductor circuit-breaker (see 4.1);
- direction of current flow and protection per pole (see 4.14)
- number of poles;
- kind of current (AC or DC) and, in the case of AC, number of phases and rated frequency.

5.3 Rated and limiting values of the main circuit

5.3.1 General

The rated values established for a semiconductor circuit-breakers shall be stated in accordance with 5.3.2 to 5.5, but it is not necessary to establish all the rated values listed.

5.3.2 Rated voltages

5.3.2.1 Rated operational voltage (U_e)

Subclause 5.3.1.1 of IEC 60947-1:2020 applies with the following amplification:

- Circuit-breakers covered by clause 5.3.1.1 item a) of IEC 60947-1:2020.

U_e is generally stated as the voltage between phases.

NOTE 1 In Canada and the USA, the rated operational voltage U_e is stated as

a) the voltage between phases and earth, together with the voltage between phases (for example 277 V/480 V) for three-phase four-wire neutral earthed systems;

b) the voltage between phases (for example 480 V) for three-phase three-wire unearthed or impedance earthed systems.

Circuit-breakers for unearthed or impedance earthed systems (IT) require additional tests according to Annex H.

- Circuit-breakers covered by clause 5.3.1.1 item b) of IEC 60947-1:2020.

These circuit-breakers require additional tests according to Annex C.

U_e shall be stated as the voltage between phases preceded by the letter C.

NOTE 2 According to present practice in Canada and the USA, circuit-breakers covered by clause 5.3.1.1 item b) of IEC 60947-1:2020 are identified by the voltage between phases only.

5.3.2.2 Rated insulation voltage (U_i)

Subclause 5.3.1.2 of IEC 60947-1:2020 applies.

5.3.2.3 Rated impulse withstand voltage (U_{imp})

Subclause 5.3.1.3 of IEC 60947-1:2020 applies.

5.3.3 Currents

5.3.3.1 Conventional free-air thermal current (I_{th})

Subclause 5.3.2.1 of IEC 60947-1:2020 applies.

5.3.3.2 Conventional enclosed thermal current (I_{the})

Subclause 5.3.2.2 of IEC 60947-1:2020 applies.

5.3.3.3 Rated current (I_n)

For semiconductor circuit-breakers, the rated uninterrupted current (I_u) (see 5.3.2.4 of IEC 60947-1:2020) is equal to the conventional free-air thermal current (I_{th}).

5.3.4 Rated frequency

Subclause 5.3.3 of IEC 60947-1:2020 applies.

5.3.5 Rated duty

The rated duties considered as normal are:

- the eight-hour duty (see 5.3.4.1 of IEC 60947-1:2020),
- the uninterrupted duty (see 5.3.4.2 of IEC 60947-1:2020).

5.3.6 Short-circuit characteristics**5.3.6.1 Rated short-circuit making capacity (I_{cm})**

The rated short-circuit making capacity of a circuit-breaker is the value of short-circuit making capacity assigned to that circuit-breaker by the manufacturer for the rated operational voltage at rated frequency and at a specified power factor for AC, or time constant for DC. It is expressed as the maximum prospective peak current.

For AC, the rated short-circuit making capacity of a circuit-breaker shall be not less than its rated ultimate short-circuit breaking capacity, multiplied by the factor n of Table 1 (see 5.3.6.3).

For DC, the rated short-circuit making capacity of a circuit-breaker shall be not less than its rated ultimate short-circuit breaking capacity.

A rated short-circuit making capacity implies that the circuit-breaker shall be able to make the current corresponding to that rated capacity at the appropriate applied voltage related to the rated operational voltage.

5.3.6.2 Rated short-circuit breaking capacities**5.3.6.2.1 General**

The rated short-circuit breaking capacities of a circuit-breaker are the values of short-circuit breaking capacity assigned to that circuit-breaker by the manufacturer for the rated operational voltage, under specified conditions.

NOTE A circuit-breaker in accordance with this standard is able to break phase-to-phase, phase-to-earth and phase-to-neutral short-circuits

A rated short-circuit breaking capacity requires that the circuit-breaker shall be able to break any value of short-circuit current up to and including the value corresponding to the rated capacity at a power-frequency recovery voltage corresponding to the prescribed test voltage values and:

for AC, at any power factor not less than that of

- Table 16 – (see 9.3.3.2.4);
- for DC, with any time constant not greater than that Table 16 (see 9.3.3.2.5).

For power-frequency recovery voltages in excess of the prescribed test voltage values (see 9.3.3.2.6), no short-circuit breaking capacity is guaranteed.

For AC, the circuit-breaker shall be capable of breaking a prospective current corresponding to its rated short-circuit breaking capacity and the related power factor given in Table 16, irrespective of the value of the inherent DC component, on the assumption that the AC component is constant.

The rated short-circuit breaking capacities are stated as:

- rated ultimate short-circuit breaking capacity I_{cu} ;
- rated service short-circuit breaking capacity I_{cs} .

5.3.6.2.2 Rated ultimate short-circuit breaking capacity (I_{cu})

The rated ultimate short-circuit breaking capacity of a circuit-breaker is the value of ultimate short-circuit breaking capacity (see 3.2.13) assigned to that circuit-breaker by the manufacturer for the corresponding rated operational voltage, under the conditions specified in 9.3.6. It is expressed as the value of the prospective breaking current, in kA.

5.3.6.2.3 Rated service short-circuit breaking capacity (I_{cs})

The rated service short-circuit breaking capacity of a circuit-breaker is the value of service short-circuit breaking capacity (see 3.2.14) assigned to that circuit-breaker by the manufacturer for the corresponding rated operational voltage, under the conditions specified in 9.3.5. It is expressed as a value of prospective breaking current, in kA, or as a % of I_{cu} (for example $I_{cs} = 25 \% I_{cu}$).

I_{cs} shall be at least equal to 25 % of I_{cu} .

5.3.6.3 Standard relationship between short-circuit making and breaking capacities and related power factor, for AC circuit-breakers

The standard relationship between short-circuit breaking capacity and short-circuit making capacity is given in Table 1.

The rated short-circuit making and breaking capacities are only valid when the circuit-breaker is operated in accordance with the requirements of 8.2.1.1 and 8.2.1.2.

For special requirements, the manufacturer may assign a value of rated short-circuit making capacity higher than that required by Table 1. Tests to verify these rated values shall be the subject of agreement between manufacturer and user.

5.4 Selectivity categories

Sec Note: to be further discussed

5.5 Electrical Control Circuits

Subclause 5.5.1 of IEC 60947-1:2020 applies, with the following addition:

If the rated control supply voltage is different from that of the main circuit, it is recommended that its value be chosen from Table 3.

5.6 Auxiliary Circuits

Subclause 5.6 of IEC 60947-1:2020 applies.

5.7 Releases

5.7.1 Release functions

For the purpose of this document, the following types of releases are considered:

- 1) Shunt release function
- 2) Over-current release function:
 - a) instantaneous;
 - a) definite time delay;
 - b) inverse time delay:
 - independent of previous load;
 - dependent on previous load (for example thermal type release).

