

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

**Interrupteurs automatiques à courant différentiel résiduel sans dispositif de protection contre les surintensités incorporé pour usages domestiques et analogues (ID) –
Partie 1: Règles générales**



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IEC Secretariat
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS
WITHOUT INTEGRAL OVERCURRENT PROTECTION
FOR HOUSEHOLD AND SIMILAR USES (RCCBS) –****Part 1: General rules****FOREWORD**

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IEC 61008-1 has been prepared by subcommittee 23E: Circuit-breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2010, Amendment 1:2012 and Amendment 2:2013. This edition constitutes a technical revision.

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

- a) harmonization of all clauses between the IEC 61008, IEC 61009 and IEC 60755 series using blocks and modules approach;

- b) harmonization of all tables and figures between the IEC 61008, IEC 61009 and IEC 60755 series;
- c) terms and definitions are now referred to IEC 62873-2;
- d) modification of 4.1 for classification according to supply conditions;
- e) new subclauses 8.17 and 9.24 for requirements and tests for the resistance to temporary overvoltages (TOV);
- f) improvement of 9.8 for test of dielectric properties;
- g) tests for screwless, flat-quick terminals and aluminium conductors are now referred to the IEC 62873-3 series.

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

Draft	Report on voting
23E/1368/FDIS	23E/1385/RVD

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

The language used for the development of this International Standard is English.

This International Standard is to be used in conjunction with the relevant product standard, either IEC 61008-2-1:2024 or IEC 61008-2-2:2024. The chosen standard, IEC 61008-2-1:2024 or IEC 61008-2-2:2024, shall be used consistently throughout the standard.

In order to maintain the same structure throughout the IEC 61008 and IEC 61009 series, some elements that are not applicable to the particular device within the scope of this document are labelled void.

In this document, the following print types are used:

- compliance statements: in *italic* type;
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This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

A list of all parts in the IEC 61008 series, published under the general title *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)*, can be found on the IEC website.

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

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

The purpose of this document is to harmonize as far as practicable all rules and requirements of a general nature applicable to RCCBs in order to obtain uniformity of requirements and tests and to avoid the need for testing to different standards.

All those parts which can be considered as general have therefore been gathered in this document, e.g. temperature-rise, dielectric properties, etc.

For each type of RCCB, only two main documents are used to determine all requirements and tests:

- 1) this document;
- 2) the relevant product standard covering RCCBs:
 - IEC 61008-2-1, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 2-1: RCCBs according to classification 4.1.1*; or
 - IEC 61008-2-2, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 2-2: RCCBs according to classification 4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6*

For Type F and Type B RCCBs, IEC 62423 applies in addition to the IEC 61008 series.

RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS WITHOUT INTEGRAL OVERCURRENT PROTECTION FOR HOUSEHOLD AND SIMILAR USES (RCCBS) –

Part 1: General rules

1 Scope

This document gives general requirements and tests for residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (hereafter referred to as RCCBs), for rated operational voltages not exceeding 440 V AC, with rated frequencies of 50 Hz, 60 Hz or 50/60 Hz and rated currents not exceeding 125 A, intended principally for protection against shock hazard.

RCCBs are intended to provide fault protection (previously referred to as protection against indirect contact), the exposed conductive parts of the installation being connected to an appropriate earth electrode. They are also intended to be used to provide protection against fire hazards due to a persistent earth fault current.

RCCBs having a rated residual operating current not exceeding 30 mA are used for fault protection and additional protection in the case of failure of the protective provisions against electric shock.

This document applies to RCCBs performing simultaneously the functions of detection of the residual current, of comparison of the value of this current with the residual operating value and of opening of the protected circuit when the residual current exceeds this value.

NOTE 1 The requirements for RCCBs are in line with the group safety publication IEC 60755.

NOTE 2 RCCBs of type AC and type A are covered by the IEC 61008 series. RCCBs of type F and type B are covered by IEC 62423 in conjunction with the IEC 61008 series.

NOTE 3 Installation and selection rules for RCCBs are given in the IEC 60364 series.

NOTE 4 Installation and application rules of RCCBs in ZA is given in SANS 10142-1.

RCCBs are intended to be operated by ordinary or uninstructed persons and designed not to require maintenance.

The requirements of this document apply for standard conditions (see 7.1). Additional requirements can be necessary for RCCBs used in locations which have severe environmental conditions. RCCBs within the scope of this document are intended for use in an environment with pollution degree 2 (see 7.3).

NOTE 5 For environments with higher pollution degrees, enclosures giving the appropriate degree of protection can be used.

NOTE 6 For RCCBs having a degree of protection higher than IP20, special constructions can be required.

RCCBs are suitable for isolation.

Special precautions (e.g. surge protective devices) can be necessary when excessive overvoltages are likely to occur on the supply side (for example in the case of supply through overhead lines, see IEC 60364-4-44 and IEC 60364-5-53).

RCCBs, with the exception of those with an uninterrupted neutral, are suitable for use in IT systems.

RCCBs of the general type are resistant to current surges, including the case where surge voltages (as a result of switching transients or induced by lightning) cause loading currents in the installation without occurrence of flashover.

RCCBs of type S are considered to be sufficiently resistant against unwanted tripping even if the surge voltage causes a flashover and a follow-on current occurs.

NOTE 7 Surge protective devices installed downstream of the general type of RCCBs and connected in common mode can cause unwanted tripping.

Particular requirements are necessary for RCCBs intended to be used at frequencies other than 50 Hz or 60 Hz.

For RCCBs incorporated in, or intended for association with socket-outlets only, the requirements of this document can be used, as far as applicable, in conjunction with the requirements of IEC 60884-1 or the national requirements of the country where the product is placed on the market.

NOTE 8 Residual current-operated protective devices (RCDs) incorporated in, or intended only for association with socket-outlets, are also covered by IEC 62640.

NOTE 9 In DK, plugs and socket-outlets are in accordance with the requirements of the heavy current regulations section 107.

NOTE 10 In the UK, the plug part associated with an RCCB complies with BS 1363-1 and the socket-outlet(s) associated with an RCCB complies with BS 1363-2. In the UK, it is not necessary for the plug part and the socket-outlet(s) associated with an RCCB to comply with any IEC 60884-1 requirements.

NOTE 11 In ZA, RCCBs are known as earth leakage switches (ELSWs).

This document does not apply to:

- RCCBs the current setting of which is adjustable without a tool;
- RCCBs including batteries.

This document is not intended to be used alone; it is intended to be used in conjunction with the relevant product standard, IEC 61008-2-1 or IEC 61008-2-2.

2 Normative references

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

IEC 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

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

IEC 60068-3-4:2023, *Environmental testing – Part 3-4: Supporting documentation and guidance – Damp heat tests*

IEC 60228, *Conductors of insulated cables*

IEC 60417, *Graphical symbols for use on equipment*, available at <https://www.graphical-symbols.info/equipment>

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

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC 60664-3, *Insulation coordination for equipment within low-voltage systems – Part 3: Use of coating, potting or moulding for protection against pollution*

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

IEC 61008-2-1:2024, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 2-1: RCCBs according to classification 4.1.1*

IEC 61008-2-2:2024, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) – Part 2-2: RCCBs according to classification 4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6*

IEC 61032, *Protection of persons and equipment by enclosures – Probes for verification*

IEC 62873-2, *Residual current operated circuit-breakers for household and similar use – Part 2: Residual current devices (RCDs) – Vocabulary*

IEC 62873-3-1, *Residual current operated circuit-breakers for household and similar use – Part 3-1: Particular requirements for devices with screwless-type terminals for external copper conductors*

IEC 62873-3-2, *Residual current operated circuit-breakers for household and similar use – Part 3-2: Particular requirements for devices with flat quick-connect terminations*

IEC 62873-3-3, *Residual current operated circuit-breakers for household and similar use – Part 3-3: Specific requirements for devices with screw-type terminals for external untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62873-2 and the following apply.

