

CONSOLIDATED VERSION

VERSION CONSOLIDÉE



**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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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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This Consolidated version of IEC 61008-1 bears the edition number 3.2. It consists of the third edition (2010) [documents 23E/681/FDIS and 23E/685/RVD], its amendment 1 (2012) [documents 23E/740/FDIS and 23E/744/RVD] and its amendment 2 (2013) [documents 23E/795/FDIS and 23E/819/RVD]. The technical content is identical to the base edition and its amendments.

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1 and 2. Additions and deletions are displayed in red, with deletions being struck through. A separate Final version with all changes accepted is available in this publication.

This publication has been prepared for user convenience.

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

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

- complete revision of EMC sequences, including the new test T.2.6 already approved in IEC 61543;
- clarification of RCDs current/time characteristics reported in Tables 1 and 2;
- revision of test procedure for $I_{\Delta n}$ between 5 A and 200 A;
- testing procedure regarding the 6mA d.c. current superimposed to the fault current;
- improvement highlighting RCDs with multiple sensitivity;
- tests for the use of RCCBs in IT systems.

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

A list of all parts of 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.

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INTRODUCTION

This part includes definitions, requirements and tests, covering all types of RCCBs. For the applicability to a specific type this part applies in conjunction with the relevant part, as follows:

Part 2-1: Applicability of the general rules to RCCBs functionally independent of line voltage.

Part 2-2: Applicability of the general rules to RCCBs functionally dependent on line voltage.

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

Part 1: General rules

1 Scope

This International Standard applies to residual current operated circuit-breakers functionally independent of, or functionally dependent on, line voltage, for household and similar uses, not incorporating overcurrent protection (hereafter referred to as RCCBs), for rated voltages not exceeding 440 V a.c. 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.

These devices are intended to protect persons against indirect contact, the exposed conductive parts of the installation being connected to an appropriate earth electrode. They may be used to provide protection against fire hazards due to a persistent earth fault current, without the operation of the overcurrent protective device.

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

This standard applies to devices 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 general requirements of IEC 60755. RCCBs are essentially intended to be operated by uninstructed persons and designed not to require maintenance. They may be submitted for certification purposes.

NOTE 2 Installation and application rules of RCCBs are given in the IEC 60364 series.

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

They are suitable for isolation.

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

Special precautions (e.g. lightning arresters) may 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).

RCCBs of the general type are resistant to unwanted tripping 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 sufficient proof against unwanted tripping even if the surge voltage causes a flashover and a follow-on current occurs.

NOTE 3 Surge arresters installed downstream of the general type of RCCBs and connected in common mode may cause unwanted tripping.

NOTE 4 For RCCBs having a degree of protection higher than IP20 special constructions may be required.

Particular requirements are necessary for

- residual current operated circuit-breakers with integral overcurrent protection (see IEC 61009-1);
- RCCBs incorporated in or intended only for association with plugs and socket-outlets or with appliance couplers for household or similar general purposes;
- RCCBs intended to be used at frequencies other than 50 Hz or 60 Hz.

~~NOTE 5 For the time being, for RCCBs incorporated in, or intended only for socket-outlets or plugs, the requirements of this standard in conjunction with the requirements of IEC 60884-1 may be used as far as applicable.~~

For RCCBs incorporated in, or intended only for association with socket-outlets, the requirements of this standard may 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 5 RCCBs incorporated in, or intended only for association with socket-outlets, can either meet IEC 62640 or this standard.

NOTE 6 In DK, plugs and socket-outlets shall be in accordance with the requirements of the heavy current regulations, section 107.

NOTE 7 In the UK, the plug part of an RCCB shall comply with BS 1363-1 and the socket-outlet part(s) of an RCCB should comply with BS 1363-2. In the UK, the plug part and the socket-outlet part(s) of an RCCB need not comply with any IEC 60884-1 requirements.

The requirements of this standard apply for normal environmental conditions (see 7.1). Additional requirements may be necessary for RCCBs used in locations having severe environmental conditions.

RCCBs including batteries are not covered by this standard.

2 Normative references

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

IEC 60038, *IEC standard voltages*

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

IEC 60060-1:1989, *High-voltage test techniques – Part 1: General definitions and test requirements*

IEC 60060-2:1994, *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: 2001, *Environmental testing – Part 3-4: Supporting documentation and guidance – Damp heat tests*

IEC 60112:2003, *Method for the determination of the proof and the comparative tracking indices of solid insulating materials*

IEC 60228:2004, *Conductors of insulated cables*

IEC 60364 (all parts), *Low-voltage electrical installations*

IEC 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60364-5-53:2001, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*

IEC 60417, *Graphical symbols for use on equipment*

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

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage 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 60695-2-10:2000, *Fire hazard testing – Part 2-10: Glowing/hot-wire based test methods – Glow-wire apparatus and common test procedure*

IEC 60884-1, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*

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

IEC 61543:1995, *Residual current-operated protective devices (RCDs) for household and similar use – Electromagnetic compatibility*

Amendment 1 (2004)

Amendment 2 (2005)

CISPR 14-1:2005, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

Where the terms "voltage" or "current" are used, they imply r.m.s. values, unless otherwise specified.

NOTE For a glossary of symbols see Annex IB.

3.1 Definitions relating to currents flowing from live parts to earth

3.1.1

earth fault current

current flowing to earth due to an insulation fault

3.1.2

earth leakage current

current flowing from the live parts of the installation to earth in the absence of an insulation fault

3.1.3

pulsating direct current

current of pulsating wave form which assumes, in each period of the rated power frequency, the value 0 or a value not exceeding 0,006 A d.c. during one single interval of time, expressed in angular measure, of at least 150°

3.1.4

current delay angle α

time, expressed in angular measure, by which the starting instant of current conduction is delayed by phase control

3.2 Definitions relating to the energization of a residual current circuit-breaker

3.2.1

energizing quantity

electrical excitation quantity which alone, or in combination with other such quantities, shall be applied to an RCCB to enable it to accomplish its function under specified conditions

3.2.2

energizing input-quantity

energizing quantity by which the RCCB is activated when it is applied under specified conditions

NOTE These conditions that may involve, for example, the energizing of certain auxiliary elements.

3.2.3

residual current

I_{Δ}

vector sum of the instantaneous values of the current flowing in the main circuit of the RCCB (expressed as r.m.s. value)

3.2.4

residual operating current

value of residual current which causes the RCCB to operate under specified conditions

3.2.5

residual non-operating current

value of residual current at which and below which the RCCB does not operate under specified conditions

3.3 Definitions relating to the operation and functions of residual current circuit-breakers

3.3.1

residual current operated circuit-breaker

mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions

3.3.2

residual current operated circuit-breaker without integral overcurrent protection

RCCB

residual current operated circuit-breaker not designed to perform the functions of protection against overloads and/or short-circuits

3.3.3

residual current operated circuit-breaker with integral overcurrent protection

RCBO

residual current operated circuit-breaker designed to perform the functions of protection against overloads and/or short-circuits

3.3.4

RCCBs functionally independent of line voltage

RCCBs for which the functions of detection, evaluation and interruption do not depend on the line voltage

3.3.5

RCCBs functionally dependent on line voltage

RCCBs for which the functions of detection, evaluation or interruption depend on the line voltage

NOTE It is understood that the line voltage is applied to the RCCB, for detection, evaluation or interruption.