NOTE 1 The term "overload release" is used to identify over-current releases intended for protection against overloads (see "3.6.31 of IEC 60947-1:2020). The term "short-circuit release" is used to identify over-current releases intended for protection against short circuits (see 3.2.10).

NOTE 2 The term "adjustable release" used in this standard also includes interchangeable releases.

- 3) Undervoltage release function (for opening);
- 4) Closing release function;
- 5) Remote release function;
- 6) Other releases function.

5.7.2 Characteristics

The following characteristics shall be considered:

- 1) shunt release and undervoltage release (for opening), and closing release:
 - rated control circuit voltage (U_c);
 - kind of current;
 - rated frequency, if AC;
- 2) over-current release:
 - rated current (I_n);
 - kind of current;
 - rated frequency, if AC;
 - current setting (or range of settings);
 - time setting (or range of settings) if applicable.

The rated current of an over-current release is the value of current (RMS, if AC) corresponding to the maximum current setting which it shall be capable of carrying under the test conditions specified in 9.3.3.5, without the temperature-rise exceeding the values specified in Table 6.

5.7.3 Current setting of over-current releases

For circuit-breakers fitted with adjustable releases (see Note 2 to 5.7.1, item 2), the current settings shall be marked on the release, or displayed on the screen of the release, or displayed

on screen of an external device connectable to the release. The information may be either directly in amperes or as a multiple of the current value. Means shall be provided by the manufacturer to read the display or the external device regardless of the status of the circuit-breaker. When applicable, the manufacturer shall specify the characteristics of the external device.

For circuit-breakers fitted with non-adjustable releases, the marking may be on the circuit-breaker. If the operating characteristics of the overload release comply with the requirements of Table 5, it will be sufficient to mark the circuit-breaker with its rated current (I_n).

The current settings may be adjusted through an external (local or remote) device connectable to the release, in which case either local setting indications shall not be exceeded, or a local indication shall show that the settings are controlled remotely. The manufacturer shall provide means to the testing laboratory to ensure settings do not change during type tests.

In the case of indirect releases operated by current transformers, the marking may refer either to the primary current of the current transformer through which they are supplied, or to the current setting of the overload release. In either case, the ratio of the current transformer shall be stated.

Unless otherwise specified:

- the operating value of overload releases other than those of the thermal type is independent of the ambient air temperature within the limits of -5 °C to $+40\text{ °C}$;

- for releases of the thermal type, the values stated are for a reference temperature of $+30\text{ °C} \pm 2\text{ °C}$. The manufacturer shall be prepared to state the influence of variations in the ambient air temperature (see 8.2.1.2.4, item b)).

5.7.4 Tripping time setting of over-current releases

The tripping time shall be stated as follows, depending on the type of over-current release:

1) Definite time-delay over-current releases

The time-delay of such releases is independent of the over-current. The tripping time setting shall be stated as the duration in seconds of the opening time of the circuit-breaker, if the time-delay is not adjustable, or the extreme values of the opening time, if the time-delay is adjustable.

2) Inverse time-delay over-current releases

The time-delay of such releases is dependent on the over-current.

The time/current characteristics shall be given in the form of curves supplied by the manufacturer. These shall indicate how the opening time, starting from the cold state, varies with current within the range of operation of the release. The manufacturer shall indicate, by suitable means, the tolerances applicable to these curves.

These curves shall be given for each extreme value of the current setting and, if the time setting for a given current setting is adjustable, it is recommended that they be given in addition for each extreme value of the time setting.

It is recommended that the current be plotted as abscissa and the time as ordinate, using logarithmic scales. Furthermore, in order to facilitate the study of co-ordination of different types of over-current protection, it is recommended that the current be plotted as multiples

of the setting current and the time in seconds on the standard graph sheets detailed in 5.6.1 of IEC 60269-1:2006.

6 Product information

6.1 Nature of the information

Subclause 6.1 of IEC 60947-1:2020 applies, as far as appropriate for a particular design.

In addition, the manufacturer shall make available, upon request, information concerning typical functional power for the various frame sizes (see 3.2.3). See Annex G.

6.2 Marking

Each circuit-breaker shall be marked in a durable manner; data to be provided and corresponding locations are indicated in Table 4.

6.3 Instructions for installation, operation and maintenance instructions, decommissioning and dismantling

Subclause 6.3 of IEC 60947-1:2020 applies with the following addition:

Additional information for the decommissioning and dismantling of the circuit-breaker shall be provided to the user in the case of a foreseeable hazardous condition, for example due to stored energy or hazardous substances.

7 Normal service, mounting and transport conditions

Clause 7 of IEC 60947-1:2020 applies with the following addition:

Pollution degree (see 7.1.3.2 of IEC 60947-1:2020).

Unless otherwise stated by the manufacturer, a circuit-breaker is intended for installation under environmental conditions of pollution degree 3.

8 Constructional and performance requirements

8.1 Constructional requirements

8.1.1 General

Subclause 8.1 of IEC 60947-1:2020 applies with the following modifications:

- a) Where, in 8.1.2.2 of IEC 60947-1:2020, the test temperature is to be specified, the value required by this document for the parts necessary to retain in position current-carrying parts is 960 °C for the main circuit and 850 °C for the other circuits.

NOTE "other circuits" cover control circuits (5.5), auxiliary circuits (5.6) and releases (5.7)

- b) The requirements of 8.1.2 of IEC 60947-1:2020 do not apply to parts with a mass lower than 2 g (insignificant mass, in accordance with 3.14 of IEC 60695-2-11:2014). For products containing more than one small part, the total mass of non-tested parts located within 3 mm of each other shall not exceed 10 g.

NOTE this distance of 3 mm is defined in 30.2 of IEC 60335-1:2020

When aluminium conductors are to be used, Annex D applies.

901 NOTE Guidance for the development of embedded software is offered in IEC TR 63201

902 It shall be possible to operate the circuit-breaker manually.

903 **8.1.2 Withdrawable circuit-breakers**

904 In the disconnected position, the isolating contacts of the main circuit and, where applicable,
905 auxiliary circuits of withdrawable circuit-breakers shall have isolating distances which comply
906 with the requirements specified for the isolating function, taking account of manufacturing
907 tolerances and changes in dimensions due to wear.

908 The withdrawable mechanism shall be fitted with a reliable indicating device which indicates
909 unambiguously the positions of the isolating contacts.

910 The withdrawable mechanism shall be fitted with interlocks which only permit the isolating
911 contacts to be separated or reclosed when the main contacts of the circuit-breaker are open.

912 In addition, the withdrawable mechanism shall be fitted with interlocks which only permit the
913 main contacts to be closed

914 – when the isolating contacts are fully closed, or

915 – when the specified isolating distance is achieved between the fixed and moving parts of
916 the isolating contacts (disconnected position).

917 When the circuit-breaker is in the disconnected position, means shall be provided to ensure
918 that the specified isolating distances between the isolating contacts cannot be inadvertently
919 reduced.

920 **8.1.3 Requirements for isolation function**

921 Subclause 8.1.7 of IEC 60947-1:2020 applies.

922 For additional requirements concerning performance, see 8.2.6.

923 For equipment provided with actuator or indicator for “control position” or “standby position”,
924 which are not the indicated open position, those positions shall be clearly identified as given in
925 Annex A. The marking of such positions shall not include the symbol “O”.

