

INTERNATIONAL STANDARD

**Residual current operated circuit-breakers with integral overcurrent protection
for household and similar uses (RCBOs) –
Part 2-2: RCBOs according to classification 4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6**

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Part 2-2: RCBOs according to classification 4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6**

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS
WITH INTEGRAL OVERCURRENT PROTECTION
FOR HOUSEHOLD AND SIMILAR USES (RCBOs) –****Part 2-2: RCBOs according to classification
4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 61009-2-2 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 second edition cancels and replaces the first edition published in 1991. 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) modification of Clause 6 for markings of RCBOs with a functional earth (FE);
- f) specific tests for operating characteristics of RCBO according to classifications 4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6;
- g) specific test conditions for dielectric properties (9.7), temperature-rise (9.8), electrical and mechanical endurance (9.10), short-circuit tests (9.11), verification of trip-free (9.15), behaviour in the event of loss of the supply voltage (9.17), surge current tests (9.19), reliability (9.20), ageing (9.21) and temporary overvoltage TOV (9.24);
- h) additional tests for RCBOs with a terminal connected to the FE: Connecting capacity of FE terminal (9.200); Limitation of standing current in the FE (9.201).

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

Draft	Report on voting
23E/1372/FDIS	23E/1390/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 IEC 61009-1:2024.

Where this document states "addition", "deletion" or "replacement", the corresponding requirement, test specification or explanatory material in IEC 61009-1:2024 is adapted accordingly.

Where this document defines a new subclause, this subclause number starts at 200 (for example an additional definition in this part would read 3.200).

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 61009 series, published under the general title *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)*, 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.

RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS WITH INTEGRAL OVERCURRENT PROTECTION FOR HOUSEHOLD AND SIMILAR USES (RCBOs) –

Part 2-2: RCBOs according to classification 4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6

1 Scope

IEC 61009-1:2024, Clause 1 is applicable except for the first paragraph, which is replaced by the first paragraph below, and the last paragraph, which is replaced by the second paragraph and note below:

This document applies to residual current operated circuit-breakers, with integral overcurrent protection, for household and similar uses (hereafter referred to as RCBOs), classified according to IEC 61009-1:2024, 4.1.2, 4.1.3, 4.1.4, 4.1.5 and 4.1.6. RCBOs according to this document are intended for voltages not exceeding 440 V AC with frequencies of 50 Hz, 60 Hz or 50/60 Hz and currents not exceeding 125 A and rated short-circuit capacities not exceeding 25 000 A for operation at 50 Hz or 60 Hz.

This document applies in conjunction with IEC 61009-1:2024. It specifies requirements, tests and test sequences to verify compliance and is used for certification purposes.

NOTE Devices according to this document are not permitted in: DE.

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 61009-1:2024, *Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) – Part 1: General rules*

IEC 61543:2022, *Residual current-operated protective devices (RCDs) for household and similar use – Electromagnetic compatibility*

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62873-2, in IEC 61009-1 and the following apply.

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

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

3.200

limiting impedance value

R_x

maximum impedance value from the FE to the supply source for which protection is ensured when the RCBO classified in accordance with 4.1.3 is supplied from any one phase only and FE

4 Classification

IEC 61009-1:2024, Clause 4 applies with the following modifications (deletion of 4.1.1):

4.1 According to the supply conditions

4.1.2 RCBO 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 RCBO does not open automatically in the event of loss of supply.

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

4.1.3 RCBO 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.

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.

4.1.4 RCBO 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 RCBO does not open automatically in the case of loss of supply.

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

4.1.5 RCBO 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 .

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

5 Characteristics of RCBOs

IEC 61009-1:2024, Clause 5 applies with the following modifications.

5.1 Summary of characteristics

IEC 61009-1:2024, 5.1 applies with the following addition:

- minimum operating voltage U_x (see 5.2.1.200);
- rated value R_x (see 5.3.200).