3.3.6

switching device

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

[IEV 441-14-01:1984]

3.3.7

mechanical switching device

switching device designed to close and to open one or more electric circuits by means of separable contacts

[IEV 441-14-02, modified]

3.3.8

trip-free RCCB

RCCB the moving contacts of which return to and remain in the open position when the automatic opening operation is initiated after the initiation of the closing operation, even if the closing command is maintained

NOTE To ensure proper breaking of the current which may have been established, it may be necessary that the contacts momentarily reach the closed position.

3.3.9

break time of an RCCB

time which elapses between the instant when the residual operating current is suddenly attained and the instant of arc extinction in all poles

3.3.10

limiting non-actuating time

maximum delay during which a value of residual current higher than the residual non-operating current can be applied to the RCCB without causing it to operate

3.3.11

time-delay RCCB

RCCB specially designed to attain a predetermined value of limiting non-actuating time, corresponding to a given value of residual current

3.3.12

closed position

position in which the predetermined continuity of the main circuit of the RCCB is secured

[IEV 441-16-22]

3.3.13

open position

position in which the predetermined clearance between open contacts in the main circuit of the RCCB is secured

[IEV 441-16-23]

3.3.14

pole

that part of an RCCB associated exclusively with one electrically separated conducting path of its main circuit provided with contacts intended to connect and disconnect the main circuit itself and excluding those portions which provide a means for mounting and operating the poles together

3.3.15

switched neutral pole

pole only intended to switch the neutral and not intended to have a short-circuit capacity

3.3.16

main circuit (of an RCCB)

all the conductive parts of an RCCB included in the current paths (see 4.3)

3.3.17

control circuit (of an RCCB)

circuit (other than a path of the main circuit) intended for the closing operation or the opening operation, or both, of the RCCB

NOTE The circuits intended for the test device are included in this definition.

3.3.18

auxiliary circuit (of an RCCB)

all the conductive parts of an RCCB intended to be included in a circuit other than the main circuit and the control circuit of the RCCB

[IEV 441-15-04]

3.3.19

RCCB type AC

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

3.3.20

RCCB type A

RCCB for which tripping is ensured for residual sinusoidal alternating currents and residual pulsating direct currents, whether suddenly applied or slowly rising

3.3.21

test device

device incorporated in the RCCB simulating the residual current conditions for the operation of the RCCB under specified conditions

3.4 Definitions relating to values and ranges of energizing quantities

3.4.1

rated value

quantity value assigned by the manufacturer for a specific operating condition of an RCCB

3.4.2

non-operating overcurrents in the main circuit

The definitions of limiting values of non-operating overcurrents are given in 3.4.2.1 and 3.4.2.2.

NOTE In the case of overcurrent in the main circuit, in the absence of residual current, operation of the detecting device may occur as a consequence of asymmetry existing in the detecting device itself.

3.4.2.1

limiting value of overcurrent in case of a load through an RCCB with two current paths

maximum value of overcurrent of a load which, in the absence of any fault to frame or to earth, and in the absence of an earth leakage current, can flow through an RCCB with two current paths without causing it to operate

3.4.2.2

limiting value of overcurrent in case of a single phase load through a three-pole or four-pole RCCB

maximum value of a single phase overcurrent which, in the absence of any fault to frame or to earth, and in the absence of an earth leakage current, can flow through three-pole or four-pole RCCB without causing it to operate

3.4.3

residual short-circuit withstand current

maximum value of the residual current for which the operation of the RCCB is ensured under specified conditions and above which the device may undergo irreversible alterations

3.4.4

prospective current

current that would flow in the circuit, if each main current path of the RCCB and of the overcurrent protective device (if any) were replaced by a conductor of negligible impedance

NOTE The prospective current may be qualified in the same manner as an actual current, for example: prospective breaking current, prospective peak current, prospective residual current, etc.

3.4.5

maximum prospective peak current (of an a.c. circuit)

prospective peak current, when the initiation of the current takes place at the instant which leads to the highest possible value

NOTE For a multipole RCCB in a polyphase circuit, the maximum prospective peak current refers to a single pole only.

3.4.6

short-circuit (making and breaking) capacity

alternating component of the prospective current, expressed by its r.m.s. value, which the RCCB is designed to make, to carry for its opening time and to break under specified conditions

3.4.7

making capacity

value of the a.c. component of a prospective current that an RCCB is capable of making at a stated voltage under prescribed conditions of use and behaviour

3.4.8

breaking capacity

value of the a.c. component of a prospective current that an RCCB is capable of breaking at a stated voltage under prescribed conditions of use and behaviour

3.4.9

residual making and breaking capacity

value of the a.c. component of a residual prospective current which an RCCB can make, carry for its opening time and break under specified conditions of use and behaviour

3.4.10

conditional short-circuit current

value of the a.c. component of a prospective current, which an RCCB, protected by a suitable short-circuit protective device (hereafter referred to as SCPD) in series can withstand under specified conditions of use and behaviour

3.4.11

conditional residual short-circuit current

value of the a.c. component of a residual prospective current which an RCCB protected by a suitable SCPD in series, can withstand under specified conditions of use and behaviour

3.4.12

limiting values (U_x and U_y) of the line voltage for RCCBs functionally dependent on line voltage

3.4.12.1

U_x

minimum value of the line voltage at which an RCCB functionally dependent on line voltage still operates under specified conditions in case of decreasing line voltage (see 9.17.1)

3.4.12.2

U_y

minimum value of the line voltage below which an RCCB functionally dependent on line voltage opens automatically in the absence of any residual current (see 9.17.2)

3.4.13

I^2t (Joule integral)

integral of the square of the current, over a given time interval (t_0 , t_1):

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

[IEV 441-18-23:1984]

3.4.14

recovery voltage

voltage which appears across the terminals of a pole of an RCCB after the breaking of the current

[IEV 441-17-25:1984]

NOTE 1 This voltage may be considered as comprising two successive intervals of time, one during which a transient voltage exists, followed by a second interval during which power-frequency voltage alone exists.

NOTE 2 This definition refers to a single-pole device. For a multipole device, the recovery voltage is the voltage across the supply terminals of the device.

3.4.14.1

transient recovery voltage

recovery voltage during the time in which it has a significant transient character

NOTE The transient voltage may be oscillatory or non-oscillatory or a combination of these depending on the characteristics of the circuit and of the RCCB. It includes the voltage shift of the neutral of a polyphase circuit.