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

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

3.1

live part

<in electrical installations and equipment> conductive part intended to be energized under normal operating conditions, including the neutral conductor and mid-point conductor, but excluding the PEN conductor, PEM conductor and PEL conductor

[SOURCE: SOURCE: IEC 60050-195:2021, 195-02-19]

3.2**functional earth****FE**

wire or terminal intended to be connected to the PE to continue providing a supply to the RCCB when the RCCB is supplied from one phase only

3.3**line to neutral voltage** **U_o**

voltage between line conductor and neutral conductor

4 Classification**4.1 According to the supply conditions****4.1.1 RCCB operating correctly on the occurrence of residual current**

- within the voltage range $1,1 U_e$ and zero volt; and
- with any number of supply conductors connected.

The RCCB does not open automatically in the event of loss of supply.

4.1.2 RCCB with 2 or 4 current paths operating correctly on the occurrence of residual current within the voltage range of $1,1 U_e$ and 85 V

The RCCB does not open automatically in the event of loss of supply.

NOTE 1 In China, the lower limit value of 50 V (line to neutral) is required (for RCCB with $I_{\Delta n} \leq 30$ mA) instead of 85 V.

NOTE 2 Devices according to this classification are not allowed in Germany.

4.1.3 RCCB according to 4.1.2 fitted with a functional earth (FE) and able to continue to provide protection when supplied from just one phase and FE

4.1.3.1 Does not open automatically in the event of loss of supply and continues to provide residual current protection in the case of supply from just one phase and FE.

NOTE Devices according to this classification are not allowed in Germany.

4.1.3.2 Does not open automatically in the event of loss of one or more phases and provides protection by opening automatically if supplied from just one phase and FE.

NOTE Devices according to this classification are not allowed in Germany.

4.1.4 RCCB with 3 current paths operating correctly on the occurrence of residual current within the voltage range of $1,1 U_e$ and $0,7 U_e$

The RCCB does not open automatically in the event of loss of supply.

These devices are not intended to be supplied from single-phase circuits.

NOTE Devices according to this classification are not allowed in Germany.

4.1.5 RCCB operating correctly on the occurrence of residual current within the voltage range $1,1 U_e$ and U_x

The device opens automatically, with or without delay, in the event of a supply voltage drop to a value less than U_x .

NOTE Devices according to this classification are not allowed in Germany.

4.1.6 RCCB according to 4.1.5, however reclosing automatically after restoration of the supply voltage

NOTE Devices according to this classification are not allowed in Germany.

4.2 According to the possibility of adjusting the residual operating current

4.2.1 RCCB with a single value of rated residual operating current

4.2.2 RCCB with multiple settings of residual operating current by fixed steps

4.3 According to their operation in response to the type of residual current

4.3.1 RCCB of type AC

NOTE In some countries the use of type AC is not allowed: Germany

4.3.2 RCCB of type A

4.4 According to time-delay (in the presence of a residual current)

4.4.1 RCCB without time-delay: type for general use

4.4.2 RCCB with time-delay: type S for selectivity

4.5 According to the protection against external influences

4.5.1 Enclosed-type RCCB (not requiring an appropriate enclosure)

4.5.2 Unenclosed-type RCCB (for use with an appropriate enclosure)

4.6 According to the method of mounting

4.6.1 Surface-type RCCB

4.6.2 Flush-type RCCB

4.6.3 Panel board type RCCB, also referred to as distribution board type

NOTE These types can be intended to be mounted on rails.

4.7 According to the method of connection

4.7.1 RCCB for which the electrical connections are not associated with the mechanical mounting

4.7.2 RCCB for which the electrical connections are associated with the mechanical mounting

NOTE Examples of this type are:

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

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

4.8 According to the type of terminals

4.8.1 RCCB with screw-type terminals for copper conductors

4.8.2 RCCB with screwless type terminals for copper conductors

NOTE Related terminal requirements for RCCBs equipped with these types of terminals are given in IEC 62873-3-1.

4.8.3 RCCB with flat quick-connect terminals for copper conductors

NOTE Related terminal requirements for RCCBs equipped with these types of terminals are given in IEC 62873-3-2.

4.8.4 RCCB with screw-type terminals for aluminium conductors

NOTE Related terminal requirements for RCCBs equipped with this type of terminal are given in IEC 62873-3-3.

4.9 According to the number of poles and current paths

4.9.1 Single-pole RCCB with two current paths

NOTE In this case, the neutral path does not contain any switching contact.

4.9.2 Two-pole RCCB

4.9.3 Three-pole RCCB

4.9.4 Three-pole RCCB with four current paths

NOTE In this case, the neutral path does not contain any switching contact.

4.9.5 Four-pole RCCB

5 Characteristics of RCCBs

5.1 Summary of characteristics

The characteristics of an RCCB shall be stated in the following terms:

- rated voltages (see 5.2.1);
- rated current I_n (see 5.2.2);
- rated frequency (see 5.2.3).
- rated making and breaking capacity I_m (see 5.2.4);
- rated residual operating current $I_{\Delta n}$ (see 5.2.5);
- rated residual non-operating current $I_{\Delta no}$ (see 5.2.6);
- rated residual making and breaking capacity $I_{\Delta m}$ (see 5.2.7);
- time-delay, if applicable (see 5.2.11);
- operating characteristics in the case of residual currents with DC components (see 5.2.10);
- rated conditional short-circuit current I_{nc} (see 5.2.8);
- rated conditional residual short-circuit current $I_{\Delta c}$ (see 5.2.9);
- degree of protection (see IEC 60529).

5.2 Rated quantities and other characteristics

5.2.1 Rated voltages

5.2.1.1 Rated operational voltage (U_e)

The rated operational voltage of an RCCB is the value of voltage, assigned by the manufacturer, to which its performance is referred.

NOTE The same RCCB can be assigned a number of rated operational voltages and associated performance characteristics.

5.2.1.2 Rated insulation voltage (U_i)

The rated insulation voltage is assumed to be equal to the highest rated operational voltage assigned to the RCCB.

Where the rated insulation voltage assigned by the manufacturer exceeds the highest rated operational voltage of the RCCB, the dielectric test voltages and creepage distances shall be chosen for that rated insulation voltage in accordance with IEC 60664-1.

5.2.1.3 Rated impulse withstand voltage (U_{imp})

The rated impulse withstand voltage of an RCCB shall comply with the standard values given in Table 19.

5.2.2 Rated current (I_n)

The current assigned by the manufacturer which the RCCB can carry in uninterrupted duty.

5.2.3 Rated frequency

The rated frequency of an RCCB is the power frequency for which the RCCB is designed and to which the values of the other characteristics correspond.

NOTE A number of rated frequencies can be assigned to the same RCCB.

5.2.4 Rated making and breaking capacity (I_m)

The RMS value of the AC component of prospective current, assigned by the manufacturer, which an RCCB can make, carry and break under specified conditions.

5.2.5 Rated residual operating current ($I_{\Delta n}$)

The value of residual operating current, assigned by the manufacturer, at which the RCCB shall operate under specified conditions.

For an RCCB having multiple settings of residual operating current, the highest setting is used to designate it.

5.2.6 Rated residual non-operating current ($I_{\Delta no}$)

The value of residual non-operating current, at which the RCCB does not operate under specified conditions. The standard value of residual non-operating current is defined in 5.3.4.

5.2.7 Rated residual making and breaking capacity ($I_{\Delta m}$)

The RMS value of the AC component of residual prospective current, assigned by the manufacturer, which an RCCB can make, carry and break under specified conditions.

5.2.8 Rated conditional short-circuit current (I_{nc})

The RMS value of prospective current, assigned by the manufacturer, which an RCCB, protected by a specified SCPD, can withstand under specified conditions without undergoing alterations impairing its functions.

5.2.9 Rated conditional residual short-circuit current ($I_{\Delta c}$)

The value of residual prospective current, assigned by the manufacturer, which an RCCB, protected by a specified SCPD, can withstand under specified conditions without undergoing alterations impairing its functions.

5.2.10 Operating characteristics in response to the type of residual current

5.2.10.1 RCCB type AC

An RCCB for which tripping is ensured for residual sinusoidal alternating currents, whether suddenly applied or slowly rising.

5.2.10.2 RCCB type A

An RCCB for which tripping is ensured:

- as for type AC;
- for residual pulsating direct currents; and
- for residual pulsating direct currents superimposed on a smooth direct current of 0,006 A

with or without phase-angle control, independent of polarity, whether suddenly applied or slowly rising.

