

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

**Low-voltage switchgear and controlgear –  
Part 2: Circuit-breakers**

**Appareillage à basse tension –  
Partie 2: Disjoncteurs**



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# INTERNATIONAL STANDARD

## NORME INTERNATIONALE

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**Low-voltage switchgear and controlgear –  
Part 2: Circuit-breakers**

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**LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –****Part 2: Circuit-breakers**

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International Standard IEC 60947-2 has been prepared by subcommittee 17B: Low-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

The main changes introduced in this new edition are an amendment to the verification of dielectric properties, the improvement of EMC clauses in Annexes B, F, J and M, and the addition of a new Annex O regarding instantaneous trip circuit-breakers.

This consolidated version of IEC 60947-2 consists of the fourth edition (2006) [documents 17B/1455/FDIS and 17B/1463/RVD] and its amendment 1 (2009) [documents 17B/1636/FDIS and 17B/1651/RVD].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 4.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

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

The IEC 60947 series comprises the following parts under the general title *Low-voltage switchgear and controlgear*:

- Part 1: General rules
- Part 2: Circuit-breakers
- Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units
- Part 4: Contactors and motor-starters
- Part 5: Control circuit devices and switching elements
- Part 6: Multiple function equipment
- Part 7: Ancillary equipment
- Part 8: Control units for built-in thermal protection (PTC) for rotating electrical machines

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## LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

### Part 2: Circuit-breakers

#### 1 General

The provisions of the general rules dealt with in IEC 60947-1 are applicable to this standard, where specifically called for. Clauses and subclauses, tables, figures and annexes of the general rules thus applicable are identified by reference to IEC 60947-1, for example, 1.2.3 of IEC 60947-1, Table 4 of IEC 60947-1, or Annex A of IEC 60947-1.

##### 1.1 Scope and object

This standard applies to circuit-breakers, the main contacts of which are intended to be connected to circuits, the rated voltage of which does not exceed 1 000 V a.c. or 1 500 V d.c.; it also contains additional requirements for integrally fused circuit-breakers.

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

The requirements for circuit-breakers which are also intended to provide earth-leakage protection are contained in Annex B.

The additional requirements for circuit-breakers with electronic over-current protection are contained in Annex F.

The additional requirements for circuit-breakers for IT systems are contained in Annex H.

The requirements and test methods for electromagnetic compatibility of circuit-breakers are contained in Annex J.

The requirements for circuit-breakers not fulfilling the requirements for over-current protection are contained in Annex L.

The requirements for modular residual current devices (without integral current breaking device) are contained in Annex M.

The requirements and test methods for electromagnetic compatibility of circuit-breaker auxiliaries are contained in Annex N.

Supplementary requirements for circuit-breakers used as direct-on-line starters are given in IEC 60947-4-1, applicable to low-voltage contactors and starters.

The requirements for circuit-breakers for the protection of wiring installations in buildings and similar applications, and designed for use by uninstructed persons, are contained in IEC 60898.

The requirements for circuit-breakers for equipment (for example electrical appliances) are contained in IEC 60934.

For certain specific applications (for example traction, rolling mills, marine service) particular or additional requirements may be necessary.

NOTE Circuit-breakers which are dealt with in this standard may be provided with devices for automatic opening under predetermined conditions other than those of over-current and undervoltage as, for example, reversal of power or current. This standard does not deal with the verification of operation under such pre-determined conditions.

The object of this standard is to state:

- a) the characteristics of circuit-breakers;
- b) the conditions with which circuit-breakers shall comply with reference to:
  - 1) operation and behaviour in normal service;
  - 2) operation and behaviour in case of overload and operation and behaviour in case of short-circuit, including co-ordination in service (discrimination and back-up protection);
  - 3) dielectric properties;
- c) tests intended for confirming that these conditions have been met and the methods to be adopted for these tests;
- d) information to be marked on or given with the apparatus.

## 1.2 Normative references

The following referenced documents are indispensable for the application 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):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*  
Amendment 1 (2000)

IEC 60051 (all parts) *Direct acting indicating analogue electrical measuring instruments and their accessories*

IEC 60068-2-14:1984, *Environmental testing – Part 2: Tests. Test N: Change of temperature*  
Amendment 1 (1986)

IEC 60068-2-30:2005, *Environmental testing – Part 2-30: Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60364 (all parts), *Electric installations of buildings*

IEC 60417, *Graphical symbols for use on equipment*

IEC 60617, *Graphical symbols for diagrams*

IEC 60695-2-10:2000, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

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

IEC 60695-2-12:2000, *Fire hazard testing – Part 2-12: Glowing/hot-wire based test methods – Glow-wire flammability test method for materials*

IEC 60695-2-13:2000, *Fire hazard testing – Part 2-13: Glowing/hot-wire based test methods – Glow-wire ignitability test method for materials*

IEC/TR 60755:1983, *General requirements for residual current operated protective devices*  
Amendment 1 (1988)  
Amendment 2 (1992)

IEC 60898, *Circuit-breakers for over-current protection for household and similar installations*

IEC 60934, *Circuit-breakers for equipment (CBE)*

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

IEC 60947-4-1:2000, *Low-voltage switchgear and controlgear – Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters*

Amendment 1 (2002)

Amendment 2 (2005)

IEC 61000-3-2:2005, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current  $\leq 16$  A per phase)*

IEC 61000-3-3:1994, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 3: Limitation of voltage fluctuations and flicker in low-voltage supply systems for equipment with rated current  $\leq 16$  A*

Amendment 1 (2001)

Amendment 2 (2005)

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

Amendment 1 (1998)

Amendment 2 (2000)

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2003, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radiofrequency fields*

Amendment 1 (2004)

Amendment 2 (2006)

IEC 61000-4-11:2004, *Electromagnetic compatibility (EMC) – Part 4-11: Testing and measurement techniques – Voltage dips, short interruptions and voltage variations immunity tests*

IEC 61000-4-13:2002, *Electromagnetic compatibility (EMC) – Part 4-13: Testing and measurement techniques – Harmonics and interharmonics including mains signalling at a.c. power port, low frequency immunity tests*

IEC/TR 61000-5-2:1997, *Electromagnetic compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling*

IEC 61008-1:1996, *Residual current operated circuit-breakers without integral over-current protection for household and similar uses (RCCBs) – Part 1: General rules*

Amendment 1 (2002)

Amendment 2 (2006)

IEC 61009-1:1996, *Residual current operated circuit-breakers with integral over-current protection for household and similar uses (RCBOs) – Part 1: General rules*

Amendment 1 (2002)

Amendment 2 (2006)

IEC 61131-1:2003, *Programmable controllers – Part 1: General information*

CISPR 11:2003, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*  
 Amendment 1 (2004)  
 Amendment 2 (2006)

CISPR 22:2005, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*  
 Amendment 1 (2005)  
 Amendment 2 (2006)

## 2 Definitions

For the majority of the definitions required in connection with this standard, see Clause 2 of IEC 60947-1.

For the purpose of this standard, the following additional definitions shall apply:

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

### 2.1

#### **circuit-breaker**

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

[IEV 441-14-20]

#### 2.1.1

##### **frame size**

a term designating a group of circuit-breakers, the external physical dimensions of which are common to a range of current ratings. Frame size is expressed in amperes corresponding to the highest current rating of the group. Within a frame size, the width may vary according to the number of poles

NOTE This definition does not imply dimensional standardization.

#### 2.1.2

##### **construction break**

a significant difference in construction between circuit-breakers of a given frame size, requiring additional type testing (see 7.1.5)

### 2.2

#### **integrally fused circuit-breaker**

a combination, in a single device, of a circuit-breaker and fuses, one fuse being placed in series with each pole of the circuit-breaker intended to be connected to a phase conductor

[IEV 441-14-22]

### 2.3

#### **current-limiting circuit-breaker**

circuit-breaker that, within a specified range of current, prevents the let-through current reaching the prospective peak value and which limits the let-through energy ( $I^2t$ ) to a value less than the let-through energy of a half-cycle wave of the symmetrical prospective current

NOTE 1 Reference may be made to either the symmetrical or asymmetrical prospective peak value of let-through current.

NOTE 2 The let-through current is also referred to as the cut-off current (see IEC 441-17-12).

NOTE 3 Templates for the graphical representation of the cut-off current characteristic and the let-through energy characteristic are given in Figures K.2 to K.5 and examples of the use of the templates in Figures K.6 and K.7.

**2.4****plug-in circuit-breaker**

a circuit-breaker which, in addition to its interrupting contacts, has a set of contacts which enable the circuit-breaker to be removed

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

**2.5****withdrawable circuit-breaker**

a circuit-breaker which, in addition to its interrupting contacts, has a set of isolating contacts which enable the circuit-breaker to be disconnected from the main circuit, in the withdrawn position, to achieve an isolating distance in accordance with specified requirements

**2.6****moulded-case circuit-breaker**

a circuit-breaker having a supporting housing of moulded insulating material forming an integral part of the circuit-breaker

[IEV 441-14-24]

**2.7****air circuit-breaker**

a circuit-breaker in which the contacts open and close in air at atmospheric pressure

[IEV 441-14-27]

**2.8****vacuum circuit-breaker**

a circuit-breaker in which the contacts open and close within a highly evacuated envelope

[IEV 441-14-29]

**2.9****gas circuit-breaker**

a circuit-breaker in which the contacts open and close in a gas other than air at atmospheric or higher pressure

**2.10****making-current release**

a release which permits a circuit-breaker to open, without any intentional time-delay, during a closing operation, if the making current exceeds a predetermined value, and which is rendered inoperative when the circuit-breaker is in the closed position

**2.11****short-circuit release**

an over-current release intended for protection against short circuits

**2.12****short-time delay short-circuit release**

an over-current release intended to operate at the end of the short-time delay (see 2.5.26 of IEC 60947-1)

**2.13****alarm switch**

an auxiliary switch which operates only upon the tripping of the circuit-breaker with which it is associated

## 2.14

### **circuit-breaker with lock-out device preventing closing**

a circuit-breaker in which each of the moving contacts is prevented from closing sufficiently to be capable of passing current if the closing command is initiated while specified conditions remain established

## 2.15

### **short-circuit breaking (or making) capacity**

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

### 2.15.1

#### **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

### 2.15.2

#### **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

## 2.16

### **opening time**

subclause 2.5.39 of IEC 60947-1 applies, with the following additions:

- in the case of a directly operated circuit-breaker, the instant of initiation of the opening time is the instant of initiation of a current large enough to cause the circuit-breaker to operate;
- in the case of a circuit-breaker operated by any form of auxiliary power, the instant of initiation of the opening time is the instant of application or removal of the auxiliary power to the opening release.

NOTE For circuit-breakers "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 when the opening command becomes irreversible.