[IEV 441-17-26:1984, modified]

3.4.14.2

power-frequency recovery voltage

recovery voltage after the transient voltage phenomena have subsided

[IEV 441-17-27:1984]

3.5 Definitions relating to values and ranges of influencing quantities

3.5.1

influencing quantity

any quantity likely to modify the specified operation of an RCCB

3.5.2

reference value of an influencing quantity

value of an influencing quantity to which the characteristics stated by the manufacturer are referred

3.5.3

reference conditions of influencing quantities

collectively, the reference values of all influencing quantities

3.5.4

range of an influencing quantity

range of values of an influencing quantity which permits the RCCB to operate under specified conditions, the other influencing quantities having their reference values

3.5.5

extreme range of an influencing quantity

range of values of an influencing quantity within which the RCCB suffers only spontaneously reversible changes, although not necessarily complying with all the requirements of this standard

3.5.6

ambient air temperature

temperature, determined under prescribed conditions of the air surrounding the RCCB (for an enclosed RCCB it is the air outside the enclosure)

3.6 Definitions relating to terminals

NOTE These definitions may be modified when the work of subcommittee 23F on terminals is completed.

3.6.1

terminal

conductive part of a device, provided for reusable electrical connection to external circuits

3.6.2

screw-type terminal

terminal for the connection and subsequent disconnection of one conductor or the interconnection of two or more conductors capable of being dismantled, the connections being made, directly or indirectly, by means of screws or nuts of any kind

3.6.3

pillar terminal

screw-type terminal in which the conductor is inserted into a hole or cavity where it is clamped under the shank of the screw(s)

NOTE 1 The clamping pressure may be applied directly by the shank of the screw or through an intermediate clamping element to which pressure is applied by the shank of the screw.

NOTE 2 Examples of pillar terminals are shown in Figure IC.1 of Annex IC.

3.6.4

screw terminal

screw-type terminal in which the conductor is clamped under the head of the screw. The clamping pressure may be applied directly by the head of the screw or through an intermediate part, such as a washer, a clamping plate or an anti-spread device

NOTE Examples of screw terminals are shown in Figure IC.2a of Annex IC.

3.6.5

stud terminal

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

NOTE 1 The clamping pressure may be applied directly by a suitably shaped nut or through an intermediate part, such as a washer, a clamping plate or an anti-spread device.

NOTE 2 Examples of stud terminals are shown in Figure IC.2b.

3.6.6

saddle terminal

screw-type terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts

NOTE Examples of saddle terminals are shown in Figure IC.3.

3.6.7

lug terminal

screw terminal or a stud terminal, designed for clamping a cable lug or a bar by means of a screw or nut

NOTE Examples of lug terminals are shown in Figure IC.4.

3.6.8

screwless terminal

connecting terminal for the connection and subsequent disconnection of one conductor or the dismantable interconnection of two or more conductors capable of being dismantled, the connection being made, directly or indirectly, by means of springs, wedges, eccentrics or cones, etc., without special preparation of the conductor other than removal of insulation

3.6.9

tapping screw

screw manufactured from a material having high resistance to deformation when applied by rotary insertion to a hole in a material having less resistance to deformation than the screw

NOTE The screw is made with a tapered thread, the taper being applied to the core diameter of the thread at the end section of the screw. The thread produced by application of the screw is formed securely only after sufficient revolutions have been made to exceed the number of threads on the tapered section.

3.6.10

thread forming tapping screw

tapping screw having an uninterrupted thread

NOTE 1 It is not a function of this thread to remove material from the hole.

NOTE 2 An example of a thread forming tapping screw is shown in Figure 1.

3.6.11

thread cutting tapping screw

tapping screw having an interrupted thread

NOTE 1 It is a function of this thread to remove material from the hole.

NOTE 2 An example of a thread cutting tapping screw is shown in Figure 2.

3.7 Definitions relating to conditions of operation

3.7.1

operation

transfer of the moving contact(s) from the open position to the closed position or vice versa

NOTE If distinction is necessary, an operation in the electrical sense (e.g. make or break) is referred to as a switching operation and an operation in the mechanical sense (e.g. close or open) is referred to as a mechanical operation.

3.7.2

closing operation

operation by which the RCCB is brought from the open position to the closed position

[IEV 441-16-08:1984]

3.7.3

opening operation

operation by which the RCCB is brought from the closed position to the open position

[IEV 441-16-09:1984]

3.7.4

operating cycle

succession of operations from one position to another and back to the first position through all other positions, if any

[IEV 441-16-02]

3.7.5

sequence of operations

succession of specified operations with specified time intervals

3.8 Definitions relating to tests

3.8.1

type test

test of one or more devices made to a certain design to show that the design meets certain requirements

3.8.2

routine test

test to which each individual device is subjected during and/or after manufacture to ascertain whether it complies with certain criteria

3.9 Definitions relating to insulation coordination

3.9.1

insulation coordination

mutual correlation of insulation characteristics of electrical equipment taking into account the expected micro-environment and the influencing stresses

[IEC 60664-1:2007, definition 3.1]

3.9.2

working voltage

highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

NOTE 1 Transients are disregarded.

NOTE 2 Both open circuit conditions and normal operating conditions are taken into account.

[IEC 60664-1:2007, definition 3.5]

3.9.3

overvoltage

any voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions

[IEC 60664-1:2007, definition 3.7]

3.9.4

impulse withstand voltage

highest peak value of impulse voltage of prescribed form and polarity, which does not cause breakdown of the insulation under specific conditions

[IEC 60664-1:2007, definition 3.8.1]

3.9.5

overvoltage category

numeral defining a transient overvoltage condition

[IEC 60664-1:2007, definition 3.10]

3.9.6

macro-environment

environment of the room or other location, in which the equipment is installed or used

[IEC 60664-1:2007, definition 3.12.1]

3.9.7

micro-environment

immediate environment of the insulation which particularly influences the dimensioning of the creepage distances

[IEC 60664-1:2007, definition 3.12.2]

3.9.8

pollution

any addition of foreign matter, solid, liquid or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation

[IEC 60664-1:2007, definition 3.11]

3.9.9

pollution degree

numeral characterizing the expected pollution of the micro-environment

[IEC 60664-1:2007, definition 3.13]

NOTE The pollution degree to which equipment is exposed may be different from that of the macro-environment where the equipment is located because of protection offered by means such as an enclosure or internal heating to prevent absorption or condensation of moisture.

3.9.10

isolation (isolating function)

function intended to cut off the supply from the whole installation or a discrete section of it by separating it from every source of electrical energy for reasons of safety

[IEC 60947-1:2007, definition 2.1.19, modified]

3.9.11

isolating distance

clearance between open contacts, meeting the safety requirements specified for isolation purposes

[IEV 441-17-35:1984, modified]

3.9.12

clearance (see Annex B)

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

[IEV 441-17-31:1984, modified]

NOTE For the purpose of determining a clearance to accessible parts, the accessible surface of an insulating enclosure should be considered conductive as if it was covered by a metal foil wherever it can be touched by a hand or a standard test finger according to Figure 3.