5.2.11 RCCB type S

A time-delay RCCB which complies with the relevant part of Table 11 or Table 12, if applicable.

5.3 Standard and preferred values

5.3.1 Standard values of rated operational voltage (U_e)

Preferred values of rated operational voltage are indicated in Table 46.

5.3.2 Preferred values of rated current (I_n)

Preferred values of rated current are:

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

5.3.3 Standard values of rated residual operating current ($I_{\Delta n}$)

Standard values of rated residual operating current are:

0,006 A – 0,01 A – 0,03 A – 0,1 A – 0,3 A – 0,5 A.

NOTE In the Republic of Korea and Japan, 0,015 A, 0,2 A and 1 A are also considered as standard values.

5.3.4 Standard value of residual non-operating current ($I_{\Delta no}$)

The standard value of residual non-operating current is $0,5 I_{\Delta n}$.

NOTE For residual pulsating direct currents, residual non-operating currents depend on the phase angle (see Table 14).

5.3.5 Preferred values of rated frequency

Preferred values of rated frequency are 50 Hz, 60 Hz and 50 / 60 Hz.

If another value is used, the rated frequency shall be marked on the device and the tests carried out at this frequency.

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

Table 19 gives the standard values of rated impulse withstand voltages as a function of the nominal voltage of the installation.

5.3.7 Standard limit values of break time and non-actuating time for RCCB of type AC and A

5.3.7.1 Standard limit values of break time and non-actuating time for alternating residual currents (RMS values) of type AC and A

Standard limit values are indicated in Table 11.

NOTE In the USA, where the tripping times are specifically related to current, the following formulas apply:

$$t = \left(\frac{20}{I} \right)^{1,43} \text{ for high-resistance faults and } t = 1,25 \left(\frac{10}{I} \right)^{1,43} \text{ for low resistance faults.}$$

5.3.7.2 Standard maximum values of break time for half-wave residual currents (RMS values) of type A

Standard limit values are indicated in Table 12.

5.3.8 Standard minimum value of non-operating overcurrent in the case of a load through an RCCB with two current paths

The standard minimum value of the non-operating current is $6 I_n$.

5.3.9 Standard minimum value of the non-operating overcurrent in the case of a single-phase load through a three-pole or four-pole RCCB

The standard minimum value of the non-operating overcurrent in the case of a single-phase load through a three-pole or four-pole RCCB is $6 I_n$.

5.3.10 Standard minimum value of the rated making and breaking capacity (I_m)

The minimum value of the rated making and breaking capacity I_m is $10 I_n$ or 500 A, whichever is the greater.

5.3.11 Standard minimum value of the rated residual making and breaking capacity ($I_{\Delta m}$)

The minimum value of the rated residual making and breaking capacity ($I_{\Delta m}$) is $10 I_n$ or 500 A, whichever is the greater.

5.3.12 Standard and preferred values of the rated conditional short-circuit current (I_{nc})

Up to and including 10 000 A, the standard values of the rated conditional short-circuit current I_{nc} are:

3 000 A – 4 500 A – 6 000 A – 10 000 A.

NOTE In the Republic of Korea, the values of 1 000 A, 1 500 A, 2 000 A, 2 500 A, 7 500 A, 9 000 A are also considered as standard values.

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

Values above 25 000 A are not considered in this document.

5.3.13 Standard values of the rated conditional residual short-circuit current ($I_{\Delta c}$)

Up to and including 10 000 A, the standard values of the rated conditional residual short-circuit current $I_{\Delta c}$ are:

3 000 A – 4 500 A – 6 000 A – 10 000 A.

The values of 500 A, 1 000 A and 1 500 A are also standard for RCCBs incorporated in or intended for association with socket-outlets.

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

Values above 25 000 A are not considered in this document.

6 Marking and other product information

Each RCCB shall be marked according to Table 1, in a durable manner.

The suitability for isolation, which is provided by all RCCBs of this document, may be indicated by the symbol  (IEC 60417-6169-1:2012-08) on the device. When affixed, this marking may be included in a wiring diagram, where it may be combined with symbols of other functions.

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

When the symbol is used on its own (i.e. not in a wiring diagram), a combination with symbols of other functions is not allowed.

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

The manufacturer shall state the Joule integral I^2t and the peak current I_p withstand capabilities of the RCCB. Where these are not stated, minimum values as given in Table 36 apply.

The manufacturer shall give the type designation or catalogue number of one or more suitable SCPD(s) in its product information.

For RCCBs other than those operated by means of push-button, the open position shall be indicated by the symbol "O" (a circle) IEC 60417-5008:2002-10 and the closed position by the symbol "I" (a short vertical straight line) IEC 60417-5007:2002-10. Additional national symbols can be required for this indication. These indications shall be readily visible when the RCCB is installed.

For RCCBs operated by means of two push-buttons, the push-button designed for the opening operation only shall be in red colour and/or be marked with the symbol "O".

Red colour shall not be used for any other push-button of the RCCB.

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

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

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

Universal terminals:

- no marking.

Non-universal terminals:

- terminals declared for rigid-solid conductors shall be marked by the letters "sol";
- terminals declared for rigid (solid and stranded) conductors shall be marked by the letter "r";
- terminals declared for flexible conductors shall be marked by the letter "f".

The marking of non-universal terminals should appear on the device or, if the space available is not sufficient, on the smallest package unit or in the product information.

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

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

7 Standard conditions for operation in service and for installation

7.1 Standard conditions

RCCBs shall be capable of operating under the standard conditions shown in Table 47.

7.2 Conditions of installation

RCCBs shall be installed in accordance with the manufacturer's instructions.

7.3 Pollution degree

RCCBs are intended for an environment with pollution degree 2, i.e. normally only non-conductive pollution occurs. However, occasionally, temporary conductivity caused by condensation may be expected.

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 General

RCCBs shall be designed and constructed so that, in normal use, their use is safe and without danger to the user or to the environment.

The residual current detection and the residual current release shall be located between the incoming and outgoing terminals of the RCCB.

It shall not be possible to alter the operating characteristics of the RCCB by means of external interventions other than those specifically intended for changing the setting of the residual operating current or of the time delay.

Changing from one setting to another shall not be possible without a tool. It shall not be possible to disable or inhibit the RCCB function by any means.

NOTE 1 In Austria, Australia, Germany, Denmark, Italy, the UK, Ireland and Switzerland, multiple settings are not allowed.

RCCBs with continuously adjustable settings are not allowed.

Provisions for remote tripping of the RCCB, if any, shall:

- not cause any current to the PE;
- not cause any fault voltage when actuated, and
- not impair the isolation function of the RCCB.

RCCBs shall not be operated by introduction of an external connection for the purpose of intentionally creating a residual current to trip the RCCB.

NOTE 2 This does not preclude the use of an RCCB with a functional earth connection.

NOTE 3 This does not preclude the use of a test instrument.

NOTE 4 This requirement does not apply in Japan.

8.1.2 Mechanism

All poles of multipole RCCBs shall be mechanically coupled so that all poles, except the neutral, if any, make and break substantially together, whether operated manually or automatically.

The neutral pole of four-pole RCCBs shall not close after and shall not open before the other poles.

Compliance is checked by inspection and by manual tests, using any appropriate means (example: indicator lights, oscilloscope, etc.).

RCCBs shall have a trip-free mechanism.

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

RCCBs shall be so constructed that the moving contacts can come to rest only in the closed position or in the open position, even when the operating means is released in an intermediate position.

RCCBs shall provide in the open position an isolation distance in accordance with the requirements necessary to satisfy the isolating function (see 8.3).

Indication of the position of the main contacts shall be provided by one or both of the following means:

- the position of the actuator (this being preferred); or
- a separate mechanical indicator.

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

NOTE In the US, the colours red and green are not used for contact position indication.

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

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

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

Locking of the operating means in the closed position is permitted.

Compliance is checked by inspection, in accordance with the instructions of the manufacturer.

Where the operating means is used to indicate the position of the contacts, the operating means, when released, shall automatically take up the position corresponding to that of the moving contacts; in this case, the operating means shall have two distinct rest positions corresponding to the position of the contacts but, for automatic opening, a third distinct position of the operating means may be provided, in which case it shall be necessary to reset the RCCB manually before reclosing is possible.