926 **8.1.4 Clearances and creepage distances**

927 Minimum values are given in Table 13 of IEC 60947-1:2020 and in Table 15 of IEC 60947
928 1:2020.

929 For Uimp values exceeding the values given in Table 13 of IEC 60947-1:2020, clearances shall
930 be obtained from Table F.2 of IEC 60664-1:2020.

931 **8.1.5 Requirements for the safety of the operator**

932 There shall be no path or opening which allows incandescent particles to be discharged from
933 the area of the manual operating means.

934 Compliance is checked by the provisions of 9.3.3.6.1, item b).

935 **8.1.6 List of construction breaks**

936 Circuit-breakers of a given frame size are considered to have a construction break (see 3.2.4)
937 if any one of the following features are not the same:

- material, finish and dimensions of internal current-carrying parts, admitting, however, the variations listed in a), b), c), f) and g) below;
- size, material, configuration and method of attachment of the isolation contacts and/or parallel mechanical contacts ;
- any integral manual operating mechanism, its materials and physical characteristics;
- moulding and insulating materials;
- the characteristics of the power semiconductor (including principle of operation, materials, supplier) and its control circuit ;
- the basic design of the over-current tripping devices, admitting, however, the variations detailed in a), b) and c) below.

Variations in the following do not constitute a construction break:

- a) dimensions of terminals, provided that creepage and clearance distances are not reduced;
- b) in the case of thermal and magnetic releases those dimensions and materials of the release components, including flexible connections, which determine the current rating;
- c) secondary windings of current transformer operated releases;
- d) external operating means, additional to the integral operating means;
- e) type designation and/or purely aesthetic features (e.g. labels);
- f) difference in embedded software (firmware) in electronic trip units, which has no impact on the required performance, in particular the tripping function;
- g) electronic trip unit hardware, due to omitted components on identical printed circuit board layout (e.g. rotary knobs, display, etc.).

8.1.7 Additional requirements for circuit-breakers provided with a neutral pole

Subclause 8.1.9 of IEC 60947-1:2020 applies with the following addition:

8.1.8 Digital inputs and outputs for use with programmable logic controllers (PLCs)

Annex S of IEC 60947-1:2020 applies. For the purposes of this standard, this requirement does not apply to digital inputs and outputs dedicated to devices other than PLCs.

8.1.9 Indication of the Stand-by position

8.1.9.1 General

Indication of the stand-by position is verified in accordance with 9.x.x.x

8.1.9.2 Devices without stand-by position indication

Stand-by position is not indicated.

8.1.9.3 Devices with stand-by position indication

8.2 Information of booting and/or queries to e.g. thermal memory. Performance requirements

8.2.1 Operating conditions

8.2.1.1 Closing

8.2.1.1.1 General

For a circuit-breaker to be closed safely on to the making current corresponding to its rated short-circuit making capacity, it is essential that it should be operated with the same speed and the same firmness as during the type test for proving the short-circuit making capacity, if applicable.

Sec Note: NCs are invited to make a proposal in regard to the operating mechanism.

8.2.1.2 Opening

8.2.1.2.1 General

Semiconductor circuit-breakers shall return to and remain in stand-by or in open position (see 4.4), when the opening (i.e. tripping) operation is initiated after the initiation of the closing operation, even if the closing command is maintained.

Semiconductor circuit-breakers shall have their energy for the tripping operation stored automatically prior to the completion of the closing operation.

8.2.1.2.2 Opening by undervoltage release function

Subclause 8.2.1.3 of IEC 60947-1:2020 applies.

8.2.1.2.3 Opening by shunt releases function

Subclause 8.2.1.4 of IEC 60947-1:2020 applies.

8.2.1.2.4 Opening by over-current function

a) Opening under short-circuit conditions

The short-circuit release shall cause tripping of the circuit-breaker with an accuracy of $\pm 20\%$ of the tripping current value of the current setting for all values of the current setting of the short-circuit current release.

Where necessary for over-current co-ordination (see XX), the manufacturer shall provide information (usually curves) showing:

- maximum cut-off (let-through) peak current (see 3.7.21 of IEC 60947-1:2020) as a function of prospective current (RMS symmetrical);

Conformity with this information may be checked during the relevant type tests in test sequences II and III (see 9.3.6).

NOTE 1 It is possible to provide other forms of data to verify co-ordination characteristics of circuit-breakers, for example, tests on combinations of short-circuit protective devices.

b) Opening under overload conditions

1) Instantaneous or definite time-delay operation

The release shall cause tripping of the circuit-breaker with an accuracy of $\pm 10\%$ of the tripping current value of the current setting for all values of current setting of the overload release.

2) Inverse time-delay operation

Conventional values for inverse time-delay operation are given in Table 5.

At the reference temperature (see 5.7.3) and at 1,05 times the current setting (see 3.6.38 of IEC 60947-1:2020), i.e. with the conventional non-tripping current (see 3.7.30 of

1015 IEC 60947-1:2020), the opening release being energized on all phase poles, tripping
1016 shall not occur in less than the conventional time (see 3.7.30 of IEC 60947-1:2020) from
1017 the cold state, i.e. with the circuit-breaker at the reference temperature.

1018 Moreover, when at the end of the conventional time the value of current is immediately
1019 raised to 1,30 times the current setting, i.e. with the conventional tripping current (see
1020 3.7.31 of IEC 60947-1:2020), tripping shall then occur in less than the conventional time
1021 later.

1022 NOTE 2 The reference temperature is the ambient air temperature on which the time-current characteristic of the
1023 circuit-breaker is based.

1024 If a release is declared by the manufacturer as substantially independent of ambient
1025 temperature, the current values of Table 5 shall apply within the temperature band declared by
1026 the manufacturer, within a tolerance of 0,3 % /K.

1027 The width of the temperature band shall be at least 10 K on either side of the reference
1028 temperature.

1029 **8.2.2 Temperature-rise**

1030 **8.2.2.1 Temperature-rise limits**

1031 The temperature-rises of the several parts of a circuit-breaker, measured under the conditions
1032 specified in 9.3.3.5, shall not exceed the limiting values stated in Table 6 during the tests made
1033 in accordance with 9.3.4.9. The temperature-rises of the terminals shall not exceed the limiting
1034 values stated in Table 6 during the tests made in accordance with 9.3.5.5 and 9.3.7.4.

1035 **8.2.2.2 Ambient air temperature**

1036 The temperature-rise limits given in Table 6 are applicable only if the ambient air temperature
1037 remains within the limits given in 7.1.1 of IEC 60947-1:2020.

1038 **8.2.2.3 Main circuit**

1039 The main circuit of a circuit-breaker, including the over-current releases which may be
1040 associated with it, shall be capable of carrying its rated current I_n , under the conditions of
1041 Clause 9, without the temperature-rises exceeding the limits specified in Table 6.

1042 **8.2.2.4 Electrical control circuits**

1043 The control circuits, including control circuit devices, used for the closing and opening
1044 operations of a circuit-breaker, shall permit the rated duty, as specified in 5.3.5, and also the
1045 temperature-rise tests under the test conditions specified in 9.3.3.5, to be made without the
1046 temperature rises exceeding the limits specified in Table 6.