3.9.13

creepage distance (see Annex B)

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

[IEV 604-03-61:1987, modified]

NOTE For the purpose of determining a creepage distance to accessible parts, the accessible surface of an insulating enclosure should be considered conductive as if it was covered by a metal foil wherever it can be touched by a hand or a standard test finger according to Figure 3.

4 Classification

RCCBs are classified:

4.1 According to the method of operation

NOTE The selection of the various types is made according to the requirements of IEC 60364-5-53.

4.1.1 RCCB functionally independent of line voltage (see 3.3.4)

4.1.2 RCCB functionally dependent on line voltage (see 3.3.5)

4.1.2.1 Opening automatically in case of failure of the line voltage, without or with delay (see 8.12):

- a) Reclosing automatically when the line voltage is restored;
- b) Not reclosing automatically when the line voltage is restored.

4.1.2.2 Not opening automatically in case of failure of the line voltage:

- a) Able to trip in case of a hazardous situation (e.g. due to an earth fault) arising on failure of the line voltage (requirements under consideration);
- b) Not able to trip in case of a hazardous situation (e.g. due to an earth fault) arising on failure of line voltage.

NOTE The selection of the RCCBs of b) is subject to the conditions of 531.2.2.2 of IEC 60364-5-53:2001.

4.2 According to the type of installation

- RCCB for fixed installation and fixed wiring;
- RCCB for mobile installation and corded connection (of the device itself to the supply).

4.3 According to the number of poles and current paths

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

4.4 According to the possibility of adjusting the residual operating current

- RCCB with a single value of rated residual operating current;
- RCCB with multiple settings of residual operating current by fixed steps

4.5 According to resistance to unwanted tripping due to voltage surges

- RCCBs with normal resistance to unwanted tripping (general type as in Table 1, and Table 2 if applicable);
- RCCBs with increased resistance to unwanted tripping (S type as in Table 1, and Table 2 if applicable).

4.6 According to behaviour in presence of d.c. components

- RCCBs of type AC;
- RCCBs of type A.

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

- RCCB without time-delay: type for general use;
- RCCB with time-delay: type S for selectivity.

4.8 According to the protection against external influences

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

4.9 According to the method of mounting

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

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

4.10 According to the method of connection

- ~~– RCCBs the connections of which are not associated with the mechanical mounting;~~
- ~~– RCCBs the connections of which are associated with the mechanical mounting, for example:~~
 - ~~• plug-in type;~~
 - ~~• bolt-on type.~~

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

- ~~– RCCBs, the electrical connections of which are not associated with the mechanical mounting;~~
- ~~– RCCBs, the electrical connections of which are associated with the mechanical mounting.~~

~~NOTE Examples of this type are:~~

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

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

4.11 According to the type of terminals

- ~~– RCCBs with screw-type terminals for external copper conductors;~~
- ~~– RCCBs with screwless type terminals for external copper conductors;~~

~~NOTE 1 The requirements for RCCBs equipped with this type of terminals are given in Annex J.~~

- ~~– RCCBs with flat quick-connect terminals for external copper conductors;~~

~~NOTE 2 The requirements for RCCBs equipped with these types of terminals are given in Annex K.~~

- ~~– RCCBs with screw-type terminals for external aluminium conductors;~~

~~NOTE 3 The requirements for RCCBs equipped with this type of terminals are given in Annex L.~~

5 Characteristics of RCCBs

5.1 Summary of characteristics

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

- type of installation (see 4.2);
- number of poles and current paths (see 4.3);
- rated current I_n (see 5.2.2);
- rated residual operating current $I_{\Delta n}$ (see 5.2.3);
- rated residual non-operating current (see 5.2.4);
- rated voltage U_n (see 5.2.1);
- rated frequency (see 5.2.5);
- rated making and breaking capacity I_m (see 5.2.6);
- rated residual making and breaking capacity $I_{\Delta m}$ (see 5.2.7);
- time-delay, if applicable, (see 5.2.8);
- operating characteristics in case of residual currents with d.c. components (see 5.2.9);
- degree of protection (see IEC 60529);
- rated conditional short-circuit current I_{nc} (see 5.4.2);
- rated conditional residual short-circuit current $I_{\Delta c}$ (see 5.4.3);
- method of mounting (see 4.9);
- method of connection (see 4.10).

For RCCBs functionally dependent on line voltage:

- behaviour of the RCCB in case of failure of line voltage (see 4.1.2).

5.2 Rated quantities and other characteristics

5.2.1 Rated voltage (U_n)

5.2.1.1 Rated operational voltage (U_e)

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

NOTE The same RCCB may be assigned a number of rated voltages.

5.2.1.2 Rated insulation voltage (U_i)

The rated insulation voltage of an RCCB is the value of voltage, assigned by the manufacturer, to which dielectric test voltages and creepage distances are referred.

Unless otherwise stated, the rated insulation voltage is the value of the maximum rated voltage of the RCCB. In no case shall the maximum rated voltage exceed the rated insulation voltage.

5.2.1.3 Rated impulse withstand voltage (U_{imp})

The rated impulse withstand voltage of an RCCB shall be equal to or higher than the standard values of rated impulse withstand voltage given in Table 3.

5.2.2 Rated current (I_n)

The value of current, assigned to the RCCB by the manufacturer, which the RCCB can carry in uninterrupted duty.

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

The value of residual operating current (see 3.2.4), assigned to the RCCB 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.

RCCBs with continuously adjustable settings are not allowed.

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

The value of residual non-operating current (see 3.2.5), assigned to the RCCB by the manufacturer, at which the RCCB does not operate under specified conditions.

5.2.5 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 The same RCCB may be assigned a number of rated frequencies.

5.2.6 Rated making and breaking capacity (I_m)

The r.m.s. value of the a.c. component of prospective current (see 3.4.4), assigned by the manufacturer, which an RCCB can make, carry and break under specified conditions.

The conditions are those specified in 9.11.2.2.

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

The r.m.s. value of the a.c. component of residual prospective current (3.2.3 and 3.4.4), assigned by the manufacturer, which an RCCB can make, carry and break under specified conditions.

The conditions are those specified in 9.11.2.3.

5.2.8 RCCB type S

A time-delay RCCB (see 3.3.11) which complies with the relevant part of Table 1, and Table 2 if applicable.