When an indicator light is used, this shall be lit when the RCCB is in the closed position and be of bright colour. The indicator light shall not be the only means to indicate the closed position.

The action of the mechanism shall not be influenced by the position of enclosures or covers and shall be independent of any removable part.

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

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

Operating means shall be securely fixed on their shafts and it shall not be possible to remove them without the aid of a tool.

Operating means directly fixed to covers are allowed. If the operating means has an "up-down" movement, when the RCCB is mounted as in normal use, the contacts shall be closed by the up movement.

Compliance is checked by inspection, by manual test and, for the trip-free mechanism, by the test of 9.11 and 9.15.

8.1.3 Clearances, creepage distances and solid insulation

8.1.3.1 General

The minimum required clearances and creepage distances are given in Table 20 which is based on the RCCB being designed for operating in an environment with pollution degree 2.

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

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

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

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

For clearances on printed wiring material, Footnote c in Table F.2 of IEC 60664-1:2020 applies: "For printed wiring material, the values for pollution degree 1 apply except that the value shall not be less than 0,04 mm, as specified in Table F.5 of IEC 60664-1:2020. A protection by means of a solder resist of high quality is the minimum requirement to allow this clearance reduction".

All measurements required in 8.1.3 are carried out in Test Sequence A on one sample. Tests according to 9.7 are carried out in Test Sequence B on three samples.

8.1.3.2 Clearances

Compliance for item 1 in Table 20 is checked by measurement and by the tests of 9.7.7.3. The test is carried out with samples not submitted to the humidity treatment described in 9.7.1.

Compliance for items 2 and 4 in Table 20 is checked by measurement and, if the clearances are reduced, by the tests of 9.7.7.2.

The clearances of items 2 and 4 in Table 20 (except for accessible surfaces after installation, see below) may be reduced provided that the measured clearances are not shorter than the minimum allowed in IEC 60664-1 for homogenous field conditions. In this case, compliance for items 2 and 4 is always checked by the test of 9.7.7.2.

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

Compliance for item 3 in Table 20 is checked by measurement.

8.1.3.3 Creepage distances

Compliance for items 1, 2, 3 and 4 in Table 20 is checked by measurement.

8.1.3.4 Solid insulation

Compliance is checked by the tests according to 9.7.2, 9.7.3, 9.7.4, 9.7.5 and 9.7.7 as applicable.

8.1.3.5 Additional requirements for control circuits connected to the main circuit

Compliance is checked by the test of 9.7.6.

8.1.4 Screws, current-carrying parts and connections

8.1.4.1 Connections

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

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

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

NOTE Screwed connections are considered to be checked by the tests of 9.8, 9.11, 9.12, 9.13 and 9.21.

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

8.1.4.2 Screws in engagement with a thread of insulating material

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

Compliance is checked by inspection and by manual test.

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

8.1.4.3 Electrical connections

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

Compliance is checked by inspection.

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

8.1.4.4 Current-carrying parts

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

Examples of suitable materials are given below:

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

If using ferrous alloys or suitably coated ferrous alloys, compliance to resistance to corrosion is checked by a test of resistance to rusting according to 9.23.

The requirements of 8.1.4.4 do not apply to contacts, magnetic circuits, heater elements, bimetals, shunts, electronic components, printed circuit boards, nor to screws, nuts, washers, clamping plates, similar parts of terminals and parts of the test circuit.

8.1.5 Terminals for external conductors

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

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

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

Compliance is checked by inspection, by the tests of 9.5 for screw-type terminals, by specific tests for plug-in or bolt-on RCCBs included in this document, or by the tests of IEC 62873-3-1, IEC 62873-3-2, and IEC 62873-3-3, as relevant for the type of connection.

8.1.5.2 RCCBs shall be provided with one of the following:

- terminals which shall allow the connection of copper conductors having nominal cross-sectional areas as shown in Table 24; or

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

- screwless type terminals for copper conductors according to IEC 62873-3-1; or
- flat quick-connect terminals for copper conductors according to IEC 62973-3-2; or
- terminals for untreated aluminium conductors and with aluminium screw-type terminals for use with copper or with aluminium conductors according to IEC 62873-3-3.

Compliance for terminals according to the first indent is checked by inspection, by measurement and by fitting in turn one conductor of the smallest and one of the largest cross-section as specified in Table 24.

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

Compliance is checked by inspection.

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

Compliance is checked by inspection.

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

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

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

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

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

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

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

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

This requirement does not apply to lug terminals.

Compliance is checked by the test of 9.5.4.

8.1.5.9 Terminals shall be so fixed or located that, when the clamping screws or nuts are tightened or loosened, their fixings do not work loose.

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

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

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

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

8.1.5.10 Clamping screws or nuts of terminals intended for the connection of protective conductors shall be adequately secured against accidental loosening and it shall not be possible to unclamp them without the use of a tool.

Compliance is checked by manual test.

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

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

Compliance is checked by inspection.

8.2 Protection against electric shock

RCCBs shall be so designed that, when they are mounted and wired as for normal use, live parts are not accessible.

A part is considered to be "accessible" if it can be touched by the standard test finger (Figure 1).

NOTE The term "normal use" implies that RCCBs be installed according to the manufacturer's instructions.

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

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

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

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

Metallic operating means shall be insulated from live parts and their conductive parts which otherwise would be "exposed conductive parts" shall be covered by insulating material, with the exception of means for coupling insulated operating means of several poles.

Metal parts of the mechanism shall not be accessible. In addition, they shall be insulated from accessible metal parts, from metal frames supporting the base of flush-type RCCBs, from screws or other means for fixing the base to its support and from metal plates used as support.

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

Lacquer and enamel are not considered to provide adequate insulation for the purpose of this Subclause 8.2.

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

8.3 Dielectric properties and isolating capability

RCCBs shall have adequate dielectric properties.

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

RCCBs shall ensure isolation.

Compliance is checked by the tests of 9.7.

8.4 Temperature-rise

8.4.1 General

RCCBs shall not suffer damage impairing its functions and its safe use taking into account the ambient air temperature at which they are intended to be used.

Compliance is checked by the tests of 9.8.

8.4.2 Temperature-rise limits

The temperature-rises of the parts of an RCCB specified in Table 28, measured under the conditions specified in 9.8.2, shall not exceed the limiting values stated in Table 28.

8.4.3 Ambient air temperature

The temperature-rise limits given in Table 28 are applicable only if the ambient air temperature remains within the limits given in Table 47.

8.5 Operating characteristics

8.5.1 General

The operating characteristics of RCCBs shall comply with the requirements of 9.9.

RCCBs shall operate according to the requirements of the following subclauses, as applicable.

8.5.2 Operation in response to the type of residual current

8.5.2.1 General

The tripping characteristic of RCCBs shall ensure protection against residual current without premature operation.

The tests shall verify the operation of the RCCBs within their voltage range according to the classification.

Compliance is checked by the tests of 9.9.

8.5.2.2 Alternating residual current

RCCBs shall operate in response to a steady increase of alternating residual current of rated frequency within the limits of the non-operating current $I_{\Delta no}$ and the rated residual operating current $I_{\Delta n}$.

8.5.2.3 Pulsating DC residual current

RCCBs type A shall operate in response to a steady increase of pulsating direct residual current of rated frequency within specified limits of the non-operating current and the operating current in accordance with Table 14.

The tripping limits shall be maintained independent of the polarity of the pulsating direct residual current.

8.5.2.4 Pulsating DC residual current superimposed by smooth direct current of 0,006 A

RCCBs type A shall operate in response to a steady increase of pulsating direct residual current of rated frequency within specified limits of the non-operating current and the operating current in accordance with Table 14 also when a smooth direct current of 0,006 A is superimposed.

The tripping limits of the pulsating direct current shall be maintained even if the polarity of the pulsating direct residual current and the smooth direct current are the same.

8.5.3 Operation in presence of a residual current equal to or greater than $I_{\Delta n}$

Compliance is checked by the tests of 9.9.

8.6 Mechanical and electrical endurance

RCCBs shall be capable of performing an adequate number of mechanical and electrical operations.

Compliance is checked by the test of 9.10.