5.2 Rated quantities and other characteristics

Add the following subclause:

5.2.1.200 Minimum operating voltage (U_x)

The minimum operating voltage, where applicable, as declared by the manufacturer for RCBOs.

5.3 Standard and preferred values

Add the following subclause:

5.3.200 Rated values for R_x

The standard value for R_x is 2 Ω for:

- single-pole RCBOs with two current paths; or
- three-pole with four current paths; or
- RCBO rated 120 V or 120/240 V

NOTE These devices are intended to be used in TN-systems only.

For other RCBOs the standard R_x value shall be 6 k Ω unless a lower value is declared by the manufacturer.

6 Marking and other product information

IEC 61009-1:2024, Clause 6 applies with the following additions.

6.200 Marking of RCBOs classified according to 4.1.3

This Subclause 6.200 applies to RCBOs classified according to 4.1.3.

RCBOs shall be marked with the rated value R_x in Ω , for values other than those specified in 5.3.200 (e.g. $R_x = 5\,000\,\Omega$).

This information may be marked on the side or on the back of the device and shall be visible only before the device is installed.

The following additional information is required in the manufacturer's instructions:

- This device will provide protection in installations where the earth loop impedance does not exceed the R_x value.

The FE-wire or terminal shall be identified by the marking "FE".

In addition, if a terminal is used, the marking of the maximum rated connecting capability (e.g. "max. 2,5 mm²") shall be visible close to the terminal.

The following colours are not allowed for the FE-wire:

- green, yellow, blue and green-and-yellow.

The manufacturer's instruction shall state that the FE shall be connected directly to the PE and looping in the FE terminal is not allowed.

Compliance is verified by inspection.

6.201 Marking of RCBOs classified according to 4.1.5 and 4.1.6

For RCBOs classified according to 4.1.5 and 4.1.6 and opening with a delay in the event of failure of the line voltage, the manufacturer shall state in its product information the range of such delay.

Compliance is verified by inspection.

7 Standard conditions for operation in service and for installation

IEC 61009-1:2024, Clause 7 applies.

8 Requirements for construction and operation

IEC 61009-1:2024, Clause 8 applies with the following modifications.

8.1.2 Mechanism

IEC 61009-1:2024, 8.1.2 applies with the following addition:

In the case of RCBOs classified according to 4.1.6, 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. For this type of RCBO, the operating means shall not be used as a means for indicating the closed and open positions.

8.1.3 Clearances, creepage distances and solid insulation

IEC 61009-1:2024, 8.1.3.1 applies with the following addition:

For RCBOs classified according to 4.1.3 of IEC 61009-1:2024, Table 20 applies with the following additional requirement:

In the evaluation of the minimum required clearances and creepage distances, the FE is considered as a live part. In the case of RCBOs provided with flying leads, the measurements are carried out with the RCBO installed as in normal use.

8.1.5 Terminals for external conductors

IEC 61009-1:2024, 8.1.5 applies with the following addition for RCBOs classified according to 4.1.3.

8.1.5.200 Additional requirements for FE terminal or FE-wire

This Subclause 8.1.5.200 applies to RCBOs classified according to 4.1.3.

The rated connecting capacity of the FE terminal shall not exceed $2,5 \text{ mm}^2$ and it shall not be possible to connect a wire greater than $2,5 \text{ mm}^2$.

The RCBO FE-wire shall have a cross-section of at least $0,75 \text{ mm}^2$.

Compliance is checked by the tests of 9.200, inspection and measurement.

8.1.5.201 Screwless or flat quick-connect terminal for FE

This Subclause 8.1.5.201 applies to RCBOs classified according to 4.1.3.

It shall not be possible to connect a wire with a cross-sectional area greater than $2,5 \text{ mm}^2$ to an FE terminal.

- If the FE terminal is of a screwless type, it shall be for one conductor only and shall comply with IEC 62873-3-1;
- If the FE terminal is of a flat quick-connect terminations type, it shall be limited to one wire and shall comply with IEC 62873-3-2.