5.2.9 Operating characteristics in case of residual currents with d.c. components

5.2.9.1 RCCB type AC

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

5.2.9.2 RCCB type A

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

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage (U_n)

Preferred values of rated voltage are as follows:

RCCBs	Circuit supplying the RCCB	Rated voltage of RCCBs for use in systems 230 V or 230/400 V or 400 V V	Rated voltage of RCCBs for use in systems 120/240 V or 240 V V
Single pole (with two current paths)	Single-phase (phase to earthed middle conductor or phase to neutral)	230	120
Two-pole	Single phase (phase to neutral or phase to phase or phase to earthed middle conductor)	230	120
	Single phase (phase to phase)	400	240
	Single phase (phase to phase, 3-wire)		120/240
	Three phase (4-wire) (230/400 V-system phase to neutral or 230 V-system phase to phase)	230	
Three-pole (with three or four current path)	Three phase (3-wire or 4-wire) (400 V or 230/400 V or 240 V-system)	400	240
Four-pole	Three phase (4-wire) (230/400 V-system)	400	
NOTE 1 In IEC 60038 the network voltage value of 230/400 V has been standardized. This value should progressively supersede the values of 220/380V and 240/415 V. NOTE 2 Wherever in this standard there is a reference to 230 V or 400 V, they may be read as 220 V or 240 V, 380 V or 415 V, respectively. NOTE 3 Wherever in this standard there is a reference to 120 V or 120/240 V or 240 V, they may be read as 100 V or 100/200 V or 200 V, respectively. NOTE 4 Wherever in this standard there is a reference to 240 V three phases, it may be read as 100 V or 120/208V.			

NOTE In Japan, phase to neutral conductor and phase to earthed conductor (grounded conductor) is thought differently because single phase 2-wire system supplied from 2-wire system source do not have a neutral point.

5.3.2 Preferred values of rated current (I_n)

Preferred values of rated current are

10 – 13 – 16 – 20 – 25 – 32 – 40 – 63 – 80 – 100 – 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 – 0,01 – 0,03 – 0,1 – 0,3 – 0,5 A.

NOTE In Korea and Japan, the values of 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 current delay angle α (see 3.1.4).

5.3.5 Standard minimum value of non-operating overcurrent in case of a multiphase balanced load through a multipole RCCB (see 3.4.2.1)

The standard minimum value of the non-operating current in case of a multiphase balanced load through a multipole RCCB is $6 I_n$.

5.3.6 Standard minimum value of the non-operating overcurrent in case of a single-phase load through a three-pole or four-pole RCCB (see 3.4.2.2)

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

5.3.7 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.

5.3.8 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.

The associated power factors are specified in Table 19.

5.3.9 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.

The associated power factors are specified in Table 19.

5.3.10 Standard and preferred values of the rated conditional short-circuit current (I_{nc})**5.3.10.1 Values up to and including 10 000 A**

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

3 000 – 4 500 – 6 000 – 10 000 A.

The associated power factors are specified in Table 19.

NOTE In KR, 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.

5.3.10.2 Values above 10 000 A

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

The associated power factors are specified in Table 19.

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

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

5.3.11.1 Values up to and including 10 000 A

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

$$3\,000 - 4\,500 - 6\,000 - 10\,000\text{ A.}$$

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.

The associated power factors are specified in Table 19.

5.3.11.2 Values above 10 000 A

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

The associated power factors are specified in Table 19.

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

5.3.12 Limit values of break time and non-actuating time for RCCB of type AC and A**5.3.12.1 Limit values of break time and non-actuating time for alternating residual currents (r.m.s. values) for type AC and A**

Limit values of break time and non-actuating time for alternating residual currents (r.m.s. values) for type AC and A RCCB are given in Table 1.

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

$$T = \left(\frac{20}{I}\right)^{143} \text{ for high-resistance faults and } T = 1,25 \left(\frac{10}{V}\right)^{143} \text{ for low resistance faults.}$$

Table 1 – Limit values of break time and non-actuating time for alternating residual currents (r.m.s. values) for type AC and A RCCB

			Limit values of break time and non-actuating time (s) for type AC and A RCCB in event of alternating residual currents (r.m.s. values) equal to						
Type	I_n A	$I_{\Delta n}$ A	$I_{\Delta n}$	$2 I_{\Delta n}$	$5 I_{\Delta n}$	$5 I_{\Delta n}$ or 0,25 A ^a	$5 A - 200 A^b$	500 A	
General	Any	< 0,03	0,3	0,15		0,04	0,04	0,04	Maximum break times
		0,03	0,3	0,15		0,04	0,04	0,04	
		> 0,03	0,3	0,15	0,04		0,04	0,04	
S	≥ 25	> 0,03	0,5	0,2	0,15		0,15	0,15	Minimum ~~non-~~ operating ~~non-~~ actuating times
		> 0,03	0,13	0,06	0,05		0,04	0,04	

^a Value to be decided by the manufacturer for this test.

^b The tests are only made during the verification of the correct operation as mentioned in 9.9.2.4.

5.3.12.2 Maximum values of break time for half-wave residual currents (r.m.s. values) for type A

Maximum values of break time for half-wave pulsating residual currents (r.m.s. values) for type A RCCB are given in Table 2.

Table 2 – Maximum values of break time for half-wave pulsating residual currents (r.m.s. values) for type A RCCB

			Maximum values of break time(s) for type A RCCB in event of half-wave pulsating residual currents (rms values) equal to							
Type	I_n A	$I_{\Delta n}$ A	$1,4 I_{\Delta n}$	$2 I_{\Delta n}$	$2,8 I_{\Delta n}$	$4 I_{\Delta n}$	$7 I_{\Delta n}$	0,35 A	0,5 A	350 A
General	Any	< 0,03		0,3		0,15			0,04	0,04
		0,03	0,3		0,15			0,04		0,04
		> 0,03	0,3		0,15		0,04			0,04
S	≥ 25	> 0,03	0,5		0,2		0,15			0,15

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

Table 3 gives the standard value of rated impulse withstand voltages as a function of the nominal voltage of the installation.

Table 3 – Rated impulse withstand voltage as a function of the nominal voltage of the installation

Rated impulse withstand voltage U_{imp} kV	Nominal voltage of the installation	
	Three-phase systems V	Single-phase system with mid-point earthed V
2,5 ^a		120/240 ^b
4 ^a	230/400	120/240, 240 ^c
NOTE 1 For test voltages to check the insulation, see Table 16.		
NOTE 2 For test voltages to check the isolation distance across open contacts, see Table ~~15~~ 22.		
^a The values 3 kV and 5 kV respectively are used for verifying the isolating distances across open contacts at the altitude of 2 000 m (see Tables 5 and ~~15~~ 22).		
^b For installation practice in Japan.		
^c For installation practice in North American countries.		

5.4 Coordination with short-circuit protective devices (SCPDs)

5.4.1 General

RCCBs shall be protected against short-circuits by means of circuit-breakers or fuses complying with their relevant standards according to the installation rules of IEC 60364.

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 that there is an adequate 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 $I_{\Delta c}$.

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

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

The conditions are those specified in 9.11.2.4 a).

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

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

The conditions are those specified in 9.11.2.4 c).