8.7 Performance at short-circuit currents

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

For coordination with short circuit protective devices (SCPDs), RCCBs shall be protected against short-circuits by means of circuit-breakers or fuses complying with their relevant standards.

The association of a short-circuit protective device with an RCCB is intended to ensure protection of the residual current device from the effects of short-circuit currents.

The short-circuit protective device shall be selected according to the following characteristics in line with the characteristics of the RCCB:

- a) maximum let-through I^2t ;
- b) maximum value of let-through peak current I_p .

The rating and type of SCPD shall be the same for 5.2.8 and 5.2.9.

Coordination between RCCBs and the SCPD shall be verified under the general conditions of 9.11.2.1 by means of the tests described in 9.11.2.4 which are designed to verify the protection of the RCCBs against short-circuit currents up to the conditional short-circuit current I_{nc} and up to the conditional residual short-circuit current $I_{\Delta c}$.

Compliance is checked by the tests of 9.11.

8.8 Resistance to mechanical shock and impact

RCCBs shall have adequate mechanical behaviour to withstand the stresses imposed during installation and use.

Compliance is checked by the test of 9.12.

8.9 Resistance to heat

RCCBs shall be sufficiently resistant to heat.

Compliance is checked by the test of 9.13.

8.10 Resistance to abnormal heat and to fire

External parts of RCCBs made of insulating material shall not be liable to ignite and to spread fire if current-carrying parts in their vicinity, under fault or overload conditions, attain a high temperature. The resistance to abnormal heat and to fire of the other parts made of insulating material is considered as being checked by the other tests of this document.

Compliance is checked by inspection and by the test of 9.14.

8.11 Test device

RCCBs shall be provided with a test device to simulate the passing through the detecting device of a residual current in order to allow a periodic testing of the ability of the residual current device to operate.

NOTE The test device is intended to check the tripping function, not the value at which this function is effective with respect to the rated residual operating current and the break times.

The ampere-turns produced when operating the test device of an RCCB supplied at rated operational voltage or at the highest value of the voltage range, if applicable, shall not exceed 2,5 times the ampere-turns produced, when a residual current equal to $I_{\Delta n}$ is passed through one of the poles of the RCCB.

In the case of RCCBs having several settings of residual operating current (see 4.2.2), the lowest setting for which the RCCBs have been designed shall be used.

The protective conductor of the installation shall not become live when the test device is operated.

It shall not be possible to energize the circuit on the load side by operating the test device when the RCCB is in the open position and connected as in normal use.

The test device shall not be the sole means of performing the opening operation and is not intended to be used for this function.

Compliance is checked by inspection and by the tests of 9.16.

8.12 Void

8.13 Behaviour of RCCBs in the event of overcurrent in the main circuit

RCCBs without integral overcurrent protection shall not operate under specified conditions of overcurrent.

Compliance is checked by the test of 9.18.

8.14 Behaviour of RCCBs in the event of current surges caused by impulse voltages

RCCBs shall adequately withstand the current surges to earth:

- due to the loading of the capacitances of the installation, or
- due to surges of atmospheric origin.

RCCBs of type S shall withstand and shall have adequate resistance against unwanted tripping in the event of surge current to earth:

- due to the loading of the capacitances of the installation, or
- due to surges of atmospheric origin, or
- due to flashovers causing follow currents.

Compliance is checked by the test of 9.19.

8.15 Reliability

RCCBs shall operate reliably even after long service, taking into account the ageing of their components.

Compliance is checked by the tests of 9.20 and 9.21.

8.16 Electromagnetic compatibility (EMC)

RCCBs shall operate reliably, even in presence of electromagnetic disturbances, and shall comply with relevant EMC requirements.

Compliance is checked by the tests of 9.22.

8.17 Resistance to temporary overvoltages (TOV)

RCCBs shall adequately withstand temporary overvoltages due to various phenomena (such as fault in the high voltage network; break of neutral; short circuit between line conductor and neutral conductor).

Withstand values of alternating overvoltage levels and duration are given in Table 30.

Compliance with the above requirements is checked by the tests of 9.24.

9 Tests

9.1 General

The characteristics of RCCBs are checked by means of type tests.

For certification purposes, type tests are carried out in test sequences.

NOTE The term "certification" denotes:

- either manufacturer's declaration of conformity; or
- third-party certification, for example by an independent certification body.

The test sequences and the number of samples are provided by IEC 61008-2-1 (RCCBs in accordance with 4.1.1) or IEC 61008-2-2 (RCCBs in accordance with 4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6) as applicable.

Unless otherwise specified in the relevant test clause, each type test (or sequence of type tests) is carried out on RCCBs in a clean and new condition, the influencing quantities having their normal reference values (see Table 47).

Routine tests to be carried out by the manufacturer on each device are given in Annex D.

Guidance for follow-up testing program for RCCBs is provided in Annex J.

9.2 Test conditions

The RCCB is mounted individually according to the manufacturer's instructions and in free air, at an ambient air temperature equal to 20 °C, unless otherwise specified in the relevant test clause, and is protected against undue external heating or cooling.

RCCBs designed for installation in individual enclosures are tested in the smallest of such enclosures specified by the manufacturer.

NOTE 1 An individual enclosure is an enclosure designed to accept one device only.

Unless otherwise specified in the relevant test clause, the RCCB is wired with the appropriate cable of cross-section *S* specified in Table 25 and is fixed on a dull black painted plywood board not less than 20 mm thickness, the method of fixing being in compliance with the requirements relating to the indications of the manufacturer concerning mounting.

NOTE 2 For AWG copper conductors, see Annex I.

Where tolerances are not specified, type tests are carried out at values not less severe than those specified in this document. Unless otherwise specified in the relevant test clause, tests are carried out at the rated frequency $\pm 5\%$.

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

For the tests of 9.8, 9.9, 9.10, 9.20.2 and 9.21, the RCCB is connected as follows:

- the connections are made by means of single-core, PVC-insulated copper cables;
- the connections are in free air and spaced not less than the distance existing between the terminals;
- the minimum length of each temporary connection from terminal to terminal is
 - 1 m for cross-sections up to and including 10 mm²;
 - 2 m for cross-sections larger than 10 mm².

The tightening torques to be applied to the terminal screws are two-thirds of those specified in Table 26.

For RCCBs with dependent manual operation, an operating speed of 0,1 m/s $\pm$ 25 % shall be used during actuation for the tests of 9.10 and 9.11. The speed is measured at the extremity when and where the operating means of the test apparatus touches the actuating means of the RCCB under test. For rotary knobs, the angular velocity shall correspond substantially to the above conditions, referred to the speed of the operating means (at its extremities) of the RCCB under test.

NOTE 3 In Japan, on request of the manufacturer, a different operating speed can be used for tests in 9.10 and 9.11.

9.3 Test of indelibility of marking

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

Aliphatic solvent hexane having both the main composition required by this document and CAS No. 110-54-3 is acceptable.

Marking made by impressing, moulding, engraving or laser printing is not subjected to this test.

After this test, the marking shall be easily legible. The marking shall also remain easily legible after all the tests of this document.

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

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

Compliance with the requirements of 8.1.4 is checked by inspection and, for screws and nuts which are operated when connecting the RCCB, by the following test.

The screws or nuts are tightened and loosened:

- 10 times for screws in engagement with a thread of insulating material;
- 5 times in all other cases.

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

The test is carried out by means of a suitable test screwdriver or spanner applying a torque as shown in Table 26.

The screws and nuts shall be tightened in one smooth and continuous motion.

The test is carried out with rigid conductors only, having the largest connectable cross-section specified in Table 24, solid or stranded, whichever is the more unfavourable. The conductor is moved each time the screw or nut is loosened.

Column I applies to screws without head if the screw, when tightened, does not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the diameter of the screw.

Column II applies to other screws which are tightened by means of a screwdriver.

Column III applies to screws and nuts which are tightened by means other than a screwdriver.

Where a screw has a hexagonal head with a slot for tightening with a screwdriver and the values in column II and column III are different, the test is carried out twice, first applying to the hexagonal head the torque specified in column III and then, on another sample, applying the torque specified in column II by means of a screwdriver. If the values in column II and column III are the same, only the test with the screwdriver is carried out.

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

Moreover, enclosures and covers shall not be damaged.