## 2.17

### **over-current protective co-ordination**

subclause 2.5.22 of IEC 60947-1 applies

### 2.17.1

#### **over-current discrimination**

subclause 2.5.23 of IEC 60947-1 applies

[IEV 441-17-15]

### 2.17.2

#### **total discrimination (total selectivity)**

over-current discrimination where, in the presence of two over-current protective devices in series, the protective device on the load side effects the protection without causing the other protective device to operate

### 2.17.3

#### **partial discrimination (partial selectivity)**

over-current discrimination where, in the presence of two over-current protective devices in series, the protective device on the load side effects the protection up to a given level of over-current, without causing the other protective device to operate

**2.17.4****selectivity limit current** **$I_s$** 

the selectivity limit current is the 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

The selectivity limit current (see Figure A.1) is a limiting value of current.

- below which, in the presence of two over-current 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 over-current 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).

**2.17.5****back-up protection**

subclause 2.5.24 of IEC 60947-1 applies

**2.17.6****take-over current** **$I_B$** 

subclause 2.5.25 of IEC 60947-1 is amplified as follows:

For the purpose of this standard, 2.5.25 of IEC 60947-1 applies to two over-current protective devices in series for operating times  $\geq 0,05$  s. For operating times  $< 0,05$  s the two over-current devices in series are considered as an association, see Annex A.

NOTE The take-over current is the current co-ordinate of the intersection between the maximum break time current characteristics of two over-current protective devices in series.

**2.18** **$I^2t$  characteristic of a circuit-breaker**

information (usually a curve) giving the maximum values of  $I^2t$  related to break time as a function of prospective current (r.m.s. symmetrical for a.c.) up to the maximum prospective current corresponding to the rated short-circuit breaking capacity and associated voltage

**2.19****resetting time**

time elapsed between a circuit-breaker tripping due to an overcurrent and subsequently reaching a condition where it can be reclosed

**2.20****rated instantaneous short-circuit current setting** **$I_i$** 

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

**2.21****programmable logic controller****PLC**

digitally operating electronic system, designed for use in an industrial environment, which uses a programmable memory for the internal storage of user-oriented instructions for implementing specific functions such as logic, sequencing, timing, counting and arithmetic, to control, through digital or analogue inputs and outputs, various types of machines or processes. Both the PLC and its associated peripherals are designed so that they can be easily integrated into an industrial control system and easily used in all their intended functions

[IEC 61131-1, definition 3.5]

### 3 Classification

Circuit-breakers may be classified:

**3.1** According to their selectivity category, A or B (see 4.4).

**3.2** According to the interrupting medium, for example:

- air-break;
- vacuum break;
- gas-break.

**3.3** According to the design, for example:

- open construction;
- moulded case.

**3.4** According to the method of controlling the operating mechanism, viz:

- dependent manual operation;
- independent manual operation;
- dependent power operation;
- independent power operation;
- stored energy operation.

**3.5** According to the suitability for isolation:

- suitable for isolation;
- not suitable for isolation.

**3.6** According to the provision for maintenance:

- maintainable;
- non-maintainable.

**3.7** According to the method of installation, for example:

- fixed;
- plug-in;
- withdrawable.

**3.8** According to the degree of protection provided by the enclosure (see 7.1.12 of IEC 60947-1).

### 4 Characteristics of circuit-breakers

#### 4.1 Summary of characteristics

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

- type of circuit-breaker (4.2);
- rated and limiting values of the main circuit (4.3);

- selectivity categories (4.4);
- control circuits (4.5);
- auxiliary circuits (4.6);
- releases (4.7);
- integral fuses (integrally fused circuit-breakers) (4.8);

## 4.2 Type of circuit-breaker

The following shall be stated:

### 4.2.1 Number of poles

### 4.2.2 Kind of current

Kind of current (a.c. or d.c.) and, in the case of a.c., number of phases and rated frequency.

## 4.3 Rated and limiting values of the main circuit

The rated values established for a circuit-breaker shall be stated in accordance with 4.3.1 to 4.4, but it is not necessary to establish all the rated values listed.

### 4.3.1 Rated voltages

A circuit-breaker is defined by the following rated voltages:

#### 4.3.1.1 Rated operational voltage ( $U_e$ )

Subclause 4.3.1.1 of IEC 60947-1 applies with the following amplification:

- Circuit-breakers covered by item a) of note 2:

$U_e$  is generally stated as the voltage between phases.

NOTE A 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 277/480 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 item b) of note 2:

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 B According to present practice in Canada and the USA, circuit-breakers covered by item b) of note 2 are identified by the voltage between phases only.

#### 4.3.1.2 Rated insulation voltage ( $U_i$ )

Subclause 4.3.1.2 of IEC 60947-1 applies.

#### 4.3.1.3 Rated impulse withstand voltage ( $U_{imp}$ )

Subclause 4.3.1.3 of IEC 60947-1 applies.

### 4.3.2 Currents

A circuit-breaker is defined by the following currents:

#### 4.3.2.1 Conventional free-air thermal current ( $I_{th}$ )

Subclause 4.3.2.1 of IEC 60947-1 applies.

#### 4.3.2.2 Conventional enclosed thermal current ( $I_{the}$ )

Subclause 4.3.2.2 of IEC 60947-1 applies.

#### 4.3.2.3 Rated current ( $I_n$ )

For circuit-breakers, the rated current is the rated uninterrupted current ( $I_u$ ) (see 4.3.2.4 of IEC 60947-1) and is equal to the conventional free-air thermal current ( $I_{th}$ ).

#### 4.3.2.4 Current rating for four-pole circuit-breakers

Subclause 7.1.9 of IEC 60947-1 applies.

### 4.3.3 Rated frequency

Subclause 4.3.3 of IEC 60947-1 applies.

### 4.3.4 Rated duty

The rated duties considered as normal are as follows:

#### 4.3.4.1 Eight-hour duty

Subclause 4.3.4.1 of IEC 60947-1 applies.

#### 4.3.4.2 Uninterrupted duty

Subclause 4.3.4.2 of IEC 60947-1 applies.

### 4.3.5 Short-circuit characteristics

#### 4.3.5.1 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 a.c., or time constant for d.c. It is expressed as the maximum prospective peak current.

For a.c. 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 2 (see 4.3.5.3).

For d.c., 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.

#### 4.3.5.2 Rated short-circuit breaking capacities

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.

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 a.c., at any power factor not less than that of Table 11 (see 8.3.2.2.4);
- for d.c., with any time constant not greater than that of Table 11 (see 8.3.2.2.5).

For power-frequency recovery voltages in excess of the prescribed test voltage values (see 8.3.2.2.6), no short-circuit breaking capacity is guaranteed.

For a.c., 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 11, irrespective of the value of the inherent d.c. component, on the assumption that the a.c. component is constant.

The rated short-circuit breaking capacities are stated as:

- rated ultimate short-circuit breaking capacity;
- rated service short-circuit breaking capacity.

##### 4.3.5.2.1 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 2.15.1) assigned to that circuit-breaker by the manufacturer for the corresponding rated operational voltage, under the conditions specified in 8.3.5. It is expressed as the value of the prospective breaking current, in kA (r.m.s. value of the a.c. component in the case of a.c.).

##### 4.3.5.2.2 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 2.15.2) assigned to that circuit-breaker by the manufacturer for the corresponding rated operational voltage, under the conditions specified in 8.3.4. It is expressed as a value of prospective breaking current, in kA, corresponding to one of the specified percentages of the rated ultimate short-circuit breaking capacity, in accordance with Table 1, and rounded up to the nearest whole number. It may be expressed as a % of  $I_{cu}$  (for example  $I_{cs} = 25 \% I_{cu}$ ).

Alternatively, when the rated service short-circuit breaking capacity is equal to the rated short-time withstand current (see 4.3.5.4), it may be stated as that value, in kA, provided that it is not less than the relevant minimum value of Table 1.

Where  $I_{cu}$  exceeds 200 kA for selectivity category A (see 4.4), or 100 kA for selectivity category B, the manufacturer may declare a value  $I_{cs}$  of 50 kA.

**Table 1 – Standard ratios between  $I_{cs}$  and  $I_{cu}$** 

| Selectivity category A<br>% of $I_{cu}$ | Selectivity category B<br>% of $I_{cu}$ |
|-----------------------------------------|-----------------------------------------|
| 25                                      | 50                                      |
| 50                                      | 75                                      |
| 75                                      | 100                                     |
| 100                                     |                                         |

#### 4.3.5.3 Standard relationship between short-circuit making and breaking capacities and related power factor, for a.c. circuit-breakers

The standard relationship between short-circuit breaking capacity and short-circuit making capacity is given in Table 2.

**Table 2 – Ratio  $n$  between short-circuit making capacity and short-circuit breaking capacity and related power factor (for a.c. circuit-breakers)**

| Short-circuit breaking capacity $I$<br>kA r.m.s.                                                                     | Power factor | Minimum value required for $n$<br>$n = \frac{\text{short - circuit making capacity}}{\text{short - circuit breaking capacity}}$ |
|----------------------------------------------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------|
| $4,5 \leq I \leq 6$                                                                                                  | 0,7          | 1,5                                                                                                                             |
| $6 < I \leq 10$                                                                                                      | 0,5          | 1,7                                                                                                                             |
| $10 < I \leq 20$                                                                                                     | 0,3          | 2,0                                                                                                                             |
| $20 < I \leq 50$                                                                                                     | 0,25         | 2,1                                                                                                                             |
| $50 < I$                                                                                                             | 0,2          | 2,2                                                                                                                             |
| NOTE For values of breaking capacity lower than 4,5 kA, for certain applications, see Table 11 for the power factor. |              |                                                                                                                                 |

The rated short-circuit making and breaking capacities are only valid when the circuit-breaker is operated in accordance with the requirements of 7.2.1.1 and 7.2.1.2.

For special requirements, the manufacturer may assign a value of rated short-circuit making capacity higher than that required by Table 2. Tests to verify these rated values shall be the subject of agreement between manufacturer and user.

#### 4.3.5.4 Rated short-time withstand current ( $I_{cw}$ )

The rated short-time withstand current of a circuit-breaker is the value of short-time withstand current assigned to that circuit-breaker by the manufacturer under the test conditions specified in 8.3.6.2.

For a.c., the value of this current is the r.m.s. value of the a.c. component of the prospective short-circuit current, assumed constant during the short-time delay.

The short-time delay associated with the rated short-time withstand current shall be at least 0,05 s, preferred values being as follows:

$$0,05 - 0,1 - 0,25 - 0,5 - 1 \text{ s}$$

The rated short-time withstand current shall be not less than the appropriate values shown in Table 3.

**Table 3 – Minimum values of rated short-time withstand current**

| Rated current $I_n$<br>A            | Rated short-time withstand current $I_{cw}$ –<br>Minimum values<br>kA |
|-------------------------------------|-----------------------------------------------------------------------|
| $I_n \leq 2\,500$<br>$I_n > 2\,500$ | 12 $I_n$ or 5 kA, whichever is the greater<br>30 kA                   |

#### 4.4 Selectivity categories

The selectivity category of a circuit-breaker shall be stated with reference to whether or not it is specifically intended for selectivity by means of an intentional time delay with respect to other circuit-breakers in series on the load side, under short-circuit conditions (see Figure A.3).