8.12 Requirements for RCBOs in the event of loss of supply

RCBOs shall operate according to their classification in the event of loss of supply (see Table 33).

For RCBOs classified according to 4.1.5 and 4.1.6, U_x shall not be greater than $0,85 U_e$ (or, if relevant, 0,85 times the minimum value of the range of rated voltages).

RCBOs classified according to 4.1.6 shall not reclose automatically after opening due to a residual current.

Compliance is checked by the test of 9.17.

8.17 Resistance to temporary overvoltages (TOV)

IEC 61009-1:2024, 8.17 applies with the following addition:

For RCBOs classified according to 4.1.3, the following additional requirements regarding the resistance to temporary overvoltages (TOV) apply:

Withstand values of alternating overvoltage levels and duration are given in Table 201.

Compliance with the above requirement is checked by the test of 9.24.200.

8.200 Standing current in the FE under normal conditions

This Subclause 8.200 applies to RCBOs classified according to 4.1.3.

The standing current from the FE through the protective conductor shall not exceed 1 mA under normal supply conditions.

Compliance is checked by the test of 9.201.2.

8.201 Standing current in the FE in the case of RCBO supplied from just one phase and FE

This Subclause 8.201 applies to RCBOs classified according to 4.1.3.

When the RCBO is supplied from just one phase and FE as for single phase conditions, the standing current in the FE shall not exceed 2 mA.

Compliance is checked by the test of 9.201.3.

9 Tests

IEC 61009-1:2024, Clause 9 applies with the following modifications.

9.1 General

IEC 61009-1:2024, 9.1 applies with the following addition:

Replace the third paragraph with:

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

9.7 Test of dielectric properties

IEC 61009-1:2024, 9.7 applies with the following modifications.

9.7.2 Insulation resistance of the main circuit

IEC 61009-1:2024, 9.7.2 applies with the following additions:

Add, at the end of 9.7.2 b), the following:

For RCBOs classified according to 4.1.3, for the purpose of this test, the FE is considered as a pole and the electronic circuit between poles and FE shall be disconnected.

For RCBOs classified according to 4.1.5 and 4.1.6 not remaining in the closed position, each pole is bridged by an external connection;

Add, at the end of 9.7.2 c), the following:

For RCBOs classified according to 4.1.3, for the purpose of this test, the FE is connected to all poles.

For RCBOs classified according to 4.1.5 and 4.1.6 not remaining in the closed position, each pole is bridged by an external connection;

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

For RCBOs classified according to 4.1.3, the text of IEC 61009-1:2024, 9.7.6 is replaced by the following:

The test is carried out on the RCBO 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: $600\text{ V }^{+25}_0\text{ V}$
- maximum ripple: 5 %
- short-circuit current: $12\text{ mA }^{+2}_0\text{ mA}$

This test voltage is applied for 1 min, in turn between each pole and the other poles connected together to the frame. For the purpose of this test the FE is considered as part of the frame.

After this treatment, under the conditions of 9.9.1.2.3, the RCBO shall trip with a test current of $I_{\Delta n}$. Only one test is carried out, the break time and shall comply with IEC 61009-1:2024, Table 11.

Moreover, the RCBO shall be capable of performing satisfactorily the tests specified in 9.9.1.5.1 or 9.9.1.5.2 as applicable with only one measurement.

9.7.7.2 Verification of clearances with the impulse withstand voltage

IEC 61009-1:2024, 9.7.7.2 applies with the following additions:

Add, after the fifth paragraph (before list item a)), the following:

For RCBOs classified according to 4.1.5 and 4.1.6, not remaining in the closed position, each pole is bridged by an external connection;

For the tests according to 9.7.7.2 b) the following applies:

For RCBOs classified according to 4.1.3, the test of 9.7.7.2 b) is carried out by applying the impulse voltage between:

- the metal support connected together with the terminal(s) intended for the protective conductor(s), or FE, and
- the phase pole(s) and neutral pole (or path) connected together.