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

9.5.1 Compliance with the requirements of 8.1.5 is checked by inspection, by the test of 9.4, for which a rigid copper conductor having the largest cross-section specified in Table 24 is placed in the terminal (for nominal cross-sections exceeding 6 mm², a rigid stranded conductor is used; for other nominal cross-sections, a solid conductor is used), and by the tests of 9.5.2, 9.5.3 and 9.5.4.

The tests of 9.5.2, 9.5.3 and 9.5.4 are carried out using a suitable test screwdriver or spanner, and applying the torque specified in Table 26.

9.5.2 The terminals are fitted with copper conductors of the same type (solid, stranded or flexible) of the smallest and largest cross-sections specified in Table 24.

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

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

- tests for solid conductors shall use conductors having cross-sections from 1 mm² up to 6 mm², as applicable;
- tests for stranded conductors shall use conductors having cross-sections from 1,5 mm² up to 50 mm², as applicable;
- tests for flexible conductors shall use conductors having cross-sections from 1 mm² up to 35 mm², as applicable.

NOTE Information on AWG is given in Annex I.

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

The clamping screws are then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 26.

Each conductor is then subjected to a pull of the value, in newtons, shown in Table 27, according to the relevant cross-section of the tested conductor.

The pull is applied without jerks, for 1 min, in the direction of the axis of the conductor space.

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

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

9.5.3 The terminals are fitted with copper conductors of the smallest and largest cross-sections specified in Table 24, solid or stranded, whichever is the more unfavourable, and the terminal screws are tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 26.

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

The conductors shall show no undue damage or severed wires.

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

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

9.5.4 The terminals are fitted with the largest cross-section area specified in Table 24 for stranded and/or flexible copper conductor.

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

The conductor is inserted into the terminal until the conductor reaches the bottom of the terminal or just projects from the far side of the terminal and in the position most likely to permit a strand (or strands) to escape. The clamping screw or nut is then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 26.

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

9.6 Verification of protection against electric shock

This requirement is applicable to those parts of RCCBs which are exposed to the operator when mounted as for normal use.

The test is made with the standard test finger shown in Figure 1 on the RCCB mounted as for normal use (see note of 8.2) and fitted with conductors of the smallest and largest cross-sections which may be connected to the RCCB.

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

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

It is recommended that a lamp be used for the indication of contact and that the voltage be not less than 40 V. The standard test finger shall not touch live parts.

RCCBs with enclosures or covers of thermoplastic material are subjected to the following additional test, which is carried out at an ambient air temperature of $(35 \pm 2) ^\circ\text{C}$, the RCCB being at this temperature.

RCCBs are subjected for 1 min to a force of 75 N, applied through the tip of a straight unjointed test finger (probe 11 according to IEC 61032). This finger is applied to all places where yielding of insulating material could impair the safety of the RCCB but is not applied to knock-outs.

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

Unenclosed RCCBs having parts not intended to be covered by an enclosure are submitted to the test with a metal front panel and mounted as for normal use.

9.7 Test of dielectric properties

9.7.1 Resistance to humidity

9.7.1.1 Preparation of the RCCB for test

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

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

9.7.1.2 Test conditions

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

The temperature of the air in which the sample is placed is maintained within $\pm 1 ^\circ\text{C}$ of any convenient value T between $20 ^\circ\text{C}$ and $30 ^\circ\text{C}$.

Before being placed in the humidity cabinet, the sample is brought to a temperature between $T ^\circ\text{C}$ and $T ^\circ\text{C} + 4 ^\circ\text{C}$.

9.7.1.3 Test procedure

The sample is kept in the cabinet for 48 h.

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

In order to achieve the specified conditions within the cabinet, it is recommended to ensure a constant circulation of the air within and to use a cabinet which is thermally insulated.

9.7.1.4 Condition of the RCCB after the test

After this treatment, the sample shall show no damage within the meaning of this document and shall withstand the tests of 9.7.2, 9.7.3, 9.7.4, 9.7.6 and 9.7.7.2 (if applicable).

9.7.2 Insulation resistance of the main circuit

The RCCB having been treated as specified in 9.7.1 is then removed from the cabinet.

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

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

The measurement of c) is carried out after having connected all auxiliary circuits to the frame.

The term "frame" includes:

- all accessible metal parts and a metal foil in contact with the surfaces of insulating material which are accessible after installation as for normal use;
- the surface on which the base of the RCCB is mounted, covered, if necessary, with metal foil;
- screws and other devices for fixing the base to its support;
- screws for fixing covers which have to be removed when mounting the RCCB;
- metal parts of operating means referred to in 8.2.

If the RCCB is provided with a terminal intended for the connection of protective conductors, this is connected to the frame.

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

The insulation resistance shall not be less than:

- 2 MΩ for the measurements according to list items a) and b);
- 5 MΩ for the other measurements.

9.7.3 Dielectric strength of the main circuit

After the RCCB has passed the tests of 9.7.2, the test voltage specified is applied for 1 min between the parts indicated in 9.7.2 with electronic components, if any, being disconnected for the test.

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

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

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

The values of the test voltage shall be as follows:

- 2 000 V for list items a) to c) of 9.7.2;
- 2 500 V for list item d) of 9.7.2.

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

No flashover or breakdown shall occur during the test.

Glow discharges without drop in voltage are disregarded.

9.7.4 Insulation resistance and dielectric strength of auxiliary circuits

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

Where electronic components connected to the main circuit in normal service are used, the temporary connections for test shall be made so that, during the tests, there is no voltage between the incoming and outgoing sides of the components.

- b) The measurements of the insulation resistance are carried out at a voltage of approximately 500 V DC:

1) between

- the auxiliary circuits connected together, and
- the frame;

2) between

- each part of the auxiliary circuit which might be separated from the other parts of the auxiliary circuit in normal service and
- the other parts of the auxiliary circuit(s) connected together,

After this voltage has been applied for 1 min, the insulation resistance shall not be less than 2 MΩ.

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

The voltage values to be applied are specified in Table 21.

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

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

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

In the case of RCCBs in which the auxiliary circuit is not accessible for verification of the requirements given in item b), the tests can be made on specially prepared samples.

Auxiliary circuits do not include the control circuit of RCCBs classified according to 4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6.

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

9.7.5 Secondary circuit of detection transformers

The circuit which includes the secondary circuit of the detection transformer is not submitted to any insulation test, provided that the circuit has no connection with accessible metal parts, with a protective conductor, or with live parts.

9.7.6 Capability of control circuits connected to the main circuit to withstand high DC voltages due to insulation measurements

The test is carried out on the RCCB fixed on a metal support, in the closed position, with all control circuits connected as in service.

A DC voltage source is used with the following characteristics:

– open voltage: 600 V $^{+25}_0$ V

– maximum ripple: 5 %

where

$$\text{ripple (\%)} = \frac{\text{max. value} - \text{mean value}}{\text{mean value}} \times 100$$

– short-circuit current: 12 mA $^{+2}_0$ mA

This test voltage is applied for 1 min in turn between each pole and the other poles connected together to the frame.

After this treatment, under the conditions of IEC 61008-2-1:2024, 9.9.1.2.3 or IEC 61008-2-2:2024, 9.9.1.2.3, as applicable, the RCCB shall trip with a test current of $I_{\Delta n}$. Only one test is carried out, the break time shall comply with Table 11.

9.7.7 Verification of impulse withstand voltages

9.7.7.1 General testing procedure for the impulse withstand voltage tests

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

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

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

When performing the impulse voltage test, the attenuation or amplification of the test voltage shall be taken into account. It shall be ensured that the required value of the test voltage is applied across the terminals of the equipment under test.

The internal surge impedance of the test apparatus shall have a nominal value not higher than 500 Ω.

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

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

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

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

9.7.7.2 Verification of clearances with the impulse withstand voltage

If the measurement of clearances of items 2 and 4 of Table 20 does not show any reduced clearance, this test is not applied.

Where measurements of clearances within the device are not feasible this test may be used to replace measurements of clearances of items 2 and 4 of Table 20.

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

The test impulse voltage values shall be chosen from Table 22 in accordance with the rated impulse withstand voltage of the RCCB as given in Table 19. These values are corrected for barometric pressure and/or altitude at which the tests are carried out, according to Table 22.