6 Marking and other product information

Each RCCB shall be marked in a durable manner with all or, for small apparatus, part of the following data:

- a) the manufacturer's name or trade mark;
- b) type designation, catalogue number or serial number;
- c) rated voltage(s);
- d) rated frequency; RCCBs with more than one rated frequency (e.g. 50/60 Hz) shall be marked accordingly;
- e) rated current;
- f) rated residual operating current;
- g) settings of residual operating current for RCCBs with multiple residual operating current settings;
- h) rated making and breaking capacity;
- j) the degree of protection (only if different from IP20);
- k) the position of use ~~(symbol according to IEC 60051)~~, if necessary;
- l) rated residual making and breaking capacity, if different from rated making and breaking capacity;
- m) the symbol  (S in a square) for type S devices;
- n) indication that the RCCB is functionally dependent on line voltage, if applicable (under consideration);
- o) operating means of the test device, by the letter T;
- p) wiring diagram;
- q) operating characteristic in presence of residual currents with d.c. components
 - RCCBs of type AC with the symbol  (IEC 60417-5032-2002-10)
 - RCCBs of type A with the symbol 

The marking shall be on the RCCB itself or on a nameplate or nameplates attached to the RCCB and shall be located so that it is legible when the RCCB is installed.

The suitability for isolation, which is provided by all RCCBs of this standard, may be indicated by the symbol  on the device. When affixed, this marking may be included in a wiring diagram, where it may be combined with symbols of other functions.

NOTE 1 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), 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, it shall comply with it, whichever the method of installation. If the higher degree of protection is obtained only by a specific method of installation and/or with the use of specific accessories (e.g. terminal covers, enclosures, etc.), this shall be specified in the manufacturer's literature.

If, for small devices, the space available does not allow all the above data to be marked, at least the information under e), f), m), o) and q) (only for type A) shall be marked and visible when the device is installed. The information under a), b), c), k), l), p) and q) (only for type AC) may be marked on the side or on the back of the device and be visible only before the device is installed. Alternatively the information under p) may be on the inside of any cover which has to be removed in order to connect the supply wires. Any remaining information not marked shall be given in the manufacturer's catalogues.

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 18 apply.

The manufacturer shall give the reference of one or more suitable SCPDs in his catalogues and in a sheet accompanying each RCCB.

For RCCBs classified according to 4.1.2.1, and opening with delay in case of failure of the line voltage, the manufacturer shall state the range of such delay.

For RCCBs other than those operated by means of push-buttons the open position shall be indicated by the symbol "O" and the closed position by the symbol "⊥" (a short straight line). Additional national symbols for this indication are allowed. Provisionally the use of national indications only is allowed. 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 RED and/or be marked with the symbol "O".

Red shall not be used for any other push-button of the RCCB. If a push-button is used for closing the contact 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 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.

If it is necessary to distinguish between the supply and the load terminals, they shall be clearly marked (e.g. by "line" and "load" placed near the corresponding terminals or by arrows indicating the direction of power flow).

Terminals exclusively intended for the connection of the neutral ~~circuit~~ conductor shall be indicated by the letter N.

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

NOTE 2 The symbol  (IEC 60417-5017), previously recommended, should be progressively superseded by the preferred symbol IEC 60417-5019-2006-08, given above.

The 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.

For universal terminals (for rigid-solid, rigid-stranded and flexible conductors):

- no marking.

For non-universal terminals:

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

The markings should appear on the RCCB or, if the space available is not sufficient, on the smallest package unit or in technical information.

7 Standard conditions for operation in service and for installation

7.1 Standard conditions

RCCBs complying with this standard shall be capable of operating under the standard conditions shown in Table 4.

Table 4 – Standard conditions for operation in service

Influencing quantity	Standard range of application	Reference value	Test tolerances ⁶⁾
Ambient temperature ^{1) 7)}	–5 °C to +40 °C ²⁾	20 °C	±5 °C
Altitude	Not exceeding 2 000 m		
Relative humidity maximum value 40 °C	50 % ³⁾		
External magnetic field	Not exceeding 5 times the earth's magnetic field in any direction	Earth's magnetic field	⁴⁾
Position	As stated by the manufacturer, with a tolerance of 2° in any direction ⁵⁾	As stated by the manufacturer	2° in any direction
Frequency	Reference value ±5 % ⁶⁾	Rated value	±2 %
Sinusoidal wave distortion	Not exceeding 5 %	Zero	5 %
¹⁾ The maximum value of the mean daily temperature is +35 °C. ²⁾ Values outside the range are admissible where more severe climatic conditions prevail, subject to agreement between manufacturer and user. ³⁾ Higher relative humidities are admitted at lower temperature (for example 90 % at 20 °C). ⁴⁾ When an RCCB is installed in proximity of a strong magnetic field, supplementary requirements may be necessary. ⁵⁾ The device shall be fixed without causing deformation liable to impair its functions. ⁶⁾ The tolerances given apply unless otherwise specified in the relevant test. ⁷⁾ Extreme limits of –20 °C and +60 °C are admissible during storage and transportation, and should be taken into account in the design of the device.			

7.2 Conditions of installation

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

7.3 Pollution degree

RCCBs complying with this standard are intended for environment with pollution degree 2, i.e.: normally, only non-conductive pollution occurs; occasionally, however, a temporary conductivity caused by condensation may be expected.

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 General

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.

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

In case of an RCCB having multiple settings of residual operating current the rating refers to the highest setting.

8.1.2 Mechanism

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

The switched neutral pole (see 3.3.15) of four-pole RCCBs shall not close after and shall not open before the other poles (see 3.3.14).

Compliance is checked by inspection and by manual tests, using any appropriate means (e.g.: 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 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 (see 3.3.12) or in the open position (see 3.3.13), even when the operating means is released in an intermediate position.

RCCBs shall provide in the open position (see 3.3.13) 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 1 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.

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

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.

Compliance is checked by inspection and by the tests of 9.11.

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

NOTE 2 Locking of the operating means in the closed position is permitted for particular applications.

Compliance is checked by inspection, taking into account 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.

In the case of RCCBs functionally dependent on line voltage, reclosing automatically (see 4.1.2.1 a)) when the line voltage is restored after failure of line voltage, the operating means shall remain in the ON position following automatic opening of the contacts; when the line voltage is re-established, the contacts shall reclose automatically unless in the meantime the operating means has been placed in the OFF position.

NOTE 3 For this type of RCCB, the operating means cannot be used as a means for indicating the closed and open positions.

When an indicator light is used, this shall be lit when the RCCB is in a closed position and be of a 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.

NOTE 4 Provisionally in certain countries top to bottom closing is allowed.

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

8.1.3 Clearances and creepage distances (see Annex B)

The minimum required clearances and creepage distances are given in Table 5 which is based on the RCCB being designed for operating in an environment with pollution degree 2.