9.8 Test of temperature-rise

IEC 61009-1:2024, 9.8 applies with the following modifications.

9.8.2 Test procedure

IEC 61009-1:2024, 9.8.2 applies with the following addition:

The test is performed at any convenient voltage, the electronic components being supplied at the rated voltage.

Special samples, permitting to supply the electronic components at the rated voltage may be prepared by the manufacturer for this test.

NOTE Figure 22 gives an example of a test circuit for supplying RCBOs including electronic components with rated voltage, but at reduced energy consumption of the complete test arrangement.

9.9 Verification of the operating characteristics

9.9.1 Verification of the operating characteristics under residual current conditions

9.9.1.1 Test circuit and test procedure

The RCBO is installed as for normal use.

The test circuit shall be of negligible inductance. For tests according to 9.9.1.2, the test circuit shall correspond to Figure 28. For tests according to 9.9.1.3, the test circuit shall correspond to Figure 29 or Figure 30, as applicable.

Unless otherwise specified in this document, the tests shall be carried out at $1,1 U_e$.

The FE, if any, is connected to the supply neutral, via the resistor R_x .

The instruments for the measurement of the residual current shall display (or allow to determine) the true RMS value.

Unless otherwise specified in this document, the tests are performed with no load at the ambient air temperature of $20\text{ °C} \pm 5\text{ °C}$.

The RCBO shall perform the tests of 9.9.1.2 and 9.9.1.3, as applicable. Each test is performed by applying the residual current to one pole only, taken at random, with five measurements, unless otherwise specified in this document.

For RCBOs having more than one rated frequency, the tests shall be carried out at the lowest and highest frequency, except for test in 9.9.1.2.5 where verification is performed at only one frequency.

For RCBOs having multiple settings of residual operating current, the tests shall be carried out for each setting.

9.9.1.2 Tests for all RCBOs

9.9.1.2.1 Verification of correct operation in the case of a steady increase of the residual current

The switches S_1 , S_2 , S_3 , S_4 and the RCBO being in the closed position, the residual current is steadily increased, starting from a value not higher than $0,2 I_{\Delta n}$, trying to attain the value of $I_{\Delta n}$ within 30 s. The test shall be performed five times, the tripping current being measured each time.

All five measured values shall be situated between $I_{\Delta no}$ and $I_{\Delta n}$.

For RCBOs where the load and line terminals are not marked, the test shall be performed by connecting the supply on one side of the poles for two samples and then on the other side of the poles for one sample.

9.9.1.2.2 Verification of correct operation on closing on a residual current

The test circuit being calibrated at the value of the rated residual operating current $I_{\Delta n}$ and the switches S_1 , S_2 , S_3 and S_4 being closed, the RCBO is closed to simulate service conditions as closely as possible. The break time is measured five times. No measurement shall exceed the limiting value specified for $I_{\Delta n}$ in IEC 61009-1:2024, Table 11, according to the type of RCBO.

9.9.1.2.3 Verification of correct operation in the case of sudden appearance of residual current

1) All types

The test circuit being successively calibrated at each of the values of residual current specified in IEC 61009-1:2024, Table 11, the switches S_2 , S_3 , S_4 and the RCBO being in the closed position, the test voltage is suddenly established by closing the switch S_1 .

The RCBO shall trip during each test.

Five measurements of the break time are made at each value of residual current.

No value shall exceed the relevant specified limiting value given in IEC 61009-1:2024, Table 11.

2) Additional test for type S

The test circuit being successively calibrated at each of the values of residual current specified in IEC 61009-1:2024, Table 11, the switches S_1 , S_3 , S_4 and the RCBO being in the closed position, the residual current is suddenly established by closing the switch S_2 for periods corresponding to the relevant minimum non-actuating times, with a tolerance of 0 to -5 %.

Each application of residual current shall be separated from the previous one by an interval of at least 1 min.

The RCBO shall not trip during any of the tests.