Tests are carried out with the RCCB in the closed position, applying the impulse voltage between:

- a) in turn between each pole and the others connected together, electronic components connected between current paths being disconnected for the test;
- b) between all poles connected together and the frame including a metal foil or part in contact with the outer surface of the housing of insulating material but with the terminal areas kept completely free to avoid flashover between terminals and the metal foil;
- c) for RCCBs with a metal enclosure having an internal lining of insulating material, between the frame and a metal foil in contact with the inner surface of the lining of insulating material, including bushings and similar devices.

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

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

The test in list item b) above is carried out after having connected all auxiliary circuits to the frame.

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

No further disruptive discharge shall occur.

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

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

The tests of this 9.7.7.3 are not preceded by the humidity treatment described in 9.7.1, according to Annex A.

The test impulse voltage values shall be chosen from Table 23, in accordance with the rated operational voltage of the installation for which the RCCB is intended to be used as given in Table 19. These values are corrected for barometric pressure and/or altitude at which the tests are carried out, according to Table 23.

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

The impulses are applied between the line terminals connected together and the load terminals connected together.

There shall be no disruptive discharges during the test.

9.8 Test of temperature-rise

9.8.1 Ambient air temperature

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

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

Care should be taken to avoid errors due to sudden temperature changes.

9.8.2 Test procedure

A current equal to I_n is passed simultaneously through all the poles of the RCCB for a period of time sufficient for the temperature-rise to reach the steady state value. In practice, this condition is reached when the variation of the temperature-rise does not exceed 1 K per hour.

For four-pole RCCBs, the test is first carried out by passing the specified current through the three-phase poles only.

The test is then repeated by passing the current through the pole intended for the connection of the neutral and the pole adjacent to the neutral.

With the agreement of the manufacturer, the test on four-pole devices may also be replaced by a single test with all poles in series including the N-pole.

During these tests, the temperature-rise shall not exceed the values shown in Table 28.

9.8.3 Measurement of the temperature of parts

The temperature of the different parts referred to in Table 28 shall be measured by means of fine wire thermocouples or by equivalent means at the nearest accessible position to the hottest spot.

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

9.8.4 Temperature-rise of a part

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

9.9 Verification of the operating characteristics

IEC 61008-2-1:2024, 9.9 or IEC 61008-2-2:2024, 9.9 applies.

9.10 Verification of mechanical and electrical endurance

9.10.1 General test conditions

The RCCB is fixed to a metal support.

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

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

If iron-core reactors are used, the iron power losses of these reactors shall not appreciably influence the recovery voltage.

The current shall have a substantially sinusoidal waveform and the power factor shall be between 0,85 and 0,9.

The RCCB is connected to the circuit with conductors of the sizes indicated in Table 25.

9.10.2 Test procedure

RCCBs are subjected to 2 000 operating cycles, each operating cycle consisting of a closing operation followed by an opening operation.

The RCCB shall be operated as for normal use.

The opening operations shall be carried out as follows:

For RCCBs having $I_{\Delta n} > 0,010$ A:

- for the first 1 000 operating cycles by using the manual operating means;
- for the following 500 operating cycles by using the test device;
- for the last 500 operating cycles by passing through one pole a residual operating current of value $I_{\Delta n}$.

For RCCBs having $I_{\Delta n} \leq 0,010$ A:

- for the first 500 operating cycles by using the manual operating means;
- for the following 750 operating cycles by using the test device;
- for the last 750 operating cycles by passing through one pole a residual operating current of value $I_{\Delta n}$.

In addition, the RCCB is further subjected without load, using the manual operating means, to:

- 2 000 operating cycles for RCCBs having $I_n \leq 25$ A;
- 1 000 operating cycles for RCCBs having $I_n > 25$ A.

The operating frequency shall be:

- four operating cycles per minute for RCCBs of $I_n \leq 25$ A, the ON period having a duration of 1,5 s to 2 s;
- two operating cycles per minute for RCCBs of $I_n > 25$ A, the ON period having a duration of 1,5 s to 2 s.

For RCCBs having multiple settings, the tests are carried out at the lowest setting.

9.10.3 Condition of the RCCB after test

Following the test of 9.10.2, the RCCB shall not show:

- undue wear;
- damage of the enclosure permitting access to live parts by the standard test finger;
- loosening of electrical or mechanical connections;
- seepage of the sealing compound, if any.

Under the conditions of IEC 61008-2-1:2024, 9.9.1.2.3 or IEC 61008-2-2:2024, 9.9.1.2.3, the RCCB shall trip with a test current of $1,25 I_{\Delta n}$. Only one test is carried out without measurement of the break time.

The RCCB shall then perform satisfactorily the dielectric strength test in 9.7.3 for 1 min but at a voltage of 900 V without previous humidity treatment.

9.11 Verification of the behaviour of the RCCB under short-circuit conditions

9.11.1 List of the short-circuit tests

The various tests to verify the behaviour of the RCCB under short-circuit conditions are shown in Table 35.

9.11.2 Short-circuit tests

9.11.2.1 General conditions for test

The conditions of 9.11.2 are applicable to any test intended to verify the behaviour of the RCCBs under short-circuit conditions.

The short circuit tests shall be performed at a convenient temperature within the range according to 7.1.

For RCCBs having multiple settings of residual operating current, the tests are carried out at the lowest setting.

a) Test circuit

Figure 5 and Figure 6 give diagrams of the circuits to be used for the tests concerning:

- a single-pole RCCB with two current paths;
- a two-pole RCCB;
- a three-pole RCCB;
- a three-pole RCCB with four current paths;
- a four-pole RCCB.

The supply S feeds a circuit including impedance Z, the SCPD (if any), the RCCB under test (D), and the additional impedance Z_1 and Z_2 , as applicable.

The values of the resistors and reactors of the test circuit shall be adjusted to satisfy the specified test conditions.

The reactors L should preferably be air-cored. They shall always be connected in series with the resistors R, and their value shall be obtained by series coupling of individual reactors; parallel connecting of reactors is possible when these reactors have practically the same time-constant.

Since the transient recovery voltage characteristics of test circuits including large air-cored reactors are not representative of normal service conditions, the air-cored reactor in any phase shall be shunted by a resistor r taking approximately 0,6 % of the current through the reactor (see Figure 7). This resistor may be omitted if agreed by the manufacturer.

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

In each test circuit the impedance Z is inserted between the supply source S and the RCCB.

The SCPD, or the equivalent impedance (see 9.11.2.2 a) and 9.11.2.3 a)), is inserted between the impedance Z and the RCCB.

The additional impedance Z_1 , if used, shall be inserted on the load side of the RCCB.

For the tests of 9.11.2.4 a) and c), the RCCB shall be connected with cables (rigid or flexible) having a length of 0,75 m per pole and the maximum cross-section corresponding to the rated current according to the rigid conductor column of Table 24.

It is recommended that a cable of 0,5 m in length be connected on the supply side and a cable of 0,25 m in length be connected on the load side of the RCCB under test.

The diagram of the test circuit shall be given in the test report.

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

Z_2 , suitably calibrated, is an impedance used to obtain one of the following currents:

- a residual current of $10 I_{\Delta n}$;
- the rated residual making and breaking current $I_{\Delta m}$;
- the rated conditional residual short-circuit current $I_{\Delta c}$.

S_1 is an auxiliary switch.

For the purpose of verifying the minimum I^2t and I_p values to be withstood by the RCCB as given in Table 36, tests shall be performed. The SCPD, if any, shall be adjusted and shall be embodied either by a silver wire or by a fuse (see example in Annex K) or by any other means. The manufacturer may specify the type of SCPD to be used in the tests.

For the purpose of this test, verification of the correctly selected and adjusted SCPD (I^2t and I_p) is made prior to testing, the RCCB being replaced by a temporary connection having a negligible impedance.

The minimum values of let-through energy I^2t and peak current I_p , based on an electrical angle of 45° , are given in Table 36.

Without an agreement of the manufacturer, these values shall not be higher than 1,1 times the values given in Table 36.

For intermediate values of short-circuit test currents the next higher short-circuit current shall apply.

The verification of the minimum I^2t and I_p values is not needed if the manufacturer has stated for the RCCBs values higher than the minimum ones in which case the stated values shall be verified.