Attention is drawn to the differences of the tests applying to the two selectivity categories (see Table 9 and 8.3.4, 8.3.5, 8.3.6 and 8.3.8).

Selectivity categories are defined in Table 4.

**Table 4 – Selectivity categories**

| Selectivity category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Application with respect to selectivity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Circuit-breakers not specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. without an intentional short-time delay provided for selectivity under short-circuit conditions, and therefore without a short-time withstand current rating according to 4.3.5.4.                                                                                                                                                                                                                                                                              |
| B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Circuit-breakers specifically intended for selectivity under short-circuit conditions with respect to other short-circuit protective devices in series on the load side, i.e. with an intentional short-time delay (which may be adjustable), provided for selectivity under short-circuit conditions. Such circuit-breakers have a short-time withstand current rating according to 4.3.5.4.<br><br>NOTE Selectivity is not necessarily ensured up to the ultimate short-circuit breaking capacity of the circuit-breakers (for example in the case of operation of an instantaneous release) but at least up to the value specified in Table 3. |
| <p>NOTE 1 The power factor or time constant associated with each value of rated short-circuit current is given in Table 11 (see 8.3.2.2.4 and 8.3.2.2.5).</p> <p>NOTE 2 Attention is drawn to the different requirements for the minimum required percentage of <math>I_{cs}</math> for selectivity categories A and B, in accordance with Table 1.</p> <p>NOTE 3 A circuit-breaker of selectivity category A may have an intentional short-time delay provided for selectivity under conditions other than those of short circuit, with a short-time withstand current less than that according to Table 3. In that case, the tests include test sequence IV (see 8.3.6) at the assigned short-time withstand current.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

#### 4.5 Control circuits

##### 4.5.1 Electrical control circuits

Subclause 4.5.1 of IEC 60947-1 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 5.

**Table 5 – Preferred values of the rated control supply voltage, if different from that of the main circuit**

| d.c.<br>V                                                                                                                                               | Single-phase a.c.<br>V          |
|---------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| 24 – 48 – 110 – 125 – 220 – 250                                                                                                                         | 24 – 48 – 110 – 127 – 220 – 230 |
| NOTE The manufacturer should be prepared to state the value or values of the current taken by the control circuits at the rated control supply voltage. |                                 |

#### 4.5.2 Air-supply control circuits (pneumatic or electro-pneumatic)

Subclause 4.5.2 of IEC 60947-1 applies.

#### 4.6 Auxiliary circuits

Subclause 4.6 of IEC 60947-1 applies.

#### 4.7 Releases

##### 4.7.1 Types

- 1) Shunt release;
- 2) Over-current release:
  - a) instantaneous;
  - b) definite time delay;
  - c) 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 2.4.30 of IEC 60947-1). The term "short-circuit release" is used to identify over-current releases intended for protection against short circuits (see 2.11).

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

- 3) Undervoltage release (for opening).
- 4) Other releases.

##### 4.7.2 Characteristics

- 1) Shunt release and undervoltage release (for opening):
  - rated control circuit voltage ( $U_c$ );
  - kind of current;
  - rated frequency, if a.c.
- 2) Over-current release:
  - rated current ( $I_n$ );
  - kind of current;
  - rated frequency, if a.c.;
  - current setting (or range of settings);
  - time setting (or range of settings).

The rated current of an over-current release is the value of current (r.m.s. if a.c.) corresponding to the maximum current setting which it shall be capable of carrying under the test conditions specified in 8.3.2.5, without the temperature-rise exceeding the values specified in Table 7.

#### 4.7.3 Current setting of over-current releases

For circuit-breakers fitted with adjustable releases (see note 2 to 4.7.1, item 2)), the current setting (or range of current-settings, as applicable) shall be marked on the release or on its scale. The marking may be either directly in amperes, or as a multiple of the current value marked on the release.

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 6, it will be sufficient to mark the circuit-breaker with its rated current ( $I_n$ ).

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  $-5\text{ °C}$  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 7.2.1.2.4, item b)).

#### 4.7.4 Tripping time setting of over-current releases

##### 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.

**NOTE** 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 and in Figures 4(I), 3(II) and 4(II) of IEC 60269-2-1.

#### 4.8 Integral fuses (integrally fused circuit-breakers)

Subclause 4.8 of IEC 60947-1 applies.

The manufacturer shall provide the necessary information.

### 5 Product information

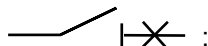
#### 5.1 Nature of the information

Subclause 5.1 of IEC 60947-1 applies, as far as appropriate for a particular design.

In addition the manufacturer shall make available, upon request, information concerning typical power losses for the various frame sizes (see 2.1.1). See Annex G.

## 5.2 Marking

Each circuit-breaker shall be marked in a durable manner.

- a) The following data shall be marked on the circuit-breaker itself or on a nameplate or nameplates attached to the circuit-breaker, and located in a place such that they are visible and legible when the circuit-breaker is installed;
  - rated current ( $I_n$ );
  - suitability for isolation, if applicable, with the symbol  ;
  - indication of the open and closed positions, with  and  respectively, if symbols are used (see 7.1.6.1 of IEC 60947-1).
- b) The following data shall also be marked externally on the circuit-breaker, as specified in item a), except that they need not be visible when the circuit-breaker is installed;
  - manufacturer's name or trade mark;
  - type designation or serial number;
  - IEC 60947-2 if the manufacturer claims compliance with this standard;
  - selectivity category;
  - rated operational voltage(s)  $U_e$  (see 4.3.1.1 and, where applicable, Annex H);
  - rated impulse withstand voltage ( $U_{imp}$ );
  - value (or range) of the rated frequency (for example 50 Hz), and/or the indication "d.c." (or the symbol  $\equiv$ );
  - rated service short-circuit breaking capacity ( $I_{cs}$ ) at the corresponding rated voltage ( $U_e$ );
  - rated ultimate short-circuit breaking capacity ( $I_{cu}$ ) at the corresponding rated voltage ( $U_e$ );
  - rated short-time withstand current ( $I_{cw}$ ), and associated short-time delay, for selectivity category B;
  - line and load terminals, unless their connection is immaterial;
  - neutral pole terminals, if applicable, by the letter N;
  - protective earth terminal, where applicable, by the symbol  (see 7.1.10.3 of IEC 60947-1);
  - reference temperature for non-compensated thermal releases, if different from 30 °C.
- c) The following data shall either be marked on the circuit-breaker as specified in item b), or shall be made available in the manufacturer's published information:
  - rated short-circuit making capacity ( $I_{cm}$ ), if higher than that specified in 4.3.5.1;
  - rated insulation voltage ( $U_i$ ), if higher than the maximum rated operational voltage;
  - pollution degree if other than 3;
  - conventional enclosed thermal current ( $I_{the}$ ) if different from the rated current;
  - IP Code, where applicable (see Annex C of IEC 60947-1);
  - minimum enclosure size and ventilation data (if any) to which marked ratings apply;
  - details of minimum distance between circuit-breaker and earthed metal parts for circuit-breakers intended for use without enclosures;
  - suitability for environment A or environment B, as applicable;
  - r.m.s. sensing, if applicable, according to F.4.1.1.

d) The following data concerning the opening and closing devices of the circuit-breaker shall be placed either on their own nameplates or on the nameplate of the circuit-breaker; alternatively, if space available is insufficient, they shall be made available in the manufacturer's published information:

- rated control circuit voltage of the closing device (see 7.2.1.2 of IEC 60947-1) and rated frequency for a.c.;
- rated control circuit voltage of the shunt release (see 7.2.1.4 of IEC 60947-1) and/or of the under-voltage release (or of the no-voltage release) (see 7.2.1.3 of IEC 60947-1), and rated frequency for a.c.;
- rated current of indirect over-current releases;
- number and type of auxiliary contacts and kind of current, rated frequency (if a.c.) and rated voltages of the auxiliary switches, if different from those of the main circuit.

e) Terminal marking

Subclause 7.1.8.4 of IEC 60947-1 applies (see also item b) above).

### 5.3 Instructions for installation, operation and maintenance

Subclause 5.3 of IEC 60947-1 applies.

## 6 Normal service, mounting and transport conditions

Clause 6 of IEC 60947-1 applies with the following addition:

*Pollution degree* (see 6.1.3.2 of IEC 60947-1)

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

## 7 Constructional and performance requirements

### 7.1 Constructional requirements

Subclause 7.1 of IEC 60947-1 applies. Where, in Subclause 7.1.2.2 of IEC 60947-1, the test temperature is to be specified, the test temperature required by this standard is 960 °C.

#### 7.1.1 Withdrawable circuit-breakers

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

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

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

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

- when the isolating contacts are fully closed, or
- when the specified isolating distance is achieved between the fixed and moving parts of the isolating contacts (disconnected position).

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

### 7.1.2 Additional requirements for circuit-breakers suitable for isolation

For additional requirements concerning performance, see 7.2.7.

Subclause 7.1.7 of IEC 60947-1 applies with the following addition:

NOTE If the tripped position is not the indicated open position, it should be clearly identified.

The indicated open position is the only position in which the specified isolating distance between the contacts is ensured.

### 7.1.3 Clearances and creepage distances

Minimum values are given in Tables 13 and 15 of IEC 60947-1.

### 7.1.4 Requirements for the safety of the operator

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

Compliance is checked by the provisions of 8.3.2.6.1, item b).

### 7.1.5 List of construction breaks

Circuit-breakers of a given frame size are considered to have a construction break (see 2.1.2) 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) and c) below;
- size, material, configuration and method of attachment of the main contacts;
- any integral manual operating mechanism, its materials and physical characteristics;
- moulding and insulating materials;
- the principle of operation, materials and construction of the arc extinction device;
- 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) in the case of the 4-pole variant, replacement of the trip unit in the 4<sup>th</sup> pole by a link, to provide an unprotected neutral.

### 7.1.6 Additional requirements for circuit-breakers provided with a neutral pole

Subclause 7.1.9 of IEC 60947-1 applies with the following addition:

If a pole with an appropriate making and breaking capacity is used as a neutral pole, then all poles, including the neutral pole, may operate substantially together.

### **7.1.7 Digital inputs and outputs for use with programmable logic controllers (PLCs)**

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

## **7.2 Performance requirements**

### **7.2.1 Operating conditions**

#### **7.2.1.1 Closing**

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.

##### **7.2.1.1.1 Dependent manual closing**

For a circuit-breaker having a dependent manual closing mechanism, it is not possible to assign a short-circuit making capacity rating irrespective of the conditions of mechanical operation.

Such a circuit-breaker should not be used in circuits having a prospective peak making current exceeding 10 kA.