~~Compliance is checked by inspection and/or by measurement and for item 1 by the test of 9.7.7.1.~~

~~The clearances of items 2, 4 and 5 may be reduced provided that the tests according to Table 16 are withstood.~~

~~Compliance is checked, if relevant, with test voltages given in Table 16 with test arrangements of 9.7.2 items b), c), d), e) and 9.20 (without further humidity treatment as described in 9.7.1).~~

~~The insulating materials are classified into material groups on the basis of their comparative tracking index (CTI) according to 2.7.1.1 and 2.7.1.3 of IEC 60664-1:2007.~~

Compliance for item 1 in Table 5 is checked by measurement and by the test of 9.7.7.4.1 and 9.7.7.4.2. The test is carried out with samples not submitted to the humidity treatment described in 9.7.1.

The clearances of items 2 and 4 (except accessible surface after installation, see Note 1) may be reduced provided that the measured clearances are not shorter than the minimum allowed in IEC 60664-1 for homogenous field conditions.

NOTE 1 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.

In this case, after the humidity treatment described in 9.7.1, compliance for items 2, 4 and 5 and arrangements of 9.7.2 items b), c), d) and e) is checked in the following order:

- Tests according to 9.7.2 to 9.7.6 as applicable,
- Test according to 9.7.7.2 is applied with test voltages given in Table 16 with test arrangements of 9.7.2 items b), c), d), e).

If measurement does not show any reduced clearance, test in 9.7.7.2 is not applied.

Compliance for item 3 in Table 5 is checked by measurement.

NOTE 2 All measurements required in 8.1.3 are carried out in Test sequence A on one sample and the tests of 9.7.7.2 are carried out before 9.7.1 on three samples of Test sequence B.

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

The insulating materials are classified into material groups on the basis of their comparative tracking index (CTI) according to 4.8.1 of IEC 60664-1:2007.

NOTE 3 Information on the requirements for design of solid insulation and appropriate testing is provided in IEC 60664-1:2007, 5.3 and 6.1.3.

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

NOTE 5 The dimensioning of clearances and creepage distances for spacings equal to or less than 2 mm for printed wiring board may be optimised under certain conditions in case of use of IEC 60664-5. Only humidity levels HL2 and HL3 are considered.

Table 5 – Minimum clearances and creepage distances

	Minimum clearances mm			Minimum creepage distances ^{e, f} mm											
				Group IIIa ^h (175 V ≤ CTI < 400 V) ^d				Group II (400 V ≤ CTI < 600 V) ^d				Group I (600 V ≤ CTI) ^d			
	Rated voltage V			Working voltage ^e V											
	<i>U</i> _{imp}														
	2,5 kV	4 kV	4 kV												
Description	120/240 120	120/240 240	230/400 230 400	>25 ≤50 ⁱ	120	250	400	>25 ≤50 ⁱ	120	250	400	>25 ≤50 ⁱ	120	250	400
1. Between live parts which are separated when the main contacts are in the open position ^a	2,0	4,0	4,0	1,2	2,0	4,0	4,0	0,9	2,0	4,0	4,0	0,6	2,0	4,0	4,0
2. Between live parts of different polarity ^a	1,5	3,0	3,0	1,2	1,5	3,0	4,0	0,9	1,5	3,0	3,0	0,6	1,5	3,0	3,0
3. Between circuits supplied from different sources, one of which being PELV or SELV ^g	3,0	6,0	8,0		3,0	6,0	8,0		3,0	6,0	8,0		3,0	6,0	8,0
				Rated voltage V											
				120 / 240		230 / 400		120 / 240		230 / 400		120 / 240		230 / 400	
4. Between live parts and - accessible surfaces of operating means - screws or other means for fixing covers which have to be removed when mounting the RCCB - surface on which the RCCB is mounted ^b - screws or other means for fixing the RCCB ^b - metal covers or boxes ^b - other accessible metal parts ^c - metal frames supporting flush-type RCCBs	1,5	3,0	3,0	1,5	4,0	1,5	3,0	1,5	3,0	1,5	3,0	1,5	3,0	1,5	3,0
~~5. Between metal parts of the mechanism and accessible metal parts^c - screws or other means for fixing the RCCB - metal frames supporting flush-type RCCBs~~															

NOTE 1 The values given for 400 V are also valid for 440 V.

NOTE 2 The parts of the neutral path, if any, are considered to be live parts.

~~NOTE 3 Dimensioning rules for solid insulation are under consideration.~~

NOTE 43 Care should be taken to provide adequate clearances and creepage distances between live parts of different polarity of RCCBs, e.g. of the plug-in type mounted close to one another. If the clearance and creepage distances requirements are not fulfilled to all the surfaces adjacent to the RCD, appropriate information will be provided for installation purposes.

Table 5 (continued)

a	For auxiliary and control contacts the values are given in the relevant standard.
b	The values are doubled if clearances and creepage distances between live parts of the device and the metallic screen or the surface on which the RCCB is mounted are not dependent on the design of the RCCB only, so that they can be reduced when the RCCB is mounted in the most unfavourable condition.
c	Including a metal foil in contact with the surfaces of insulating material which are accessible after installation for normal use. The foil is pushed into corners, grooves, etc., by means of a straight unjointed test finger according to 9.6 (see Figure 3).
d	See IEC 60112.
e	Interpolation is allowed in determining creepage distances corresponding to voltage values intermediate to those listed as working voltage. When interpolating, linear interpolation shall be used and values shall be rounded to the same number of digits as the values picked up from the tables. For determination of creepage distances, see Annex B.
f	Creepage distances cannot be less than the associated clearances.
g	To cover all different voltages including ELV in an auxiliary contact.
h	For material group IIIb ($100\text{ V} \leq \text{CTI} < 175\text{ V}$), the values for material group IIIa multiplied by 1,6 apply.
i	For working voltages up to and including 25 V, reference may be made to IEC 60664-1.

8.1.4 Screws, current-carrying parts and connections

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

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

NOTE 1 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.

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

NOTE 2 Screwed connections are considered as checked by the tests of 9.8, 9.11, 9.12, 9.13 and 9.23.

8.1.4.2 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.

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

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

Compliance is checked by inspection.

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

8.1.4.4 ~~Current-carrying parts including parts intended for protective conductors, if any, shall be of~~

~~—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.~~

~~NOTE New requirements and appropriate tests for determining the resistance to corrosion are under consideration. These requirements should permit other materials to be used if suitably coated.~~

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

Examples of suitable materials are given below:

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

In case of using ferrous alloys or suitably coated ferrous alloys, compliance to resistance to corrosion is checked by a test of resistance to rusting (9.25).

The requirements of this subclause do not apply to contacts, magnetic circuits, heater elements, bimetals, shunts, parts of electronic devices or to screws, nuts, washers, clamping plates, similar parts of terminals and parts of the test circuit.