1047 The requirements of this subclause shall be verified on a new circuit-breaker. Alternatively, at
1048 the discretion of the manufacturer, the verification may be made during the temperature-rise
1049 test of 9.3.4.9.

1050 **8.2.2.5 Auxiliary circuits**

1051 Auxiliary circuits, including auxiliary devices, shall be capable of carrying their conventional
1052 thermal current without the temperature-rises exceeding the limits specified in Table 6 when
1053 tested in accordance with 9.3.3.5.

1054 **8.2.3 Dielectric properties**

1055 **8.2.3.1 General**

1056 Subclauses 8.2.3.1 a) and 8.2.3.1 b) of IEC 60947-1:2020 apply

1057 Type tests shall be made in accordance with 9.3.4.3.

1058 The verification of dielectric withstand during all test sequences shall be made in accordance
1059 with 9.3.4.8.

1060 Routine tests shall be made in accordance with 9.4.6.

1061 **8.2.3.2 Impulse withstand voltage**

1062 Subclause 8.2.3.2 of IEC 60947-1:2020 applies.

1063 For circuit-breakers rated above 1 000 V AC, the impulse withstand voltage shall be agreed
1064 between the manufacturer and the user but shall not be less than the corresponding values for
1065 1 000 V AC.

1066 **8.2.3.3 Power-frequency withstand voltage of the main, auxiliary and control circuits**

1067 Power-frequency tests are used in the following cases:

- 1068 – dielectric tests as type tests for the verification of solid insulation;
- 1069 – dielectric withstand verification, as a criterion of failure, after switching or short-circuit
1070 type tests;
- 1071 – routine tests.

1072 **8.2.3.4 Clearances**

1073 Subclause 8.2.3.4 of IEC 60947-1:2020 applies.

1074 **8.2.3.5 Creepage distances**

1075 Subclause 8.2.3.5 of IEC 60947-1:2020 applies.

1076 **8.2.3.6 Solid insulation**

1077 Solid insulation shall be verified by either power-frequency tests, in accordance with 9.3.3.4.1,
1078 item 3) of IEC 60947-1:2020, or DC tests (test voltages for DC tests are under consideration).

1079 For the purposes of this standard, control and auxiliary circuits incorporating solid-state devices
1080 and bridging the solid insulation of the main circuits shall be disconnected for the tests.

1081 **8.2.3.7 Spacing between separate circuits**

1082 Subclause 8.2.3.7 of IEC 60947-1:2020 applies.

1083 **8.2.4 Ability to make and break under no load, normal load and overload conditions**

1084 **8.2.4.1 Overload performance**

1085 This requirement applies to circuit-breakers of rated current up to and including 630 A.

1086 The circuit-breaker shall be capable of carrying out the number of operating cycles with current
1087 in the main circuit exceeding its rated current, under the test conditions according to 9.3.4.6.

1088 Each operating cycle consists of a making operation followed by a breaking operation.

1089 **8.2.4.2 Operational performance capability**

1090 Subclause 8.2.4.2 of IEC 60947-1:2020 applies with the following additions:

The circuit-breaker shall be capable of meeting the requirements of Table 7:

- for the test of operational performance without current in the main circuit under the test conditions specified in 9.3.4.5.3;
- for the test of operational performance with current in the main circuit under the test conditions specified in 9.3.4.5.4.

Each operating cycle consists of, either a closing operation followed by an opening operation, or an opening operation followed by a closing operation (both with or without current).

8.2.5 Ability to make and break under short-circuit conditions

Subclause 8.2.5 of IEC 60947-1:2020 applies with the following amplifications:

The rated short-circuit making capacity shall be in accordance with 5.3.6.1 and 5.3.6.3.

The rated short-circuit breaking capacity shall be in accordance with 5.3.6.2.

NOTE It is the manufacturer's responsibility to ensure that the tripping characteristic of the circuit-breaker is compatible with the capability of the circuit-breaker to withstand the inherent thermal and electrodynamic stresses.

8.2.6 Requirements for isolation function

Subclause 8.2.7 of IEC 60947-1:2020 applies and tests shall be made in accordance with 9.3.4.3, 9.3.4.8, 9.3.4.12, 9.3.5.4, 9.3.6.4 and 9.3.8.8, as applicable.

8.3 Electromagnetic compatibility (EMC)

Requirements and test methods are given in Annex J.

9 Tests

9.1 Kind of tests

9.1.1 General

Subclause 9.1 of IEC 60947-1:2020 applies, with the following additions:

The tests to verify the characteristics of circuit-breakers are:

- type tests (see 9.3);
- routine tests (see 9.4);
- special tests (see 9.5).

9.1.2 Type tests

Type tests include the tests listed in Table 8.

Type tests shall be carried out by the manufacturer, in his workshop or at any suitable laboratory of his choice.

9.1.3 Routine tests

Routine tests comprise the tests listed in 9.4.

9.1.4 Special tests

Special tests comprise the tests listed in 9.5.

9.2 Compliance with constructional requirements

Subclause 9.2 of IEC 60947-1:2020 applies.

9.3 Type tests

9.3.1 General

In order to avoid repetition of identical tests applicable to the various test sequences, the general test conditions have been grouped together at the beginning of this subclause under three headings:

- test conditions applicable to all sequences (9.3.4 to 9.3.9);
- test conditions applicable to temperature-rise tests (9.3.3.5);
- test conditions applicable to short-circuit tests (9.3.3.6).

Wherever appropriate, these general test conditions refer back to, or are based on, the general rules of IEC 60947-1.

Each test sequence refers back to the general test conditions applicable. This requires the use of cross-references, but enables each test sequence to be presented in a much simplified form.

Throughout this clause the term "test" has been used for every test to be made; "verification" should be interpreted as "test for the verification" and has been used where it is intended to verify the condition of the circuit-breaker following an earlier test in a test sequence whereby it may have been adversely affected.

In order to facilitate locating a particular test condition or test, an alphabetical index is given in Table 9, using the terms most likely to be used (not necessarily the exact terms appearing in the relevant subclause heading).

9.3.2 Test sequences

9.3.2.1 General

Type tests are grouped together in a number of sequences, as shown in Table 10.

For each sequence, tests shall be made in the order listed unless otherwise specified in this document.

9.3.2.2 Tests omitted from sequence I and made separately

With reference to 9.1.1 of IEC 60947-1:2020, the following tests of test sequence I (see 9.3.4) may be omitted from the sequence and made on separate samples:

- tripping limits and characteristics (9.3.4.2); in which case the sample(s) tested in the sequence shall be subjected to the tests of 9.3.4.2.4 only on the phase poles at the maximum setting, at room temperature and without the additional test of item b) to verify the time-current characteristic;
- test of dielectric properties (9.3.4.3);
- test of under-voltage releases of 9.3.4.5.2.3 and 9.3.4.5.3 to verify the requirements of 8.2.1.3 of IEC 60947-1:2020, and tests of under-voltage releases at alternative frequencies (see 9.3.3.1);
- test of shunt releases of 9.3.4.5.2.4 and 9.3.4.5.3 to verify the requirements of 8.2.1.4 of IEC 60947-1:2020, and tests of shunt releases at alternative frequencies (see 9.3.3.1);
- additional tests for operational performance capability without current for withdrawable circuit-breakers (9.3.4.5.5).