However, this does not apply in the case of a circuit-breaker having a dependent manual closing mechanism and incorporating an integral fast-acting opening release which causes the circuit-breaker to break safely, irrespective of the speed and firmness with which it is closed on to prospective peak currents exceeding 10 kA; in this case, a rated short-circuit making capacity can be assigned.

##### **7.2.1.1.2 Independent manual closing**

A circuit-breaker having an independent manual closing mechanism can be assigned a short-circuit making capacity rating irrespective of the conditions of mechanical operation.

##### **7.2.1.1.3 Dependent power closing**

The power-operated closing mechanism, including intermediate control relays where necessary, shall be capable of securing the closing of the circuit-breaker in any condition between no-load and its rated making capacity, when the supply voltage, measured during the closing operation, remains between the limits of 110 % and 85 % of the rated control supply voltage, and, when a.c., at the rated frequency.

At 110 % of the rated control supply voltage, the closing operation performed on no-load shall not cause any damage to the circuit-breaker.

At 85 % of the rated control supply voltage, the closing operation shall be performed when the current established by the circuit-breaker is equal to its rated making capacity within the limits allowed by the operation of its relays or releases and, if a maximum time limit is stated for the closing operation, in a time not exceeding this maximum time limit.

##### **7.2.1.1.4 Independent power closing**

A circuit-breaker having an independent power closing operation can be assigned a rated short-circuit making capacity irrespective of the conditions of power closing.

Means for charging the operating mechanism, as well as the closing control components, shall be capable of operating in accordance with the manufacturer's specification.

#### 7.2.1.1.5 Stored energy closing

This type of closing mechanism shall be capable of ensuring closing of the circuit-breaker in any condition between no-load and its rated making capacity.

When the stored energy is retained within the circuit-breaker, a device shall be provided which indicates when the storing mechanism is fully charged.

Means for charging the operating mechanism, as well as the closing control components, shall be capable of operating when the auxiliary supply voltage is between 85 % and 110 % of the rated control supply voltage.

It shall not be possible for the moving contacts to move from the open position unless the charge is sufficient for satisfactory completion of the closing operation.

When the energy storing mechanism is manually operated, the direction of operation shall be indicated.

This last requirement does not apply to circuit-breakers with an independent manual closing operation.

#### 7.2.1.2 Opening

##### 7.2.1.2.1 General

Circuit-breakers which open automatically shall be trip-free and, unless otherwise agreed between manufacturer and user, shall have their energy for the tripping operation stored prior to the completion of the closing operation.

##### 7.2.1.2.2 Opening by undervoltage releases

Subclause 7.2.1.3 of IEC 60947-1 applies.

##### 7.2.1.2.3 Opening by shunt releases

Subclause 7.2.1.4 of IEC 60947-1 applies.

##### 7.2.1.2.4 Opening by over-current releases

###### 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 2.17), the manufacturer shall provide information (usually curves) showing

- maximum cut-off (let-through) peak current (see 2.5.19 of IEC 60947-1) as a function of prospective current (r.m.s. symmetrical);
- $I^2t$  characteristics (see 2.18) for circuit-breakers of selectivity category A and, if applicable, B for circuit-breakers with instantaneous override (see note to 8.3.5).

Conformity with this information may be checked during the relevant type tests in test sequences II and III (see 8.3.4 and 8.3.5).

NOTE It may be 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 6.

At the reference temperature (see 4.7.3) and at 1,05 times the current setting (see 2.4.37 of IEC 60947-1), i.e. with the conventional non-tripping current (see 2.5.30 of IEC 60947-1), the opening release being energized on all phase poles, tripping shall not occur in less than the conventional time (see 2.5.30 of IEC 60947-1) from the cold state, i.e. with the circuit-breaker at the reference temperature.

Moreover, when at the end of the conventional time the value of current is immediately raised to 1,30 times the current setting, i.e. with the conventional tripping current (see 2.5.31 of IEC 60947-1), tripping shall then occur in less than the conventional time later.

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

**Table 6 – Characteristics of the opening operation of inverse time-delay over-current opening releases at the reference temperature**

| All poles loaded                         |                               | Conventional time<br>h |
|------------------------------------------|-------------------------------|------------------------|
| Conventional non-tripping current        | Conventional tripping current |                        |
| 1,05 times current setting               | 1,30 times current setting    | 2 <sup>a</sup>         |
| <sup>a</sup> 1 hour when $I_n \leq 63$ A |                               |                        |

If a release is declared by the manufacturer as substantially independent of ambient temperature, the current values of Table 6 shall apply within the temperature band declared by the manufacturer, within a tolerance of 0,3 %/K.

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

## 7.2.2 Temperature-rise

### 7.2.2.1 Temperature-rise limits

The temperature-rises of the several parts of a circuit-breaker, measured under the conditions specified in 8.3.2.5, shall not exceed the limiting values stated in Table 7, during the tests made in accordance with 8.3.3.6. The temperature-rises of the terminals shall not exceed the limiting values stated in Table 7 during the tests made in accordance with 8.3.4.4 and 8.3.6.3.

#### 7.2.2.2 Ambient air temperature

The temperature-rise limits given in Table 7 are applicable only if the ambient air temperature remains within the limits given in 6.1.1 of IEC 60947-1.

#### 7.2.2.3 Main circuit

The main circuit of a circuit-breaker, including the over-current releases which may be associated with it, shall be capable of carrying the conventional thermal current ( $I_{th}$  or  $I_{the}$ , as applicable, see 4.3.2.1 and 4.3.2.2) without the temperature-rises exceeding the limits specified in Table 7.

#### 7.2.2.4 Control circuits

The control circuits, including control circuit devices, used for the closing and opening operations of a circuit-breaker, shall permit the rated duty, as specified in 4.3.4, and also the temperature-rise tests under the test conditions specified in 8.3.2.5, to be made without the temperature rises exceeding the limits specified in Table 7.

The requirements of this subclause shall be verified on a new circuit-breaker. Alternatively, at the discretion of the manufacturer, the verification may be made during the temperature-rise test of 8.3.3.6.

#### 7.2.2.5 Auxiliary circuits

Auxiliary circuits, including auxiliary devices, shall be capable of carrying their conventional thermal current without the temperature-rises exceeding the limits specified in Table 7, when tested in accordance with 8.3.2.5.

**Table 7 – Temperature-rise limits for terminals and accessible parts**

| Description of part <sup>a</sup>                                                                                                                                                                                                                                                                                                                                            | Temperature-rise limits <sup>b</sup><br>K |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------|
| – Terminals for external connections                                                                                                                                                                                                                                                                                                                                        | 80                                        |
| – Manual operating means:<br>metallic                                                                                                                                                                                                                                                                                                                                       | 25                                        |
| non-metallic                                                                                                                                                                                                                                                                                                                                                                | 35                                        |
| – Parts intended to be touched but not hand-held:<br>metallic                                                                                                                                                                                                                                                                                                               | 40                                        |
| non-metallic                                                                                                                                                                                                                                                                                                                                                                | 50                                        |
| – Parts which need not be touched for normal operation:<br>metallic                                                                                                                                                                                                                                                                                                         | 50                                        |
| non-metallic                                                                                                                                                                                                                                                                                                                                                                | 60                                        |
| <sup>a</sup> No value is specified for parts other than those listed but no damage should be caused to adjacent parts of insulating materials.<br><sup>b</sup> The temperature-rise limits specified are not intended to apply to a new sample, but are those applicable to the temperature-rise verifications during the appropriate test sequences specified in Clause 8. |                                           |

#### 7.2.3 Dielectric properties

Subclauses 7.2.3 a) and 7.2.3 b) of IEC 60947-1 apply.

Type tests shall be made in accordance with 8.3.3.2.

The verification of dielectric withstand during all test sequences shall be made in accordance with 8.3.3.5.

Routine tests shall be made in accordance with 8.4.5.

##### 7.2.3.1 Impulse withstand voltage

Subclause 7.2.3.1 of IEC 60947-1 applies.

### 7.2.3.2 Power-frequency withstand voltage of the main, auxiliary and control circuits

Power-frequency tests are used in the following cases:

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

### 7.2.3.3 Clearances

Subclause 7.2.3.3 of IEC 60947-1 applies.

### 7.2.3.4 Creepage distances

Subclause 7.2.3.4 of IEC 60947-1 applies.

### 7.2.3.5 Solid insulation

Solid insulation shall be verified by either power-frequency tests, in accordance with 8.3.3.4.1, item 3), of IEC 60947-1, or d.c. tests (test voltages for d.c. tests are under consideration).

For the purposes of this standard, circuits incorporating solid-state devices shall be disconnected for the tests.

### 7.2.3.6 Spacing between separate circuits

Subclause 7.2.3.6 of IEC 60947-1 applies.

## 7.2.4 Ability to make and break under no load, normal load and overload conditions

### 7.2.4.1 Overload performance

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

The circuit-breaker shall be capable of carrying out the number of operating cycles with current in the main circuit exceeding its rated current, under the test conditions according to 8.3.3.4.

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

### 7.2.4.2 Operational performance capability

Subclause 7.2.4.2 of IEC 60947-1 applies with the following additions:

The circuit-breaker shall be capable of meeting the requirements of Table 8:

- for the test of operational performance without current in the main circuit under the test conditions specified in 8.3.3.3.3;
- for the test of operational performance with current in the main circuit under the test conditions specified in 8.3.3.3.4.

Each operating cycle consists of, either a closing operation followed by an opening operation (test of operational performance without current), or a making operation followed by a breaking operation (test of operational performance with current).

**Table 8 – Number of operating cycles**

| 1                                                                                                                                                                                                                                                                                                                                                                                                                                                      | 2                                                   | 3                          | 4                         | 5      |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|----------------------------|---------------------------|--------|
| Rated current <sup>a</sup><br>A                                                                                                                                                                                                                                                                                                                                                                                                                        | Number of operating<br>cycles per hour <sup>b</sup> | Number of operating cycles |                           |        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                     | Without current            | With current <sup>c</sup> | Total  |
| $I_n \leq 100$                                                                                                                                                                                                                                                                                                                                                                                                                                         | 120                                                 | 8 500                      | 1 500                     | 10 000 |
| $100 < I_n \leq 315$                                                                                                                                                                                                                                                                                                                                                                                                                                   | 120                                                 | 7 000                      | 1 000                     | 8 000  |
| $315 < I_n \leq 630$                                                                                                                                                                                                                                                                                                                                                                                                                                   | 60                                                  | 4 000                      | 1 000                     | 5 000  |
| $630 < I_n \leq 2 500$                                                                                                                                                                                                                                                                                                                                                                                                                                 | 20                                                  | 2 500                      | 500                       | 3 000  |
| $2 500 < I_n$                                                                                                                                                                                                                                                                                                                                                                                                                                          | 10                                                  | 1 500                      | 500                       | 2 000  |
| <sup>a</sup> This means the maximum rated current for a given frame size.<br><sup>b</sup> Column 2 gives the minimum operating rate. This rate may be increased with the consent of the manufacturer; in this case the rate used shall be stated in the test report.<br><sup>c</sup> During each operating cycle, the circuit-breaker shall remain closed for a sufficient time to ensure that the full current is established, but not exceeding 2 s. |                                                     |                            |                           |        |

### 7.2.5 Ability to make and break under short-circuit conditions

Subclause 7.2.5 of IEC 60947-1 applies with the following amplifications:

The rated short-circuit making capacity shall be in accordance with 4.3.5.1 and 4.3.5.3.