8.1.5 Terminals for external conductors

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

~~In this standard, screw-type terminals for external copper conductors only are considered.~~

~~NOTE Requirements for flat quick-connect terminations, screwless terminals and terminals for the connection of aluminium conductors are under consideration.~~

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

Such arrangements may be either of the plug-in or of the bolt-on type.

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

~~Compliance is checked by inspection and by the tests of 9.5.~~

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 the standard, or by the tests of Annex J, K or L, as relevant for the type of connection.

8.1.5.2 ~~RCCBs shall be provided with terminals which shall allow the connection of copper conductors having nominal cross-sectional areas as shown in Table 6.~~

~~NOTE Examples of possible designs of terminals are given in Annex IC.~~

~~Compliance is checked by inspection, by measurement and by fitting in turn one conductor of the smallest and one of the largest cross-sectional area as specified.~~

Table 6 – Connectable cross-sections of copper conductors for screw-type terminals

Rated current ^a A		Range of nominal cross-section to be clamped ^b mm ²	
Greater than	Up to and including	Rigid (solid or stranded) conductors	Flexible conductors
–	13	1 to 2,5	1 to 2,5
13	16	1 to 4	1 to 4
16	25	1,5 to 6	1,5 to 6
25	32	2,5 to 10	2,5 to 6
32	50	4 to 16	4 to 10
50	80	10 to 25	10 to 16
80	100	16 to 35	16 to 25
100	125	25 to 50	25 to 35

a – A range of RCCBs having the same fundamental design and having the same design and construction of terminals, the terminals are fitted with copper conductors of the smallest cross-section for the minimum rated current and largest cross-section for the maximum rated current, as specified, solid and stranded, as applicable.

b – It is required that, for current ratings up to and including 50 A, terminals be designed to clamp solid conductors as well as rigid stranded conductors. Nevertheless, it is permitted that terminals for conductors having cross-sections from 1 mm² up to 6 mm² be designed to clamp solid conductors only.

NOTE For AWG cross-sections see Annex ID.

RCCBs shall be provided with:

- either terminals which shall allow the connection of copper conductors having nominal cross sectional areas as shown in Table 6;

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

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

Compliance is checked by inspection, by measurement and by fitting, in turn, one conductor of the smallest and one of the largest cross-sectional area as specified.

Table 6 – Connectable cross-sections of copper conductors for screw-type terminals

Rated current ^{a)} A		Range of nominal cross-section to be clamped ^{b)} mm ²	
Greater than	Up to and including	Rigid (solid or stranded ^{c)} conductors	Flexible conductors
–	13	1 to 2,5	1 to 2,5
13	16	1 to 4	1 to 4
16	25	1,5 to 6	1,5 to 6
25	32	2,5 to 10	2,5 to 6
32	50	4 to 16	4 to 10
50	80	10 to 25	10 to 16
80	100	16 to 35	16 to 25
100	125	25 to 50	25 to 35

NOTE Information on AWG is given in Annex ID.

a) A range of RCCBs having the same fundamental design and having the same design and construction of terminals, the terminals are fitted with copper conductors of the smallest cross-section for the minimum rated current and largest cross-section for the maximum rated current, as specified, solid and stranded, as applicable.

b) It is required that, for current ratings up to and including 50 A, terminals be designed to clamp solid conductors as well as rigid stranded conductors. Nevertheless, it is permitted that terminals for conductors having cross-sections from 1 mm² up to 6 mm² be designed to clamp solid conductors only.

c) Rigid stranded conductors shall be used for conductors having cross-sections from 1,5 mm² up to 50 mm² and shall be in compliance with class 2 of IEC 60228, related to stranded conductors for single-core.

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

Compliance is checked by inspection and by the tests of 9.5.

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

Compliance is checked by inspection.

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

8.1.5.5 Terminals shall have adequate mechanical strength.

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

Compliance is checked by inspection and by the tests of 9.4 and 9.5.1.

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 9.5.2.

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

Compliance is checked by inspection and by the tests of 9.4 and 9.5.1.

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

This requirement does not apply to lug terminals.

Compliance is checked by the test of 9.5.3.

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 standard.

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 standard.

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 a tool.

Compliance is checked by manual test.

In general, the designs of terminals of which examples are shown in annex IC 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 tapping screw type.

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.

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

A part is considered to be "accessible" if it can be touched by the standard test finger (see 9.6).

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 conditions of use, shall either be of insulating material, or be lined throughout with insulating material, unless the live parts are within an internal enclosure of insulating material.

Linings shall be fixed in such a way that they are not likely to be lost during installation of the 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.

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 and shall ensure isolation.

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

Compliance is checked by the tests of 9.7 ~~and 9.20~~.

8.4 Temperature-rise

8.4.1 Temperature-rise limits

The temperature rises of the parts of an RCCB specified in Table 7, measured under the conditions specified in 9.8.2, shall not exceed the limiting values stated in that table.

The RCCB shall not suffer damage impairing its functions and its safe use.

Table 7 – Temperature-rise values

Parts ^{a, b}	Temperature rise K
Terminals for external connections ^c	65
External parts liable to be touched during manual operation of the RCCB, including operating means of insulating material and metallic means for coupling insulated operating means of several poles	40
External metallic parts of operating means	25
Other external parts, including that face of the RCCB in direct contact with the mounting surface	60
^a No value is specified for the contacts, since the design of most RCCBs is such that a direct measurement of the temperature of those parts cannot be made without the risk of causing alterations or displacement of parts likely to affect the reproducibility of the tests. The test of reliability (see 9.22) is considered to be sufficient for checking indirectly the behaviour of the contacts with respect to undue temperature-rises in service. ^b No value is specified for parts other than those listed, but no damage shall be caused to adjacent parts of insulating materials, and the operation of the RCCB shall not be impaired. ^c For plug-in type RCCBs the terminals of the base on which they are installed.	

8.4.2 Ambient air temperature

The temperature-rise limits given in Table 7 are applicable only if the ambient air temperature remains between the limits given in Table 4.

8.5 Operating characteristic

The operating characteristic of RCCBs shall comply with the requirements of 9.9.1, ~~and 9.9.21~~, 9.9.3 and 9.9.4 if applicable.

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.

Compliance is checked by the tests of 9.11.

8.8 Resistance to mechanical shock and impact

RCCBs shall have adequate mechanical behaviour so as 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 checked by the other tests of this standard.

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 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 4.4) the lowest setting for which the RCCBs have been designed shall be used. The test device shall comply with the test of 9.16.

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.

8.12 Requirements for RCCBs functionally dependent on line voltage

RCCBs functionally dependent on line voltage shall operate correctly at any value of the line voltage between 0,85 and 1,1 times their rated voltage, for which purpose multipole RCCBs shall have all current paths supplied from the phases and neutral, if any.

Compliance is checked by the test of 9.17 under the supplementary test conditions specified in 9.9.2. According to their classification, RCCBs shall comply with the requirements given in Table 8.