9.3.2.3 Applicability of sequences according to the relationship between short-circuit ratings

The applicability of test sequences according to the relationship between I_{CS} , I_{CU} and I_{CW} is given in Table 11.

9.3.2.4 Alternative test programmes for AC circuit-breakers having a different number of poles

These alternative test programs may only be applied to AC ratings and when all the ratings are the same or lower than the variant submitted to the full program of Table 10, and construction breaks are the same for all variants. In the case of 1-pole circuit-breakers the voltage ratings shall be equal to or lower than the line-to neutral voltage of the variant tested to Table 10. A 2-pole circuit-breaker produced by removing the center current path from a 3-pole circuit-breaker tested to program 1 or program 2 of this subclause need not be tested as it is considered to be covered by the tests on the 3-pole variant.

Compliance with the test requirements is met by carrying out one of the alternative programs 1 or 2 below.

- Programme 1: The applicable test sequences according to Table 10 shall be carried out on the three-pole variant. In addition, where applicable, the tests or test sequences listed in Table 13 shall be carried out on the other variants.
- Programme 2: The applicable test sequences according to Table 10 shall be carried out on the four-pole variant. In addition, where applicable, the tests or test sequences listed in Table 14 shall be carried out on the other variants.

The principle for the application of the alternative test programs is illustrated in the Table 12.

9.3.3 General test conditions

9.3.3.1 General requirements

Unless otherwise agreed by the manufacturer, each test sequence shall be made on a sample circuit-breaker (or set of samples) in a clean and new condition.

The number of samples to be tested for each test sequence and the test conditions (for example setting of overload releases, terminal connections), according to the circuit-breaker parameters, are given in Table 15 or, where applicable, for the alternative test programs in Table 13 and Table 14 (see 9.3.2.4).

Where necessary, additional information is given in the relevant subclauses.

Unless otherwise specified, tests are to be performed on a circuit-breaker having the maximum rated current for a given frame size and are deemed to cover all rated currents of that frame size.

In the case of one or more construction breaks (see 3.2.4 and 8.1.9) within the frame size, further samples shall be tested in accordance with Table 13 and/or Table 15 as applicable.

Unless otherwise stated, short-circuit releases shall be set at maximum (time and current) for all tests.

The circuit-breakers to be tested shall, in all their essential details, correspond to the design of the type which they represent.

Unless otherwise stated, the tests shall be made with the same kind of current and, in the case of AC, at the same rated frequency and with the same number of phases as in the intended

1209 service. Tests performed at 50 Hz cover 60 Hz applications and vice-versa, except for the
1210 performance of under-voltage and shunt releases (see 8.2.1 of IEC 60947-1:2020 and 8.2.2.7
1211 of IEC 60947-1:2020).

1212 If the mechanism is electrically controlled, it shall be supplied at the minimum voltage as
1213 specified in XXX. In addition, electrically controlled mechanisms shall be energized via the
1214 appropriate circuit-breaker control circuits complete with switching devices. It shall be verified
1215 that the circuit-breaker operates correctly on no-load when it is operated under the above
1216 conditions.

1217 In case of circuit-breakers with dependent manual operation (see 3.6.12 of 60947-1:2020), the
1218 circuit-breaker shall be operated with an operating speed, during actuation, of $0,1 \text{ m/s} \pm 25 \%$,
1219 this speed being measured where the operating means of the test apparatus touches the
1220 actuating means of the circuit-breaker under test. For rotary handles the angular velocity shall
1221 correspond substantially to the above conditions, referred to the speed of the operating means
1222 (at its extremities) of the circuit-breaker under test.

1223 The circuit-breaker under test shall be mounted complete on its own support or an equivalent
1224 support.

1225 Unless otherwise stated, the connections of the complete circuit-breaker, and of the separate
1226 release (when applicable, see 9.3.4.2.1), shall be made as for normal service, with conductors
1227 of cross-section corresponding to the rated current (I_n) (see Table 9 and Table 10 and Table
1228 11 of IEC 60947-1:2020) and of length according to 9.3.3.3.4 of IEC 60947-1:2020. In case of
1229 aluminium conductors, their cross sections shall be in accordance with Table D.7 or Table D.8,
1230 as applicable.

1231 Circuit-breakers shall be tested in free air.

1232 If a circuit-breaker may be used in specified individual enclosures and has been tested in free
1233 air, it shall be additionally tested in the smallest of such enclosures stated by the manufacturer,
1234 using a new sample, for each of the following:

- 1235 a) A short-circuit test according to 9.3.6, at U_e max, and corresponding I_{cu} , with release
1236 settings at maximum (see Footnote ^a of Table 15).
- 1237 b) A temperature-rise test according to the general conditions of 9.3.3.5 on a circuit-breaker
1238 having a maximum I_{th} , at the conventional enclosed thermal rating I_{the} (see 5.3.3.2). The
1239 temperature-rises shall meet the requirements of 8.2.2 except that the temperature rise of
1240 the terminals shall not exceed 70 K.

1241 Details of these tests, including the dimensions of the enclosure, shall be stated in the test
1242 report.

1243 NOTE An individual enclosure is an enclosure designed and dimensioned to contain one circuit-breaker only.

1244 However, if a circuit-breaker may be used in specified individual enclosures and is tested
1245 throughout in the smallest of such enclosures stated by the manufacturer, the tests in free air
1246 need not be made provided that such enclosure is bare metallic, without insulation. Details,
1247 including the dimensions of the enclosure, shall be stated in the test report.

1248 For the tests in free air, for tests concerning overload performance (9.3.4.6), short-circuit
1249 (9.3.5.2, 9.3.6.3, 9.3.7.5, 9.3.8.2, 9.3.8.6, 9.3.8.7 and 9.3.9.4), and short-time withstand current
1250 (9.3.7.3 and 9.3.9.3) where applicable, a metallic screen shall be placed on all sides of the
1251 circuit-breaker in accordance with the manufacturer's instructions. Details, including distances
1252 of the metallic screen from the circuit-breaker, shall be stated in the test report.

1253 The characteristics of the metallic screen shall be as follows:

- 1254 • structure: woven wire mesh; or
- 1255 perforated metal; or
- 1256 expanded metal;
- 1257 • ratio hole area/total area: 0,45 to 0,65;
- 1258 • size of hole: not exceeding 30 mm²;
- 1259 • finish: bare or conductive plating;
- 1260 • resistance: shall be included in the calculation for the prospective fault current in the fusible
- 1261 element circuit (see 9.3.4.1.2, item d) of IEC 60947-1:2020) when measured from the
- 1262 furthest point on the metallic screen likely to be reached by arc emissions.

1263 The tightening torques to be applied to the terminal screws shall be in accordance with the
1264 manufacturer's instructions (see 6.2 and Table 4).

1265 Unless otherwise stated, all tests shall be performed with forward connections.

1266 Maintenance or replacements of parts is not permitted.

1267 If, for convenience of testing, it appears useful to increase the severity of a test (for example to
1268 adopt a higher frequency of operation in order to reduce the duration of the test), this shall not
1269 be done without the consent of the manufacturer.