The rated short-circuit breaking capacity shall be in accordance with 4.3.5.2.

The rated short-time withstand current shall be in accordance with 4.3.5.4.

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.

### 7.2.6 Vacant

### 7.2.7 Additional requirements for circuit-breakers suitable for isolation

Subclause 7.2.7 of IEC 60947-1 applies and tests shall be made in accordance with 8.3.3.2, 8.3.3.5, 8.3.3.9, 8.3.4.3, 8.3.5.3 and 8.3.7.7, as applicable.

### 7.2.8 Specific requirements for integrally fused circuit-breakers

NOTE For the co-ordination between circuit-breakers and separate fuses associated in the same circuit, see 7.2.9.

An integrally fused circuit-breaker shall comply with this standard in all respects up to the rated ultimate short-circuit breaking capacity. In particular, it shall meet the requirements of test sequence V (see 8.3.7).

The circuit-breaker shall function, without causing the fuses to operate, at the occurrence of over-currents not exceeding the selectivity limit current  $I_s$  declared by the manufacturer.

For all over-currents up to and including the rated ultimate short-circuit breaking capacity assigned to the composite unit, the circuit-breaker shall open when one or more fuses operate (in order to prevent single-phasing). If the circuit-breaker is stated by the manufacturer to be with lock-out device preventing closing (see 2.14), it shall not be possible to reclose the circuit-breaker until either the melted fuse-links or any missing fuse-links have been replaced or the lock-out means has been reset.

### 7.2.9 Co-ordination between a circuit-breaker and another short-circuit protective device

For the co-ordination between a circuit-breaker and another short-circuit protective device, see Annex A.

## 7.3 Electromagnetic compatibility (EMC)

Requirements and test methods are given in Annex J.

## 8 Tests

### 8.1 Kind of tests

Subclause 8.1 of IEC 60947-1 applies, with the following additions:

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

- type tests (see 8.3);
- routine tests (see 8.4);
- special tests (see 8.5).

8.1.2 Type tests include the following tests:

| Test                                             | Subclause       |
|--------------------------------------------------|-----------------|
| Temperature-rise                                 | 8.3.2.5         |
| Tripping limits and characteristics              | 8.3.3.1         |
| Dielectric properties                            | 8.3.3.2         |
| Operational performance capability               | 8.3.3.3         |
| Overload performance (where applicable)          | 8.3.3.4         |
| Short-circuit breaking capacities                | 8.3.4 and 8.3.5 |
| Short-time withstand current (where applicable)  | 8.3.6           |
| Performance of integrally fused circuit-breakers | 8.3.7           |

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

8.1.3 Routine tests comprise the tests listed in 8.4.

### 8.2 Compliance with constructional requirements

Subclause 8.2 of IEC 60947-1 applies.

### 8.3 Type tests

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 (8.3.2.1 to 8.3.2.4);
- test conditions applicable to temperature-rise tests (8.3.2.5);
- test conditions applicable to short-circuit tests (8.3.2.6).

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 8.3.1, using the terms most likely to be used (not necessarily the exact terms appearing in the relevant subclause heading).

### **8.3.1 Test sequences**

#### **8.3.1.1 General**

Type tests are grouped together in a number of sequences, as shown in Table 9.

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

#### **8.3.1.2 Tests omitted from sequence I and made separately**

With reference to 8.1.1 of IEC 60947-1, the following tests of test sequence I (see 8.3.3) may be omitted from the sequence and made on separate samples:

- tripping limits and characteristics (8.3.3.1); in which case the sample(s) tested in the sequence shall be subjected to the tests of 8.3.3.1.3, at the maximum setting only and without the additional test of item b) to verify the time-current characteristic;
- test of dielectric properties (8.3.3.2);
- test of under-voltage releases of 8.3.3.3.2 (item c) and 8.3.3.3.3, to verify the requirements of 7.2.1.3 of IEC 60947-1, and tests of under-voltage releases at alternative frequencies (see 8.3.2.1);
- test of shunt releases of 8.3.3.3.2 (item d) and 8.3.3.3.3, to verify the requirements of 7.2.1.4 of IEC 60947-1, and tests of shunt releases at alternative frequencies (see 8.3.2.1);
- additional tests for operational capability without current for withdrawable circuit-breakers (8.3.3.3.5).

#### **8.3.1.3 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 9a.

### Alphabetical index of tests

| General test conditions                                                      | Subclause                                                                                               |
|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| Arrangement of circuit-breakers, general                                     | 8.3.2.1                                                                                                 |
| Arrangement of circuit-breakers for short-circuit tests                      | 8.3.2.6.1                                                                                               |
| Frequency                                                                    | 8.3.2.2.3                                                                                               |
| Power factor                                                                 | 8.3.2.2.4                                                                                               |
| Records (interpretation of)                                                  | 8.3.2.6.6                                                                                               |
| Recovery voltage                                                             | 8.3.2.2.6                                                                                               |
| Short-circuit test circuits                                                  | 8.3.2.6.2                                                                                               |
| Short-circuit test procedure                                                 | 8.3.2.6.4                                                                                               |
| Temperature-rise test                                                        | 8.3.2.5                                                                                                 |
| Time constant                                                                | 8.3.2.2.5                                                                                               |
| Tolerances                                                                   | 8.3.2.2.2                                                                                               |
| Tests<br>(for overall schema of test sequences, see Table 9)                 | Subclause                                                                                               |
| Dielectric properties                                                        | 8.3.3.2                                                                                                 |
| Dielectric withstand (verification)                                          | 8.3.3.5 – 8.3.4.3 – 8.3.5.3 –<br>8.3.6.5 – 8.3.7.3 – 8.3.7.7 – 8.3.8.5                                  |
| Individual pole short-circuit test (for phase-earthed systems)               | Annex C                                                                                                 |
| Individual pole short-circuit test (for IT systems)                          | Annex H                                                                                                 |
| Indication of main contact position                                          | 8.3.3.9                                                                                                 |
| Integrally fused circuit-breakers (short-circuit tests)                      | 8.3.7.1 – 8.3.7.5 – 8.3.7.6                                                                             |
| Operational performance capability                                           | 8.3.3.3 – 8.3.4.2 – 8.3.4.4                                                                             |
| Overload performance                                                         | 8.3.3.4                                                                                                 |
| Overload releases (verification)                                             | 8.3.3.7 – 8.3.4.4 – 8.3.5.1 –<br>8.3.5.4 – 8.3.6.1 – 8.3.6.6 – 8.3.7.4 –<br>8.3.7.8 – 8.3.8.1 – 8.3.8.6 |
| Service short-circuit breaking capacity                                      | 8.3.4.1 – 8.3.8.3                                                                                       |
| Short-circuit breaking capacity test at maximum short-time withstand current | 8.3.6.4                                                                                                 |
| Short-time withstand current                                                 | 8.3.6.2 – 8.3.8.2                                                                                       |
| Temperature-rise (verification)                                              | 8.3.3.6 – 8.3.4.3 – 8.3.6.3 –<br>8.3.7.2 – 8.3.8.5                                                      |
| Tripping limits and characteristics                                          | 8.3.3.1                                                                                                 |
| Ultimate short-circuit breaking capacity                                     | 8.3.5.2                                                                                                 |
| Withdrawable circuit-breakers (additional tests)                             | 8.3.3.3.5                                                                                               |

**Table 9 – Overall schema of test sequences <sup>a</sup>**

| Test sequence                                                                                                                                                                                                                                                                                                                                                                                                                         | Applicable to                                                                                                                                                                               | Tests                                                                                                                                                                                                                                                                                                                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I<br>General performance characteristics (8.3.3)                                                                                                                                                                                                                                                                                                                                                                                      | All circuit-breakers                                                                                                                                                                        | Tripping limits and characteristics<br>Dielectric properties<br>Mechanical operation and operational performance capability<br>Overload performance (where applicable)<br>Verification of dielectric withstand<br>Verification of temperature-rise<br>Verification of overload releases<br>Verification of undervoltage and shunt releases (where applicable)<br>Verification of main contact position (where applicable) |
| II<br>Rated service short-circuit breaking capacity (8.3.4)                                                                                                                                                                                                                                                                                                                                                                           | All circuit-breakers <sup>b</sup>                                                                                                                                                           | Rated service short-circuit breaking capacity<br>Operational performance capability<br>Verification of dielectric withstand<br>Verification of temperature-rise<br>Verification of overload releases                                                                                                                                                                                                                      |
| III<br>Rated ultimate short-circuit breaking capacity (8.3.5)                                                                                                                                                                                                                                                                                                                                                                         | All circuit-breakers <sup>c</sup> of selectivity category A and circuit-breakers of selectivity category B with instantaneous override*                                                     | Verification of overload releases<br>Rated ultimate short-circuit breaking capacity<br>Verification of dielectric withstand<br>Verification of overload releases                                                                                                                                                                                                                                                          |
| IV<br>Rated short-time withstand current (8.3.6)                                                                                                                                                                                                                                                                                                                                                                                      | Circuit-breakers of selectivity category B <sup>b</sup>                                                                                                                                     | Verification of overload releases<br>Rated short-time withstand current<br>Verification of temperature-rise<br>Short-circuit breaking capacity at maximum short-time withstand current<br>Verification of dielectric withstand<br>Verification of overload releases                                                                                                                                                       |
| V<br>Performance of integrally fused circuit-breakers (8.3.7)                                                                                                                                                                                                                                                                                                                                                                         | <div>Stage 1</div> <div>Integrally fused circuit-breakers</div> <div>Stage 2</div>                                                                                                          | <div> Short-circuit at the selectivity limit current<br/> Verification of temperature-rise<br/> Verification of dielectric withstand </div> <div> Verification of overload releases<br/> Short-circuit at 1,1 times the take-over current<br/> Short-circuit at rated ultimate short-circuit breaking capacity<br/> Verification of dielectric withstand<br/> Verification of overload releases </div>                    |
| VI<br>Combined test sequence (8.3.8)                                                                                                                                                                                                                                                                                                                                                                                                  | Circuit-breakers of selectivity category B:<br>when $I_{CW} = I_{CS}$<br>(replaces test sequences II and IV)<br>when $I_{CW} = I_{CS} = I_{CU}$<br>(replaces test sequences II, III and IV) | Verification of overload releases<br>Rated short-time withstand current<br>Rated service short-circuit breaking capacity<br>Operational performance capability<br>Verification of dielectric withstand<br>Verification of temperature-rise<br>Verification of overload releases                                                                                                                                           |
| Individual pole short-circuit test sequence (Annex C)                                                                                                                                                                                                                                                                                                                                                                                 | Circuit-breakers for use on phase-earthed systems                                                                                                                                           | Individual pole short-circuit breaking capacity ( $I_{su}$ )<br>Verification of dielectric withstand<br>Verification of overload releases                                                                                                                                                                                                                                                                                 |
| Individual pole short-circuit test sequence (Annex H)                                                                                                                                                                                                                                                                                                                                                                                 | Circuit-breakers for use in IT systems                                                                                                                                                      | Individual pole short-circuit breaking capacity ( $I_{IT}$ )<br>Verification of dielectric withstand<br>Verification of overload releases                                                                                                                                                                                                                                                                                 |
| * See note to 8.3.5<br><sup>a</sup> For the selection of circuit-breakers for tests and the applicability of the various test sequences according to the relationship between $I_{CS}$ , $I_{CU}$ and $I_{CW}$ , see Table 9a.<br><sup>b</sup> Except where Sequence VI is applied.<br><sup>c</sup> Except    – where $I_{CS} = I_{CU}$ (but see 8.3.5)<br>– where Sequence VI is applied<br>– for integrally fused circuit-breakers. |                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                           |