9.9.1.2.4 Verification of correct operation in the case of sudden appearance of residual currents between $5 I_{\Delta n}$ and 500 A

The test circuit is calibrated successively to the following values of the residual current:

5 A, 10 A, 20 A, 50 A, 100 A and 200 A.

The switches S_1 , S_3 , S_4 and the RCBO being in the closed position, the residual current is suddenly established by closing the switch S_2 .

The RCBO shall trip during each test. The break time shall not exceed the times given in IEC 61009-1:2024, Table 11.

The test is carried out once for each value of residual current on one pole only, taken at random.

9.9.1.2.5 Verification of correct operation with load

The tests of 9.9.1.2.2 and 9.9.1.2.3 are repeated, the pole under test and one other pole of the RCBO being loaded with rated current at rated voltage. For 9.9.1.2.2, the device is open before the test.

For the test of 9.9.1.2.3, the switches S_1 , S_3 , S_4 and the RCBO are in closed position. The residual current is established by closing S_2 .

For this test it is not intended to reach thermal steady-state conditions.

NOTE The loading with rated current is not shown in Figure 28

9.9.1.2.6 Tests at the temperature limits

The RCBO shall perform the tests specified in 9.9.1.2.3 under the following conditions, successively:

- 1) ambient air temperature: $-5\text{ }^{\circ}\text{C}$, off-load, RCBO according to 4.1.2 and 4.1.3 are supplied at $0,85\ U_e$, RCBOs according to 4.1.4 are supplied at $0,7\ U_e$, RCBOs according to 4.1.5 and 4.1.6 are supplied at U_x .
- 2) ambient air temperature: $+40\text{ }^{\circ}\text{C}$, the RCBO having been previously loaded with the rated current, until it attains thermal steady-state conditions. The verification of correct operation at residual currents is performed at $1,1\ U_e$

Preheating may be carried out at any convenient voltage at either 50 Hz or 60 Hz but auxiliary circuits and the electronic circuitry shall be connected to their normal operating voltage.

In practice, these conditions are reached when the variation of temperature-rise does not exceed 1 K per hour.

For the tripping tests in 2), the flow of rated current may be interrupted, provided that the total interruption period does not exceed 30 s. As soon as the sum of interruption periods exceeds 30 s, the RCBO shall be loaded again with rated current for 5 min before next tripping time measurement.

9.9.1.3 Additional verification of correct operation for RCBOs of type A

9.9.1.3.1 Verification of correct operation in the case of a continuous rise of residual pulsating direct current

The test shall be performed according to Figure 29.

The switches S_1 , S_2 , S_4 and the RCBO shall be closed. The relevant thyristor shall be controlled in such a manner that current delay angles α of 0° , 90° and 135° are obtained. Each pole of the RCBO shall be tested twice at each of the current delay angles, in position I as well as in position II of the switch S_3 .

For each test, the current shall be steadily increased at an approximate rate of $1,4\ I_{\Delta n} / 30$ amperes per second for RCBOs with $I_{\Delta n} > 0,01\text{ A}$, and at an approximate rate of $2\ I_{\Delta n} / 30$ amperes per second for RCBOs with $I_{\Delta n} \leq 0,01\text{ A}$, starting from zero. The tripping current shall be in accordance with IEC 61009-1:2024, Table 14.

9.9.1.3.2 Verification of correct operation in the case of suddenly appearing residual pulsating direct currents

The RCBO shall be tested according to Figure 29.

The circuit being successively calibrated at the values specified hereafter and the switches S_1 , S_4 and the RCBO being in the closed position, the residual current is suddenly established by closing the switch S_2 .

The test is carried out at each value of residual current specified in IEC 61009-1:2024, Table 12, according to the type of RCBO.

Two measurements of the break time are made at each value of residual current, at a current delay angle $\alpha = 0^\circ$ with the switch S_3 in position I for the first measurement and in position II for the second measurement.

No value shall exceed the specified limiting values.

9.9.1.3.3 Verification of correct operation with load

The tests of 9.9.1.3.1 are repeated, the pole under test and one other pole of the RCBO being loaded with the rated current, at the rated voltage.