1270 For single-phase tests on individual poles of multipole circuit-breakers intended for use on
1271 phase-earthed systems, see Annex C.

1272 For additional tests for circuit-breakers for unearthed or impedance earth systems (IT), see
1273 Annex H.

1274 **9.3.3.2 Test quantities**

1275 **9.3.3.2.1 Values of test quantities**

1276 Subclause 9.3.2.2.1 of IEC 60947-1:2020 applies.

1277 **9.3.3.2.2 Tolerances on test quantities**

1278 Subclause 9.3.2.2.2 of IEC 60947-1:2020 applies.

1279 **9.3.3.2.3 Frequency of the test circuit for AC**

1280 All tests shall be made at the rated frequency of the circuit-breaker. For all short-circuit tests,
1281 if the rated breaking capacity is essentially dependent on the value of the frequency, the
1282 tolerance shall not exceed ± 5 %.

1283 If the manufacturer declares the rated breaking capacity to be substantially unaffected by the
1284 value of the frequency, the tolerance shall not exceed ± 25 %.

1285 **9.3.3.2.4 Power factor Time constant of the test circuit**

1286 Subclause 9.3.4.1.3 of IEC 60947-1:2020 applies with the following modification:

1287 Table 16 of IEC 60947-1:2020 is replaced by Table 16 of this document.

1288 **9.3.3.2.5 Time constant of the test circuit**

1289 Subclause 9.3.4.1.4 of IEC 60947-1:2020 applies with the following modification:

1290 Table 16 of IEC 60947-1:2020 is replaced by Table 16 of this document.

1291 **9.3.3.2.6 Power-frequency recovery voltage**

1292 Subclause 9.3.2.2.3, item a) of IEC 60947-1:2020.

1293 **9.3.3.2.7 Ripple of the test current for DC**

1294 The test current shall comply with the requirements of 6.3.1 of IEC 62475:2010.

1295 **9.3.3.3 Evaluation of test results**

1296 The condition of the circuit-breaker after tests shall be checked by the verifications applicable
1297 to each sequence.

1298 A circuit-breaker is deemed to have met the requirements of this standard if it meets the
1299 requirements of each sequence as applicable.

1300 The case shall not be broken but hairline cracks are acceptable.

1301 NOTE Hairline cracks are a consequence of high gas pressure or thermal stresses due to arcing when interrupting
1302 very high fault currents and are of a superficial nature. Consequently, they do not develop through the entire thickness
1303 of the moulded case of the device.

1304 **9.3.3.4 Test reports**

1305 Subclause 9.3.2.4 of IEC 60947-1:2020 applies.

1306 **9.3.3.5 Test conditions for temperature-rise test**

1307 The circuit-breaker shall meet the requirements of 8.2.2.

1308 Subclause 9.3.3.3 of IEC 60947-1:2020 applies, except 9.3.3.3.6, with the following addition:

1309 The circuit-breaker shall be mounted in accordance with 9.3.3.1.

1310 During the temperature-rise test of sequence I (see 9.3.4.9) coils of under-voltage releases,
1311 where applicable, shall be supplied at one rated frequency and corresponding voltage, chosen
1312 at random. Additional tests to verify coils at other rated frequencies and voltages shall be made
1313 outside the sequence.

1314 For four-pole AC circuit-breakers, a test shall first be made on the three poles which incorporate
1315 over-current releases. For a circuit-breaker having a value of rated current not exceeding 63 A,
1316 an additional test shall be made by passing the test current through the fourth pole and its
1317 adjacent pole. For higher rated current values, the method of testing shall be the subject of a
1318 separate agreement between manufacturer and user.

1319 DC circuit-breakers shall be connected in accordance with manufacturer's instructions. The
1320 details of the connections shall be stated in the test report.

1321 **9.3.3.6 Test conditions for short-circuit tests**

1322 **9.3.3.6.1 General requirements**

1323 Subclause 9.3.4.1.1 of IEC 60947-1:2020 is amplified as follows:

1324 a) The circuit-breaker shall be mounted in accordance with 9.3.3.1.

- b) Unless it can be shown that, with the manual operating means in any position, there is no opening around the manual operating means through which a music wire of 0,26 mm diameter can be inserted so as to reach the arc chamber area, the following test arrangement shall apply:

For opening operations only, a clear, low density polyethylene sheet, 0,05 mm $\pm$ 0,01 mm thick, of a size 100 mm $\times$ 100 mm, positioned as shown in Figure 4, fixed and reasonably stretched in a frame, is placed at a distance of 10 mm from:

- either the maximum projection of the manual closing means of a circuit-breaker without recess for this closing means;
- or the rim of the recess for the manual closing means of a circuit-breaker with recess for this closing means.

The polyethylene sheet shall have the following physical properties:

- density at 23 °C: 0,92 g/cm³ $\pm$ 0,05 g/cm³;
- melting point: 110 °C to 120 °C.

On the side remote from the circuit-breaker there shall be an appropriate backing to obviate tearing of the polyethylene sheet due to the pressure wave which may occur during the short-circuit test (see Figure 4).

For tests other than those in an individual enclosure, a shield which may be of insulating material or of metal is placed between the metallic screen and the polyethylene sheet (see Figure 4).

NOTE This test arrangement applies to O operations only, since it is difficult to arrange for CO operations and it is accepted that O operations are no less severe than CO operations (see 9.3.3.6.4).

- c) The circuit-breaker shall be operated during tests to simulate service conditions as closely as possible

A circuit-breaker having a dependent power operation shall be closed during tests with the control supply (voltage or pressure) at 85 % of its rated value.

A circuit-breaker having an independent power operation shall be closed during tests with the operating mechanism charged to its maximum value stated by the manufacturer.

A circuit-breaker having a stored energy operation shall be closed during tests with the operating means charged at 85 % of the rated voltage of the auxiliary supply.

- d) If a circuit-breaker is fitted with adjustable over-current releases, the setting of these releases shall be as specified for each test sequence.

For circuit-breakers without over-current releases but fitted with a shunt release, this release shall be energized by the application of a voltage equal to 70 % of the rated control supply voltage of the release (see 8.2.1.2.3), at a time not earlier than that of the initiation of the short-circuit nor later than 10 ms after the initiation of the short-circuit.

- e) For all these tests, the line side of the test circuit shall be connected to the corresponding terminals of the circuit-breaker as marked by the manufacturer. In the absence of such markings, the test connections shall be as specified in Table 15.

9.3.3.6.2 Test circuit

Subclause 9.3.4.1.2 of IEC 60947-1:2020.

9.3.3.6.3 Calibration of the test circuit

Subclause 9.3.4.1.5 of IEC 60947-1:2020 applies.

9.3.3.6.4 Test procedure

9.3.3.6.4.1 General

Subclause 9.3.4.1.6 of IEC 60947-1:2020 applies, with the following addition.

1371 Before each short-circuit operation, a temperature stabilization of the circuit-breaker in
1372 accordance with 9.3.2.7 shall be carried out.

1373 **Sec Note:** NCs are asked to prepare proposals for a practical test procedure.