**Table 9a – Applicability of test sequences according to the relationship between  $I_{CS}$ ,  $I_{CU}$  and  $I_{CW}$  <sup>a</sup>**

| $I_{CS}$ , $I_{CU}$ and $I_{CW}$ relationship                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Test sequence | Selectivity category |                          |                |                          |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|----------------------|--------------------------|----------------|--------------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |               | A                    | A<br>Integrally<br>fused | B              | B<br>Integrally<br>fused |
| CASE 1<br><br>$I_{CS} \neq I_{CU}$ for selectivity category A<br>$I_{CS} \neq I_{CU} \neq I_{CW}$ for selectivity category B                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | I             | X                    | X                        | X              | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | II            | X                    | X                        | X              | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | III           | X                    |                          | X <sup>b</sup> |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | IV            | X <sup>d</sup>       |                          | X              | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | V             |                      | X                        |                | X                        |
| CASE 2<br><br>$I_{CS} = I_{CW} \neq I_{CU}$ for selectivity category B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | I             |                      |                          | X              | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | II            |                      |                          | X              | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | III           |                      |                          | X <sup>b</sup> |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | IV            |                      |                          | X              | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | V             |                      |                          |                | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | VI (combined) |                      |                          | X <sup>c</sup> | X <sup>c</sup>           |
| CASE 3<br><br>$I_{CS} = I_{CU}$ for selectivity category A<br>$I_{CS} = I_{CU} \neq I_{CW}$ for selectivity category B                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | I             | X                    | X                        | X              | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | II            | X                    | X                        | X              | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | III           |                      |                          |                |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | IV            | X <sup>d</sup>       |                          | X              | X                        |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | V             |                      | X                        |                | X                        |
| CASE 4<br><br>$I_{CS} = I_{CU} = I_{CW}$ for selectivity category B                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | I             |                      |                          | X              |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | II            |                      |                          | X              |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | III           |                      |                          |                |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | IV            |                      |                          | X              |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | V             |                      |                          |                |                          |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | VI (combined) |                      |                          | X <sup>c</sup> |                          |
| <sup>a</sup> Table applies to any one value of $U_e$ . For multiple $U_e$ ratings, the table applies to each $U_e$ rating. The applicability of a test sequence is indicated by X in the relevant space.<br><sup>b</sup> Test applicable only if $I_{CU} > I_{CW}$ .<br><sup>c</sup> At the discretion of, or in agreement with the manufacturer, this sequence may be applied to circuit-breakers of selectivity category B, in which case it replaces test sequences II and IV.<br><sup>d</sup> Test sequence IV applies only in the case of circuit-breakers covered by note 3 of Table 4. |               |                      |                          |                |                          |

#### 8.3.1.4 Alternative test programmes for circuit-breakers having both three-pole and four-pole variants

These alternative test programmes may be applied when there is no construction break (see 7.1.5) between the poles of the four-pole variant and the poles of the three-pole variant.

Compliance with the test requirements may be met by carrying out one of the alternative programmes 1 or 2 below.

- Programme 1: The applicable test sequences according to Table 9 shall be carried out on the three-pole variant of the circuit-breaker. In addition, the tests or test sequences listed in Table 9b shall be carried out on the four-pole variant.
- Programme 2: The applicable test sequences according to Table 9 shall be carried out on the four-pole variant of the circuit-breaker. In addition, the tests or test sequences listed in Table 9c shall be carried out on the three-pole variant.

**Table 9b – Applicability of tests or test sequences to four-pole circuit-breakers in a given frame size and design when tested according to the alternative programme 1 of 8.3.1.4**

| Test sequence | Test clause                                                   | Test                                                                                                    | Four identical poles, neutral identified or not                  | Fourth pole identified, neutral unprotected<br>(See Note 2 to 8.3.1.4) | Fourth pole identified, neutral protected rated differently to the phase poles                                                                                                   |
|---------------|---------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I             | <b>8.3.3.1</b>                                                | <b>Test of tripping limits and characteristics</b>                                                      |                                                                  |                                                                        |                                                                                                                                                                                  |
|               | 8.3.3.1.1                                                     | General                                                                                                 |                                                                  |                                                                        |                                                                                                                                                                                  |
|               | 8.3.3.1.2                                                     | Short-circuit releases                                                                                  | X<br>one test on one pair of poles chosen at random <sup>a</sup> | X<br>one test on one pair of phase poles chosen at random <sup>a</sup> | X<br>i) one test on one pair of phase poles chosen at random <sup>a</sup><br><br>X<br>ii) one test on N + one phase pole at random                                               |
|               | 8.3.3.1.3 a)<br><br>or<br><br>8.3.3.1.3 b)<br>(as applicable) | Overload releases:<br>–instantaneous/definite time-delay<br><br>–inverse time-delay                     | X<br>3-phase<br><br>X<br>3-phase                                 | X<br>3-phase<br><br>X<br>3-phase                                       | X<br>i) 3-phase poles<br>X<br>ii) N<br><br>X<br>i) 3-phase poles<br>X<br>ii) N                                                                                                   |
|               | 8.3.3.1.4                                                     | Additional test for definite time-delay releases:<br>– overload releases<br><br>–short-circuit releases |                                                                  |                                                                        | X<br>i) 3-phase poles<br>X<br>ii) N<br><br>X<br>i) one test on one pair of phase poles chosen at random <sup>a</sup><br>X<br>ii) one test on N + one phase pole chosen at random |

Table 9b (continued)

| Test sequence                                                                                                                                                          | Test clause        | Test                                                        | Four identical poles, neutral identified or not         | Fourth pole identified, neutral unprotected<br>(See Note 2 to 8.3.1.4) | Fourth pole identified, neutral protected rated differently to the phase poles |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------------------------------------------------|---------------------------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------------|
|                                                                                                                                                                        | 8.3.3.2            | Dielectric properties                                       | X                                                       | X                                                                      | X                                                                              |
|                                                                                                                                                                        | 8.3.3.3            | Mechanical operation and operational performance capability |                                                         |                                                                        |                                                                                |
|                                                                                                                                                                        | 8.3.3.3.1          | General                                                     |                                                         |                                                                        |                                                                                |
|                                                                                                                                                                        | 8.3.3.3.2          | Construction and mechanical operation                       | X                                                       | X                                                                      | X                                                                              |
|                                                                                                                                                                        | 8.3.3.3.3          | Operational performance capability without current          | X                                                       | X                                                                      | X                                                                              |
|                                                                                                                                                                        | 8.3.3.3.4          | Operational performance capability with current             | X                                                       | X                                                                      | X                                                                              |
|                                                                                                                                                                        | 8.3.3.3.5          | Withdrawable circuit-breakers                               | X                                                       | X                                                                      | X                                                                              |
|                                                                                                                                                                        | 8.3.3.4            | Overload performance                                        | X                                                       | X                                                                      | X                                                                              |
|                                                                                                                                                                        | 8.3.3.5            | Verification of dielectric withstand                        | X                                                       | X                                                                      | X                                                                              |
|                                                                                                                                                                        | 8.3.3.6            | Verification of temperature-rise                            | X                                                       | X                                                                      | X                                                                              |
|                                                                                                                                                                        | 8.3.3.7            | Verification of overload releases                           |                                                         |                                                                        |                                                                                |
|                                                                                                                                                                        | 8.3.3.8            | Verification of undervoltage and shunt releases             | X                                                       | X                                                                      | X                                                                              |
|                                                                                                                                                                        | 8.3.3.9            | Verification of the main contact position                   | X                                                       | X                                                                      | X                                                                              |
| II                                                                                                                                                                     | 8.3.4              | Rated service short-circuit breaking capacity               |                                                         |                                                                        |                                                                                |
| III                                                                                                                                                                    | 8.3.5 <sup>b</sup> | Rated ultimate short-circuit breaking capacity              | X                                                       | X                                                                      | X                                                                              |
| IV                                                                                                                                                                     | 8.3.6              | Rated short-time withstand current                          | X<br>4th pole and adjacent pole only<br>(see 8.3.2.6.4) | X<br>4th pole and adjacent pole only<br>(see 8.3.2.6.4)                | X<br>4th pole and adjacent pole only<br>(see 8.3.2.6.4)                        |
| V                                                                                                                                                                      | 8.3.7              | Performance of integrally fused circuit-breakers            |                                                         |                                                                        |                                                                                |
| VI                                                                                                                                                                     | 8.3.8              | Combined test sequence                                      |                                                         |                                                                        |                                                                                |
| NOTE The applicability of a test or test sequence is indicated by X in the relevant space.                                                                             |                    |                                                             |                                                         |                                                                        |                                                                                |
| <sup>a</sup> In the case of an electronic trip unit, these tests may be made on one pole chosen at random.                                                             |                    |                                                             |                                                         |                                                                        |                                                                                |
| <sup>b</sup> This test sequence also applies when, for the 3-pole testing, Sequence III on the 3-pole variant is replaced by Sequence II or Sequence VI (see Table 9). |                    |                                                             |                                                         |                                                                        |                                                                                |