For coordination with circuit-breakers, tests with this combination are necessary.

All the conductive parts of the RCCB normally earthed in service, including the metal support on which the RCCB is mounted or any metal enclosure (see 9.11.2.1 f)), shall be connected to the neutral point of the supply or to a substantially non-inductive artificial neutral permitting a prospective fault current of at least 100 A.

This connection shall include a copper wire F of 0,1 mm diameter and not less than 50 mm in length for the detection of the fault current and, if necessary, a resistor R_2 limiting the value of the prospective fault current to about 100 A.

The voltage sensors are connected:

- across the terminals of the pole, for single-pole RCCBs;
- across the supply terminals, for multipole RCCBs.

b) Tolerances on test quantities

All the tests concerning the verification of rated making and breaking capacity and of the correct coordination between RCCBs and SCPDs shall be performed at values of influencing quantities and factors as stated by the manufacturer in accordance with Table 47 of this document, unless otherwise specified.

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

- current: $\begin{matrix} +5 \\ 0 \end{matrix} \%$
- frequency: $\pm 5 \%$
- power factor: $\begin{matrix} 0 \\ -0,05 \end{matrix}$
- voltage: (including recovery voltage): $\pm 5 \%$

c) Power factor of the test circuit

The power factor of each phase of the test circuit shall be determined according to a method which shall be stated in the test report. Two examples are given in Annex E.

The power factor of a polyphase circuit is considered as the mean value of the power factor of each phase.

The power factor shall be in accordance with Table 29.

d) Power frequency recovery voltage

The value of the power frequency recovery voltage shall be equal to a value corresponding to 105 % of the rated operational voltage of the RCCB under test. The value of 105 % of the rated operational voltage is deemed to cover the effects of the variations of the system voltage under normal service conditions. The upper limit value may be increased with the approval of the manufacturer.

After each arc extinction, the power-frequency recovery voltage shall be maintained for not less than 0,1 s.

e) Calibration of the test circuit

The RCCB and the SCPD, if any, are replaced by temporary connections G_1 having a negligible impedance compared with that of the test circuit.

For the test of 9.11.2.4 a) the load terminals of the RCCB being short-circuited by means of the connections G_2 of negligible impedance, the impedance Z is adjusted so as to obtain, at the test voltage, a current equal to the rated conditional short-circuit current at the prescribed power-factor; the test circuit is energized simultaneously in all poles and the current curve is recorded with the current sensor.

Moreover, for the tests of 9.11.2.2, 9.11.2.3, 9.11.2.4 b) and c) the additional impedances Z_2 and/or Z_1 are used, as necessary, so as to obtain the required test current values (I_m , $I_{\Delta m}$ and $I_{\Delta c}$ respectively).

f) Condition of the RCCB for test

RCCBs shall be tested in free air according to 9.11.2.1 f) 1), unless they are designed for use only in enclosures specified by the manufacturer or are intended for use in individual enclosures only, in which cases they shall be tested according to 9.11.2.1 f) 2) or, with the agreement of the manufacturer, according to 9.11.2.1 f) 1).

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

The RCCB shall be operated simulating as closely as possible the normal operation.

1) Test in free air

The RCCB under test is mounted as shown in Figure C.1 of Annex C.

The polyethylene sheet and the barrier of insulating material specified in Annex C are placed as shown in Figure C.1 for opening (O) operations only.

The grid(s) specified in Annex C shall be so positioned that the bulk of the emitted ionized gases passes through the grid(s). The grid(s) shall be placed in the most unfavourable position(s).

If the position of the vents is not obvious, or if there are no vents, appropriate information should be provided by the manufacturer. If no information is available, two grids, one above and one below the RCCB, shall be used.

The grid circuit(s) (see Figure C.3) shall be connected to the points B and C according to the test circuit diagrams of Figure 5 and Figure 6.

The resistor R' shall have a resistance of 1,5 Ω . The copper wire F' (see Figure C.3) shall have a length of 50 mm and a diameter of 0,12 mm for RCCBs having a rated operational voltage of 230 V and 0,16 mm for RCCBs having a rated operational voltage of 400 V.

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

For higher short-circuit currents up to I_{nc} , the distance "a" may be increased and/or additional barriers or insulating means may be fitted, as stated by the manufacturer; "a", if increased, shall be chosen from the series 40 – 45 – 50 – 55 – mm and stated by the manufacturer.

2) Test in enclosures

The grid and the barrier of insulating material shown in Figure C.1 are omitted.

The test shall be performed with the RCCB placed in an enclosure having the most unfavourable configuration, under the most unfavourable conditions.

This means that if other RCCBs (or other devices) are normally fitted in the direction(s) in which the grid(s) would be placed, they should be installed there. These RCCBs (or other devices) should be supplied as in normal use but via F' and R' as defined in 9.11.2.1 f) 1) and connected as shown in Figure 5 and Figure 6.

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

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

g) Sequence of operations

The test procedure consists of a sequence of operations.

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

- O represents an opening operation, the short-circuit being established by the making switch T, with the RCCB and the SCPD, if any, in the closed position;
- CO represents a closing operation of the RCCB, both the making switch T and the SCPD, if any, being in the closed position, followed by an automatic opening (in the case of an SCPD (see 9.11.2.4);
- t represents the time interval between two successive short-circuit operations which shall be 3 min or such longer time as can be required for resetting or renewing the SCPD, if any.

h) Behaviour of the RCCB during tests

During tests, the RCCB shall not endanger the operator.

Furthermore, there shall be no permanent arcing, no flashover between poles or between poles and exposed conductive parts, no melting of the fuse F and, if applicable, of the fuse F' .

i) Condition of the RCCB after tests

After each of the applicable tests carried out in accordance with 9.11.2.2, 9.11.2.3, 9.11.2.4 a), 9.11.2.4 b) and 9.11.2.4 c), the RCCBs shall show no damage impairing their further use and shall be capable, without maintenance, of withstanding the following tests:

- leakage current across open contacts (suitability for isolation), by applying separately on each pole of the RCCB at a voltage equal to 1,1 times its rated operational voltage, the RCCB being in the open position. The leakage current flowing across the open contacts of each pole is measured after stabilization and shall not exceed 2 mA;
- dielectric strength tests according to 9.7.3 carried out between 2 h and 24 h after the short-circuit test at a voltage of twice its rated operational voltage, for 1 min, without previous humidity treatment;
- making and breaking one time its rated current at its rated operational voltage.

During these tests, after the test carried out under the conditions specified in item a) of 9.7.2, it shall be verified that the indicating means show the open position and during the test carried out under the condition specified in item b) of 9.7.2 the indicating means shall show the closed position.

Under the conditions of IEC 61008-2-1:2024, 9.9.1.2.3 or IEC 61008-2-2:2024, 9.9.1.2.3 (as relevant), the RCCB shall trip with a test current of $1,25 I_{\Delta n}$. Only one test is carried out without measurement of the break time.

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

j) Interpretation of records

1) Determination of the applied and power-frequency recovery voltages

The applied and power frequency recovery voltages are determined from the record corresponding to the break test made with the RCCB under test. The applied voltage is evaluated as indicated in Figure 23.

The voltage on the supply side shall be measured during the first cycle after arc extinction in all poles and after high frequency phenomena have subsided.

2) Determination of the prospective short-circuit current

The AC component of the prospective current is taken as being equal to the RMS value of the AC component of the calibration current (value corresponding to A_2 of Figure 23).

Where applicable, the prospective short-circuit current shall be the average of the prospective currents in all the phases.

9.11.2.2 Verification of the rated making and breaking capacity (I_m)

This test is intended to verify the ability of the RCCB to make, to carry for a specified time and to break short-circuit currents, while a residual current causes the RCCB to operate.

a) Test conditions

The RCCB is tested in a circuit according to the general test conditions specified in 9.11.2.1, no SCPD being inserted in the circuit.

The connections G_1 of negligible impedance are replaced by the RCCB and by connections having approximately the impedance of the SCPD.

The auxiliary switch S_1 remains closed.

b) Test procedure

With a residual operating current equal to $10 I_{\Delta n}$ flowing through the switch S_1 and the impedance Z_2 , the following sequence of operation is performed:

CO – t – CO – t – CO.