1374 **9.3.3.6.4.2 Tests on one-, two- and three-pole circuit-breakers**

1375 After calibration of the test circuit in accordance with 9.3.3.6.3 the temporary connections are
1376 replaced by the circuit-breaker under test and its connecting cables if applicable.

1377 Tests for the performance under short-circuit conditions shall be made according to the
1378 sequences in Table 10 (see 9.3.2).

1379 For circuit-breakers having a rated current up to and including 630 A, a cable of maximum
1380 length 75 cm, having a cross-section corresponding to the conventional thermal current (see
1381 9.3.3.3.4, Tables 9 and Table 10 of IEC 60947-1:2020) shall be included as follows:

- 1382 – approximately 50 cm on the supply side;
- 1383 – approximately 25 cm on the load side.

1384 For ratings ≤ 20 A, the manufacturer may specify a larger cross-section, in which case this
1385 cross-section shall be used for all relevant short-circuit tests, and stated in the test report. In
1386 addition, a verification of inverse-time delay releases according to 9.3.4.2.4 b) shall be made
1387 with this cross-section.

1388 The sequence of operations shall be that which is applicable to each test sequence, as specified
1389 in 9.3.5.2, 9.3.6.3, 9.3.7.5 and 9.3.8.7.

1390 Alternative test programs for circuit-breakers having three-pole and four-pole variants are given
1391 in 9.3.2.4.

1392 **9.3.3.6.4.3 Tests on four-pole circuit-breakers**

1393 Additional sequences of operations on one or more new samples, in accordance with Table 15,
1394 shall be carried out on the fourth pole and its adjacent pole, according to test sequences III or
1395 V, as applicable, and test sequence IV if applicable. This requirement applies even when test
1396 sequence III is replaced by test sequence II ($I_{cu} = I_{cs}$) or test sequence IV is replaced by test
1397 sequence VI ($I_{cw} = I_{cs}$), i.e., additional tests according to test sequence III or V, and test
1398 sequence IV, as applicable, are required.

1399 Alternatively, at the request of the manufacturer, these tests may be combined with the tests of
1400 9.3.3.6.4.2 and made on the same samples, in which case the test in each relevant test
1401 sequence shall comprise

- 1402 – the test on three adjacent poles,
- 1403 – the test on the fourth pole and the adjacent pole.

1404 The tests on the fourth pole and the adjacent pole are made at an applied voltage of $U_e/\sqrt{3}$, in
1405 the circuit shown in Figure 12 of IEC 60947-1:2020 with the connections C1 and C2 removed.
1406 The test current shall be agreed between manufacturer and user but shall be not less than 60 %
1407 of I_{cu} or I_{cw} , as applicable.

1408 Alternative test programmes for circuit-breakers having three-pole and four-pole variants are
1409 given in 9.3.2.4. When programme 1 is chosen, this subclause applies to the four-pole samples
1410 listed in Table 12.

9.3.3.6.4.4 Test operations

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

O represents a breaking operation;

CO represents a making operation followed, after the appropriate opening time, by a breaking operation:

t represents the time interval between two successive short-circuit operations which shall be as short as possible, allowing for the resetting time of the circuit-breaker, but not less than 3 min. The actual value of t shall be stated in the test report.

The maximum resetting time shall be 15 min or such longer time as may be stated by the manufacturer, but not exceeding 1 h, during which time the circuit-breaker shall not be displaced. Attempts to reclose the circuit-breaker during the resetting time shall be spaced by at least 1 min.

The maximum value of I^2t (see 3.7.18 of IEC 60947-1:2020) during these tests may be recorded in the test report (see 8.2.1.2.4, item a)).

9.3.3.6.5 Behaviour of the circuit-breaker during short-circuit making and breaking tests

Subclause 9.3.4.1.7 of IEC 60947-1:2020 applies.

9.3.3.6.6 Interpretation of records

Subclause 9.3.4.1.8 of IEC 60947-1:2020 applies.

9.3.3.6.7 Verification after short-circuit tests

After the opening operations of the short-circuit making and breaking capacity tests of 9.3.5.2, 9.3.6.3, 9.3.7.5, 9.3.8.2, 9.3.8.7, 9.3.9.4, as applicable, the following conditions shall be met:

- there shall be no damage to the insulation on conductors used to wire the device;
- the polyethylene sheet, where applicable, shall show no holes visible with normal or corrected vision without additional magnification. Minuscule holes of less than 0,26 mm diameter can be ignored;
- the case shall not be broken but hairline cracks are acceptable.

NOTE Hairline cracks are a consequence of high gas pressure or thermal stresses due to arcing when interrupting very high fault currents and are of superficial nature. Consequently, they do not develop through the entire thickness of the moulded case of the device.

Additionally, after the short-circuit tests, the circuit-breaker shall comply with the verifications specified for each test sequence, as applicable.

9.3.3.7 Temperature stabilization at the rated current before type tests

The room temperature shall be equal to the maximum ambient temperature allowed by the manufacturer. Alternatively, the room temperature may be decreased if the current is increased up to the value ensuring the same temperature on semiconductor's housing.

The temperature stabilization shall be carried out in accordance with Figure 5, the switch S1 being closed and the switch S2 being open. The circuit-breaker shall carry its rated current until stabilization of the temperature measured on the semiconductor's housing.

The type test shall be performed, opening S1 and closing S2 10ms the latest after S1 has opened as per Figure 5

9.3.4 Test sequence I: General performance characteristics**9.3.4.1 General**

This test sequence applies to all circuit-breakers and comprises the tests in Table 17.

The number of samples to be tested and the setting of adjustable releases shall be in accordance with Table 15.

See 9.3.2 for tests that may be omitted from the sequence and made on separate samples.

9.3.4.2 Test of tripping limits and characteristics**9.3.4.2.1 General**

Subclause 9.3.3.2 of IEC 60947-1:2020 is amplified as follows:

The ambient air temperature shall be measured as for the temperature-rise tests (see 9.3.3.5).

When the over-current opening release is normally a built-in part of the circuit-breaker, it shall be verified inside the corresponding circuit-breaker.

Any separate release shall be mounted approximately as under normal service conditions. The complete circuit-breaker shall be mounted in accordance with 9.3.3.1. The equipment under test shall be protected against undue external heating or cooling.

For circuit-breakers with adjustable over-current releases, tests shall be made at:

- a) minimum current setting and minimum time-delay setting, as applicable; and
- b) maximum current setting and maximum time-delay setting, as applicable,

in each case with conductors corresponding to the rated current I_n (see 5.3.3.3).

For tests for which the tripping characteristic is independent of the temperature of the terminals (e.g. electronic overload releases, magnetic releases), connection data (type, cross-section, length) may be different from those required in 9.3.3.3.4 of IEC 60947-1:2020. The connections should be compatible with the test current and induced thermal stresses.

For circuit-breakers having a neutral pole provided with an overload release, the verification of this overload release shall be made on the neutral pole alone.

The tests may be made at any suitable voltage.

9.3.4.2.2 I^2t withstand

The tripping function shall be deactivated.