**Table 9c – Applicability of tests or test sequences to 3-pole circuit-breakers in a given frame size and design when tested according to the alternative programme 2 of 8.3.1.4**

| Test sequence                                                                                                                                                          | Test clause                                           | Test                                                                                                | Test or sequence of tests on 3-pole variant |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------|---------------------------------------------|
| I                                                                                                                                                                      | <b>8.3.3.1</b>                                        | <b>Test of tripping limits and characteristics</b>                                                  |                                             |
|                                                                                                                                                                        | 8.3.3.1.1                                             | General                                                                                             |                                             |
|                                                                                                                                                                        | 8.3.3.1.2                                             | Short-circuit releases                                                                              |                                             |
|                                                                                                                                                                        | 8.3.3.1.3 a)<br>or<br>8.3.3.1.3 b)<br>(as applicable) | Overload releases:<br>– instantaneous/definite time-delay<br><br>– inverse time-delay               |                                             |
|                                                                                                                                                                        | 8.3.3.1.4                                             | Additional test for definite time-delay releases:<br>– overload release<br>– short-circuit releases |                                             |
|                                                                                                                                                                        | <b>8.3.3.2</b>                                        | <b>Dielectric properties</b>                                                                        | X                                           |
|                                                                                                                                                                        | <b>8.3.3.3</b>                                        | <b>Mechanical operation and operational performance capability</b>                                  |                                             |
|                                                                                                                                                                        | 8.3.3.3.1                                             | General                                                                                             |                                             |
|                                                                                                                                                                        | 8.3.3.3.2                                             | Construction and mechanical operation                                                               |                                             |
|                                                                                                                                                                        | 8.3.3.3.3                                             | Operational performance capability without current                                                  | X                                           |
|                                                                                                                                                                        | 8.3.3.3.4                                             | Operational performance capability with current                                                     | X                                           |
|                                                                                                                                                                        | 8.3.3.3.5                                             | Withdrawable circuit-breakers                                                                       |                                             |
|                                                                                                                                                                        | <b>8.3.3.4</b>                                        | <b>Overload performance</b>                                                                         | X                                           |
|                                                                                                                                                                        | <b>8.3.3.5</b>                                        | <b>Verification of dielectric withstand</b>                                                         | X                                           |
|                                                                                                                                                                        | <b>8.3.3.6</b>                                        | <b>Verification of temperature-rise</b>                                                             | X                                           |
|                                                                                                                                                                        | <b>8.3.3.7</b>                                        | <b>Verification of overload releases</b>                                                            |                                             |
|                                                                                                                                                                        | <b>8.3.3.8</b>                                        | <b>Verification of undervoltage and shunt releases</b>                                              |                                             |
|                                                                                                                                                                        | <b>8.3.3.9</b>                                        | <b>Verification of the main contact position</b>                                                    |                                             |
| II                                                                                                                                                                     | <b>8.3.4</b>                                          | <b>Rated service short-circuit breaking capacity</b>                                                |                                             |
| III                                                                                                                                                                    | <b>8.3.5<sup>b</sup></b>                              | <b>Rated ultimate short-circuit breaking capacity</b>                                               | X                                           |
| IV                                                                                                                                                                     | <b>8.3.6</b>                                          | <b>Rated short-time withstand current</b>                                                           |                                             |
| V                                                                                                                                                                      | <b>8.3.7</b>                                          | <b>Performance of integrally fused circuit-breakers</b>                                             |                                             |
| VI                                                                                                                                                                     | <b>8.3.8</b>                                          | <b>Combined test sequence</b>                                                                       |                                             |
| <b>NOTE</b> The applicability of a test or test sequence is indicated by X in the relevant space.                                                                      |                                                       |                                                                                                     |                                             |
| <sup>a</sup> In the case of an electronic trip unit, these tests may be made on one pole chosen at random.                                                             |                                                       |                                                                                                     |                                             |
| <sup>b</sup> This test sequence also applies when, for the 4-pole testing, Sequence III on the 4-pole variant is replaced by Sequence II or Sequence VI (see Table 9). |                                                       |                                                                                                     |                                             |

### 8.3.2 General test conditions

NOTE Tests according to the requirements of this standard do not preclude the need for additional tests concerning circuit-breakers incorporated in assemblies, for example tests in accordance with IEC 60439.

#### 8.3.2.1 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 10.

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 2.1.2 and 7.1.5) within the frame size, further samples shall be tested in accordance with table footnote g of Table 10.

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 a.c., at the same rated frequency and with the same number of phases as in the intended service. Tests performed at 50 Hz cover 60 Hz applications and vice-versa, except for the performance of under-voltage and shunt releases (see 7.2.2 and 7.2.2.6 of IEC 60947-1).

If the mechanism is electrically controlled, it shall be supplied at the minimum voltage as specified in 7.2.1.1.3. In addition, electrically controlled mechanisms shall be energized via the appropriate circuit-breaker control circuits complete with switching devices. It shall be verified that the circuit-breaker operates correctly on no-load when it is operated under the above conditions.

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

Circuit-breakers shall be tested in free air.

If a circuit-breaker may be used in specified individual enclosures and has been tested in free air, it shall be additionally tested in the smallest of such enclosures stated by the manufacturer, using a new sample, according to 8.3.5, at  $U_e$  max/corresponding  $I_{cu}$ , with release settings at maximum (see table footnote a of Table 10).

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

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

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

For the tests in free air, for tests concerning overload performance (8.3.3.4), short-circuit (8.3.4.1, 8.3.5.2, 8.3.6.4, 8.3.7.1, 8.3.7.5, 8.3.7.6 and 8.3.8.3), and short-time withstand current (8.3.6.2 and 8.3.8.2) where applicable, a metallic screen shall be placed on all sides of the circuit-breaker in accordance with the manufacturer's instructions. Details, including distances of the metallic screen from the circuit-breaker, shall be stated in the test report.

The characteristics of the metallic screen shall be as follows:

- structure: woven wire mesh,  
or perforated metal,  
or expanded metal;
- ratio hole area/total area: 0,45-0,65;
- size of hole: not exceeding 30 mm<sup>2</sup>;
- finish: bare or conductive plating;
- resistance: shall be included in the calculation for the prospective fault current in the fusible element circuit (see 8.3.4.1.2, item d) of IEC 60947-1) when measured from the furthest point on the metallic screen likely to be reached by arc emissions.

The tightening torques to be applied to the terminal screws shall be in accordance with the manufacturer's instructions or, in the absence of such instructions, in accordance with Table 4 of IEC 60947-1.

Maintenance or replacements of parts is not permitted.

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

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

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

Table 10 – Number of samples for test

| Test sequence                                 | Number of marked $U_e$ ratings |   |      | Terminals marked line/load |    | Number of samples | Sample No. | Current setting <sup>a</sup> |      | Test voltage    | Test current |      | Temperature-rise verification | Foot-notes |
|-----------------------------------------------|--------------------------------|---|------|----------------------------|----|-------------------|------------|------------------------------|------|-----------------|--------------|------|-------------------------------|------------|
|                                               | 1                              | 2 | Mul. | Yes                        | No |                   |            | Min.                         | Max. |                 | Corr.        | Max. |                               |            |
| I                                             | X                              | X | X    | X                          | X  | 1                 | 1          |                              | X    | $U_e$ max       | See 8.3.3    |      | X                             | g          |
| II<br>( $I_{cs}$ )<br>and<br>VI<br>(combined) | X                              |   |      | X                          |    | 2                 | 1          |                              | X    | $U_e$           | X            |      | X                             | h          |
|                                               |                                |   |      |                            |    |                   | 2          | X                            |      | $U_e$           | X            |      |                               | b          |
|                                               | X                              |   |      |                            | X  | 3                 | 1          |                              | X    | $U_e$           | X            |      | X                             | h          |
|                                               |                                |   |      |                            |    |                   | 2          | X                            |      | $U_e$           | X            |      |                               | b          |
|                                               |                                |   |      |                            |    |                   | 3          |                              | X    | $U_e$           | X            |      | X                             | j          |
|                                               |                                | X |      | X                          | X  | 3                 | 1          |                              | X    | $U_e$ max corr. |              | X    | X                             | h          |
|                                               |                                |   |      |                            |    |                   | 2          | X                            |      | $U_e$ max corr. |              | X    |                               | b          |
|                                               |                                |   |      |                            |    |                   | 3          |                              | X    | $U_e$ max       | X            |      | X                             | k          |
|                                               |                                |   | X    | X                          | X  | 4                 | 1          |                              | X    | $U_e$ max corr. |              | X    | X                             | h          |
|                                               |                                |   |      |                            |    |                   | 2          | X                            |      | $U_e$ max corr. |              | X    |                               | b          |
|                                               |                                |   |      |                            |    |                   | 3          |                              | X    | $U_e$ intermed. | X            |      | X                             | e          |
|                                               |                                |   |      |                            |    |                   | 4          |                              | X    | $U_e$ max       | X            |      | X                             | k          |
| III<br>( $I_{cu}$ )                           | X                              |   |      | X                          |    | 2                 | 1          |                              | X    | $U_e$           | X            |      |                               | g          |
|                                               |                                |   |      |                            |    |                   | 2          | X                            |      | $U_e$           | X            |      |                               | b          |
|                                               | X                              |   |      |                            | X  | 3                 | 1          |                              | X    | $U_e$           | X            |      |                               | g          |
|                                               |                                |   |      |                            |    |                   | 2          | X                            |      | $U_e$           | X            |      |                               | b          |
|                                               |                                |   |      |                            |    |                   | 3          |                              | X    | $U_e$           | X            |      |                               | c          |
|                                               |                                | X |      | X                          | X  | 3                 | 1          |                              | X    | $U_e$ max corr. |              | X    |                               | g          |
|                                               |                                |   |      |                            |    |                   | 2          | X                            |      | $U_e$ max corr. |              | X    |                               | b          |
|                                               |                                |   |      |                            |    |                   | 3          |                              | X    | $U_e$ max       | X            |      |                               | d          |
|                                               |                                |   | X    | X                          | X  | 4                 | 1          |                              | X    | $U_e$ max corr. |              | X    |                               | g          |
|                                               |                                |   |      |                            |    |                   | 2          | X                            |      | $U_e$ max corr. |              | X    |                               | b          |
|                                               |                                |   |      |                            |    |                   | 3          |                              | X    | $U_e$ intermed. | X            |      |                               | e          |
|                                               |                                |   |      |                            |    |                   | 4          |                              | X    | $U_e$ max       | X            |      |                               | d          |
|                                               |                                |   |      |                            |    |                   |            |                              |      |                 |              |      |                               |            |

| Test sequence                   | Number of marked $I_{cw}$ ratings |  |      | Terminals marked line/load |    | Number of samples | Sample No. | Current setting <sup>a</sup> |      | Test voltage    | Rated $I_{cw}$ |      |            |      | Temperature-rise verification | Foot-notes |
|---------------------------------|-----------------------------------|--|------|----------------------------|----|-------------------|------------|------------------------------|------|-----------------|----------------|------|------------|------|-------------------------------|------------|
|                                 | 1                                 |  | Mul. | Yes                        | No |                   |            | Min.                         | Max. |                 | Test current   |      | Time delay |      |                               |            |
|                                 |                                   |  |      |                            |    |                   |            |                              |      |                 | Corr.          | Max. | Corr.      | Max. |                               |            |
| IV<br>( $I_{cw}$ ) <sup>1</sup> | X                                 |  |      | X                          | X  | 2                 | 1          |                              | X    | $U_e$ max       |                | X    |            | X    | X                             | g          |
|                                 |                                   |  |      |                            |    |                   | 2          |                              | X    | $U_e$ max       |                | X    |            | X    | X                             | m          |
|                                 |                                   |  | X    | X                          | X  | 3                 | 1          |                              | X    | $U_e$ max corr. |                | X    | X          |      | X                             | g          |
|                                 |                                   |  |      |                            |    |                   | 2          |                              | X    | $U_e$ max corr. | X              |      | X          |      | X                             | i          |
|                                 |                                   |  |      |                            |    |                   | 3          |                              | X    | $U_e$ max       | X              |      | X          |      | X                             | m          |
|                                 |                                   |  |      |                            |    |                   |            |                              |      |                 |                |      |            |      |                               |            |