For this test it is not intended to reach thermal steady-state conditions.

NOTE The loading with rated current is not shown in Figure 29.

9.9.1.3.4 Verification of correct operation in case of residual pulsating direct currents superimposed by a smooth direct current of 0,006 A

The RCBO shall be tested according to Figure 30 with a half-wave rectified residual current (current delay angle $\alpha = 0^\circ$) superimposed by a smooth direct current of 0,006 A of same polarity.

Each pole of the RCBO is tested in turn, twice at each of positions I and II.

For each test, the current shall be steadily increased at an approximate rate of $1,4 I_{\Delta n} / 30$ amperes per second for RCBOs with $I_{\Delta n} > 0,01$ A, and at an approximate rate of $2 I_{\Delta n} / 30$ amperes per second for RCBOs with $I_{\Delta n} \leq 0,01$ A, starting from zero. The tripping current shall be in accordance with the upper limit of IEC 61009-1:2024, Table 14.

9.9.1.4 Additional tests at minimum voltage

For all types of RCBOs the tests of 9.9.1.2.1, 9.9.1.2.2 and additionally, for type A RCBOs the tests of 9.9.1.3.1 and 9.9.1.3.2 (at $1,4 I_{\Delta n}$ or $2 I_{\Delta n}$ as relevant), are repeated in the following conditions:

- for RCBOs according to 4.1.2 and 4.1.3, at 85 V connected to any two current paths chosen at random, one of the current paths being the neutral, if available;
- for RCBOs according to 4.1.4, at $0,7 U_e$ connected to any two current paths chosen at random;
- for RCBOs according to 4.1.5 and 4.1.6, at U_x connected to any current paths chosen at random, one of the current paths being the neutral, if available.

9.9.1.5 Verification of the correct operation of RCBOs classified according to 4.1.3

9.9.1.5.1 Verification for RCBO classified according to 4.1.3.1 when supplied between one phase and FE

The test is performed under the test conditions of 9.9.1.2.3. Figure 28 applies, but one supply phase is connected to a pole, taken at random, not being the neutral pole, the FE is connected to the supply neutral through a resistor R_x . The test voltage shall be equal to $0,85 U_e$.

The test circuit being successively calibrated at $I_{\Delta n}$ and 5 times $I_{\Delta n}$, the switch S_2 and the RCBO being in the closed position, switch S_4 being open, the test voltage is suddenly established by closing the switch S_1 .

The RCBO shall trip during each test.

Five measurements of the break time are made at each value of residual current. No value shall exceed the relevant specified limiting value given in IEC 61009-1:2024, Table 11.

9.9.1.5.2 Verification for RCBO classified according to 4.1.3.2 when supplied between one phase and FE

The RCBO is installed according to Figure 28 and supplied with a test voltage equal to $0,85 U_e$. The FE is connected to the supply neutral through the resistor R_X .

The switch S_4 in the neutral conductor is opened and the RCBO shall trip.

The time interval between the switching-off of S_4 and the opening of the main contacts is measured.

Five measurements are made and the maximum value shall not exceed 3 s.

At the end of the last operation, S_4 remains open, the operating means of the RCBO is moved to the closed position and the RCBO shall not reclose or shall open automatically within 3 s.

9.9.1.5.3 Verification of the behaviour of the RCBO in the case of first fault in IT system

The tests of this Subclause 9.9.1.5.3 are not applicable for single-pole RCBOs with two current paths or for three-pole RCBOs with four current paths.

A supply voltage of 400 V is applied between one phase terminal chosen at random and the FE terminal of the RCBO for 1 h. The source of the test voltage shall be capable of supplying a short-circuit current of at least 0,2 A.

During the test the RCBO may trip.

After this test the RCBO shall be tested according to 9.9.1.2.3.

9.10 Verification of mechanical and electrical endurance

IEC 61009-1:2024, 9.10 applies with the following modifications.