A temperature stabilization of the circuit-breaker in accordance with 9.3.3.7 shall be carried out. Immediately after 9.3.3.7, the circuit-breaker shall carry 120% of its maximum short time withstand current (I_{sd}) during its maximum thermal time delay setting (t_r).

After this test, a temperature stabilization of the circuit-breaker in accordance with 9.3.3.7 shall be carried out. Immediately after 9.3.3.7, the circuit-breaker shall carry 120% of its maximum instantaneous current (I_i) during its maximum short time delay setting (t_{sd}).

1486 When the manufacturer decides to verify the tripping of I_{sd} and I_i (see 409.3.4.2.3) at a lower
1487 percentage value, 120% is replaced with this value. In this case, routine tests (9.4.3.2) are
1488 modified accordingly.”

1489 **Sec Note:** NCs are asked to prepare proposals for a practical test procedure and the acceptance criteria.

1490 **9.3.4.2.3 Short-circuit releases**

1491 The operation of short-circuit releases (see 5.7.1) shall be verified at 80 % and 120 % of the
1492 short-circuit current setting of the release. For AC tests, the test currents shall have no
1493 asymmetry. For DC tests, the current shall exhibit no overshoot at switch-on, and the time
1494 constant shall be less than 10 ms.

1495 At a test current having a value equal to 80 % of the short-circuit current setting, the release
1496 shall not operate, the current being maintained:

- 1497 – for 0,2 s in the case of instantaneous releases (see 3.6.25 of IEC 60947-1:2020).
1498 Alternatively, in the case of a circuit-breaker having also a short-time delay short-circuit
1499 release (see XX), the current shall be maintained during the non-tripping duration stated
1500 by the manufacturer instead of 0,2 s (if the short-time delay short-circuit release is
1501 adjustable, the time-delay shall be adjusted to its maximum setting value for this test);
- 1502 – for an interval of time equal to twice the time-delay stated by the manufacturer, in the
1503 case of definite time-delay releases.

1504 At a test current having a value equal to 120 % of the short-circuit current setting, the release
1505 shall operate:

- 1506 – within 0,2 s in the case of instantaneous releases (see 3.2.22);
- 1507 – within an interval of time equal to twice the time-delay stated by the manufacturer, in the
1508 case of definite time-delay releases.

1509 For circuit-breakers with an electronic overcurrent release, the operation of the short-circuit
1510 releases shall be verified by one test only on each pole individually.

1511 For circuit-breakers with electromagnetic overcurrent releases, the operation of multipole short-
1512 circuit releases shall be verified by one test only on each combination of two phase poles in
1513 series. For circuit-breakers having an identified neutral pole provided with a short-circuit
1514 release, the neutral pole shall be tested in series with one phase pole chosen at random. In
1515 addition, the operation of the short-circuit releases shall be verified once on each pole
1516 individually, at 120 % of either the value declared by the manufacturer for individual poles, or
1517 the short-circuit current setting (if no value is declared for individual poles), at which value they
1518 shall operate:

- 1519 – within 0,2 s in the case of instantaneous releases (see 3.2.22);
- 1520 – within an interval of time equal to twice the time-delay stated by the manufacturer, in the
1521 case of definite time-delay releases.

1522 Definite time-delay releases shall, in addition, comply with the requirements of 9.3.4.2.5.

1523 **9.3.4.2.4 Overload releases**

1524 a) Instantaneous or definite time-delay releases

1525 The operation of instantaneous or definite time-delay overload releases (see Note 1 of
1526 5.7.1) shall be verified at 90 % and 110 % of the overload setting of the release. For AC
1527 tests, the test currents shall have no asymmetry. For DC tests, the current shall exhibit no
1528 overshoot at switch-on, and the time constant shall be less than 10 ms. The operation of
1529 multipole overload releases shall be verified with all phase poles loaded simultaneously with
1530 the test current.

1531 Definite time-delay releases shall, in addition, comply with the requirements of 9.3.4.2.5.

1532 At a test current having a value equal to 90 % of the current setting, the release shall not
1533 operate, the current being maintained

1534 – for 0,2 s in the case of instantaneous releases (see 3.2.22),

1535 – for an interval of time equal to twice the time-delay stated by the manufacturer, in the
1536 case of definite time-delay releases.

1537 At a test current having a value equal to 110 % of the current setting, the release shall
1538 operate

1539 – within 0,2 s in the case of instantaneous releases (see 3.2.22),

1540 – within an interval of time equal to twice the time-delay stated by the manufacturer, in the
1541 case of definite time-delay releases.

1542 For circuit-breakers having an identified neutral pole provided with an overload release
1543 (see 9.3.4.2.1), the test current for this release shall have a value equal to 1,2 times 110 %
1544 of the current setting.

1545 b) Inverse time-delay releases

1546 The operating characteristics of inverse time-delay overload releases shall be verified in
1547 accordance with the performance requirements of 8.2.1.2.4, item b), 2).

1548 For circuit-breakers having an identified neutral pole provided with an overload release
1549 (see 9.3.4.2.1), the test currents for this release shall be those given in Table 5 except that
1550 the test current at the conventional tripping current shall be multiplied by the factor 1,2.

1551 For releases dependent on ambient air temperature, the operating characteristic shall be
1552 verified at the reference temperature (see 5.7.3 and Table 4 item 2.14), the release being
1553 energized on all phase poles.

1554 If this test is made at a different ambient air temperature, a correction shall be made in
1555 accordance with the manufacturer's temperature/current data.

1556 For thermal-magnetic releases declared by the manufacturer to be independent of ambient
1557 air temperature, the operating characteristic shall be verified by two measurements, one at
1558 $30\text{ °C} \pm 2\text{ °C}$, the other at $20\text{ °C} \pm 2\text{ °C}$ or at $40\text{ °C} \pm 2\text{ °C}$, the release being energized on
1559 all phase poles.

1560 For electronic releases, the operating characteristic shall be verified at the ambient
1561 temperature of the test room (see 7.1.1 of IEC 60947-1:2020), the release being energised
1562 on all phase poles.

1563 An additional test, at a current value equal to or greater than two times the current setting,
1564 shall be made to verify that the time/current characteristics of the release conform (within
1565 the stated tolerances) to the curves provided by the manufacturer.

1566 NOTE In addition to the tests in this subclause, the releases of circuit-breakers are also verified on each pole singly,
1567 during test sequences III, IV, V and VI (see 9.3.6.2 9.3.6.5, 9.3.7.2, 9.3.7.7, 9.3.8.5, 9.3.8.9, 9.3.9.2 and 9.3.9.8).

1568 9.3.4.2.5 Additional tests for definite time-delay releases

1569 Definite time-delay releases shall be tested to verify the values of the time-delay and the non-
1570 tripping duration

1571 a) Time-delay

1572 This test is made at a current equal to 1,5 times the current setting:

1573 – in the case of overload releases, with all phase poles loaded;

1574 – for circuit-breakers having an identified neutral pole provided with an overload release
1575 (see 9.3.4.2.1), the test current for this release shall be 1,5 times the current setting;

1576 – in the case of electromagnetic short-circuit releases, with two poles in series carrying
1577 the test current, using successively all possible combinations of phase poles having a
1578 short-circuit release.

1579 – in the case of electronic short-circuit releases, on one pole chosen at random.