Table 10 (continued)

| Test sequence                          | Number of marked $U_e$ ratings |   |      | Terminals marked line/load |    | Number of samples | Sample No. | Current setting <sup>a</sup> |       | Test voltage           | Test current         |      | Temperature-rise verification | Foot-notes |
|----------------------------------------|--------------------------------|---|------|----------------------------|----|-------------------|------------|------------------------------|-------|------------------------|----------------------|------|-------------------------------|------------|
|                                        | 1                              | 2 | Mul. | Yes                        | No |                   |            | Min.                         | Max.  |                        | Corr.                | Max. |                               |            |
| V<br>Integral fused ( $I_{cu}$ )       | X                              | X | X    | X                          | X  | 2                 | 1<br>2     | <br>X                        | X<br> | $U_e$ max<br>$U_e$ max | X<br>X               |      | X                             | f, g<br>b  |
| Individual pole (Annex C) ( $I_{su}$ ) | X                              | X | X    | X                          | X  | 2                 | 1<br>2     | <br>X                        | X<br> | $U_e$ max<br>$U_e$ max | $I_{su}$<br>$I_{su}$ |      |                               | g<br>–     |
| Individual pole (Annex H) ( $I_{IT}$ ) | X                              | X | X    | X                          | X  | 1                 | 1          |                              | X     | $U_e$ max              | $I_{IT}$             |      |                               | g          |

Mul. = multiple; Corr. = corresponding; Intermed. = intermediate

NOTE The applicability of a test or test sequence is indicated by X in the relevant space.

- a Min means the minimum  $I_n$  of a given frame size; in the case of adjustable overload releases, it means the minimum setting of the minimum  $I_n$ . Max means the maximum  $I_n$  of a given frame size.
- b This sample is omitted in the following cases:
- a circuit-breaker having a single non-adjustable current setting for a given frame size;
  - a circuit-breaker provided only with a shunt release (i.e. without an integral overcurrent release);
  - a circuit-breaker with electronic overcurrent protection, of a given frame size, having an adjustable current rating by electronic means only (i.e. without change of current sensors).
- c Connections reversed.
- d Connections reversed, if terminals unmarked.
- e To be agreed between test station and manufacturer.
- f If terminals unmarked, an additional sample shall be tested with connections reversed.
- g In the case of one or more construction breaks (see 2.1.2 and 7.1.5) within the frame size, a further sample is tested at the maximum rated current corresponding to each construction, under the conditions applicable to sample 1.
- h The requirement of footnote g applies to sequence VI (combined) and also to sequence II where  $I_{cs} = I_{cu}$ .
- i This sample is selected based on the highest value of thermal energy ( $I_{cw}^2 t$ ; where “t” is the corresponding short-time delay, see 4.3.5.4). This sample is omitted if the highest thermal energy condition is met by sample 1 or 3.
- j This sample, with connections reversed, is only required when sequence III is replaced by sequence II ( $I_{cu} = I_{cs}$ , see 8.3.5).
- k Connections reversed, if terminals unmarked, when sequence III is replaced by sequence II ( $I_{cu} = I_{cs}$ , see 8.3.5) or when sequence VI replaces sequences II, III and IV ( $I_{cu} = I_{cs} = I_{cw}$ , see 8.3.8), otherwise this sample is tested forward connected.
- l Applies to category B circuit-breakers and also to category A circuit-breakers covered by Note 3 of Table 4.
- m This sample, with connections reversed, is only required when sequence III is replaced by sequence IV ( $I_{cu} = I_{cw}$ , see 8.3.5).

### 8.3.2.2 Test quantities

#### 8.3.2.2.1 Values of test quantities

Subclause 8.3.2.2.1 of IEC 60947-1 applies.

#### 8.3.2.2.2 Tolerances on test quantities

Subclause 8.3.2.2.2 of IEC 60947-1 applies.

### 8.3.2.2.3 Frequency of the test circuit for a.c.

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

If the manufacturer declares the rated breaking capacity to be substantially unaffected by the value of the frequency, the tolerance shall not exceed  $\pm 25\%$ .

### 8.3.2.2.4 Power factor of the test circuit

Subclause 8.3.4.1.3 of IEC 60947-1 applies with the following modification:

Table 16 of IEC 60947-1 is replaced by Table 11 of this standard.

**Table 11 – Values of power factors and time constants corresponding to test currents**

| Test current /<br>kA | Power factor  |                                          |          | Time constant<br>ms |                                          |          |
|----------------------|---------------|------------------------------------------|----------|---------------------|------------------------------------------|----------|
|                      | Short-circuit | Operational<br>performance<br>capability | Overload | Short-circuit       | Operational<br>performance<br>capability | Overload |
| $I \leq 3$           | 0,9           | 0,8                                      | 0,5      | 5                   | 2                                        | 2,5      |
| $3 < I \leq 4,5$     | 0,8           |                                          |          | 5                   |                                          |          |
| $4,5 < I \leq 6$     | 0,7           |                                          |          | 5                   |                                          |          |
| $6 < I \leq 10$      | 0,5           |                                          |          | 5                   |                                          |          |
| $10 < I \leq 20$     | 0,3           |                                          |          | 10                  |                                          |          |
| $20 < I \leq 50$     | 0,25          |                                          |          | 15                  |                                          |          |
| $50 < I$             | 0,2           |                                          |          | 15                  |                                          |          |

### 8.3.2.2.5 Time constant of the test circuit

Subclause 8.3.4.1.4 of IEC 60947-1 applies with the following modification:

Table 16 of IEC 60947-1 is replaced by Table 11 of this standard.

### 8.3.2.2.6 Power-frequency recovery voltage

Subclause 8.3.2.2.3, item a) of IEC 60947-1 applies.

### 8.3.2.3 Evaluation of test results

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

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

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 a superficial nature. Consequently, they do not develop through the entire thickness of the moulded case of the device.

### 8.3.2.4 Test reports

Subclause 8.3.2.4 of IEC 60947-1 applies.

### 8.3.2.5 Test conditions for temperature-rise test

The circuit-breaker shall meet the requirements of 7.2.2.

Subclause 8.3.3.3 of IEC 60947-1 applies, except 8.3.3.3.6, with the following addition:

The circuit-breaker shall be mounted in accordance with 8.3.2.1.

During the temperature rise test of sequence I (see 8.3.3.6) coils of under-voltage releases, where applicable, shall be supplied at one rated frequency and corresponding voltage, chosen at random. Additional tests to verify coils at other rated frequencies and voltages shall be made outside the sequence.

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

### 8.3.2.6 Test conditions for short-circuit tests

#### 8.3.2.6.1 General requirements

NOTE 1 Attention is drawn to note 3, which has been introduced to avoid unnecessary retesting due to the new requirement of item b).

Subclause 8.3.4.1.1 of IEC 60947-1 is amplified as follows:

- a) The circuit-breaker shall be mounted in accordance with 8.3.2.1.
- 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 1, 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/cm<sup>3</sup>  $\pm$  0,05 g/cm<sup>3</sup>;
- 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 1).

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 1).

NOTE 2 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 8.3.2.6.4).

NOTE 3 In order to obviate the need for making a new series of short-circuit test sequences to prove compliance with this subclause, it is permitted provisionally, with the agreement of the manufacturer, to verify this by means of a separate O operation for each test sequence applicable.

- 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 7.2.1.2.3), 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 10.

#### **8.3.2.6.2 Test circuit**

Subclause 8.3.4.1.2 of IEC 60947-1 applies.

#### **8.3.2.6.3 Calibration of the test circuit**

Subclause 8.3.4.1.5 of IEC 60947-1 applies.

#### **8.3.2.6.4 Test procedure**

##### **8.3.2.6.4.1 General**

Subclause 8.3.4.1.6 of IEC 60947-1 applies, with the following addition.

##### **8.3.2.6.4.2 Tests on one-, two- and three-pole circuit-breakers**

After calibration of the test circuit in accordance with 8.3.2.6.3, the temporary connections are replaced by the circuit-breaker under test and its connecting cables if applicable.

Tests for the performance under short-circuit conditions shall be made according to the sequences in Table 9 (see 8.3.1).

For circuit-breakers having a rated current up to and including 630 A, a cable of maximum length 75 cm, having a cross-section corresponding to the conventional thermal current (see 8.3.3.3.4, Tables 9 and 10 of IEC 60947-1) shall be included as follows:

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

The sequence of operations shall be that which is applicable to each test sequence, as specified in 8.3.4.1, 8.3.5.2, 8.3.6.4 and 8.3.7.6.

Alternative test programmes for circuit-breakers having three-pole and four-pole variants are given in 8.3.1.4.

##### **8.3.2.6.4.3 Tests on four-pole circuit-breakers**

The requirements of 8.3.2.6.4.2 apply.

An additional sequence of operations on one or more new samples, in accordance with Table 10, shall be made on the fourth pole and its adjacent pole for sequences III and IV, or IV and V, or VI, as applicable. At the request of the manufacturer these tests may be combined with the three-pole tests of 8.3.2.6.4.2 and made on the same samples, in which case the test in each relevant test sequence shall comprise

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

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

Alternative test programmes for circuit-breakers having three-pole and four-pole variants are given in 8.3.1.4.

#### 8.3.2.6.4.4 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 (see 2.19), 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 re-close the circuit-breaker during the resetting time shall be spaced by at least 1 min.

The maximum value of  $I^2t$  (see 2.5.18 of IEC 60947-1) during these tests may be recorded in the test report (see 7.2.1.2.4, item a).

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

Subclause 8.3.4.1.7 of IEC 60947-1 applies.

#### 8.3.2.6.6 Interpretation of records

Subclause 8.3.4.1.8 of IEC 60947-1 applies.

#### 8.3.2.6.7 Verification after short-circuit tests

- a) After the opening operations of the short-circuit making and breaking capacity tests of 8.3.4.1, 8.3.5.2, 8.3.6.4, 8.3.7.1, 8.3.7.6, 8.3.8.3, as applicable, the polyethylene sheet shall show no holes visible with normal or corrected vision without additional magnification.

NOTE Minute visible holes of less than 0,26 mm diameter can be ignored.

- b) After the short-circuit tests, the circuit-breaker shall comply with the verifications specified for each test sequence, as applicable.