9.10.2 Test procedure

IEC 61009-1:2024, 9.10.2 applies with the following addition:

For RCBOs classified according to 4.1.3.1, the last 250 operating cycles of the sequence passing through one pole a residual operating current of $I_{\Delta n}$ are carried out with the neutral disconnected.

For RCBO classified according to 4.1.5 and 4.1.6, the following additional test is carried out:

- 1 000 operating cycles without load by switching off the supply voltage.

After each opening operation the voltage is restored.

RCBO classified according to 4.1.5 are reclosed by using the manual operating means.

RCBO classified according to 4.1.6 shall reclose automatically.

9.11 Short-circuit tests

IEC 61009-1:2024, 9.11 applies with the following modifications.

9.11.1 General conditions for test

IEC 61009-1:2024, 9.11.1 applies by adding, just before the last dashed list, the following:

In the case of RCBOs according to 4.1.3, Figure 33 and Figure 34 respectively give diagrams of the circuits to be used for the tests.

In the case of RCBOs according to 4.1.5 and 4.1.6, in order to permit the breaking operations to be made, it is necessary either to position the device T making the short-circuit on the load side of the RCBO or to insert an additional short-circuit making device in that position.

9.11.11 Test procedure

9.11.11.2.2 Short-circuit test on RCBOs for verifying their suitability for use in IT systems

IEC 61009-1:2024, 9.11.11.2.2 is applicable and in addition the following applies for classification 4.1.3.1:

An additional test according to 9.11.11.2.2 is carried out on three new samples with the supply neutral not connected to the RCBO.

9.11.13.2 Verification of the RCBO after residual current making and breaking test

Add, after the last paragraph, the following:

In addition, RCBOs shall be capable of satisfying the test of 9.17, as applicable.

9.15 Verification of the trip-free mechanism

9.15.1 General test conditions

The RCBO is mounted and wired as in normal use and supplied under the conditions of 9.9.1.1. It is tested in a substantially non-inductive circuit, the diagram of which is shown in Figure 28.

For RCBOs having multiple settings, the test is carried out for each setting.

If the RCBO is fitted with more than one operating means, the trip-free operation is verified for all operating means.

9.15.2 Test procedure

A residual current equal to $1,5 I_{\Delta n}$ is passed by closing the switch S_2 , the RCBO, S_1 , S_3 and S_4 having been closed and the operating means being held in the closed position. The RCBO shall trip.

This test is then repeated by moving the operating means of the RCBO slowly over a period of approximately 1 s to a position where the current starts to flow. Tripping shall occur without further movement of the operating means.

Both tests are carried out three times, at least once on each pole intended to be connected to a phase.

9.15.3 Additional test procedure for RCBOs according to 4.1.5 and 4.1.6

The switch S_1 is opened, the operating means being held in the closed position. The RCBO shall trip. The test is repeated three times.

9.17 Verification of the behaviour of RCBOs in the event of loss of the supply voltage

9.17.1 Verification of the behaviour of RCBOs classified under 4.1.5 and 4.1.6

9.17.1.1 Verification of correct operation at the minimum operating voltage (U_x)

A voltage equal to U_e is applied to any two current paths of the RCBO chosen at random and the voltage is gradually reduced to U_x and is then progressively lowered at a rate of approximately 5 V/s until automatic opening occurs.

The opening voltage is measured.

Five measurements are made on each sample.

None of the opening voltage values measured shall exceed U_x .

U_x shall not exceed 0,85 times the rated voltage or 0,85 times the minimum value of the range of rated voltages.

Following these measurements, the voltage is set to U_e and then reduced to a value 5 % above the maximum measured opening voltage. Under this condition it shall be verified that the RCBO operates in accordance with IEC 61009-1:2024, Table 11 at $I_{\Delta n}$.

If all measured opening voltages are below 85 V, this test is applied at a value of 85 V.

NOTE In China, the value of 50 V is required (for RCBOs with $I_{\Delta n} \leq 30$ mA) instead of 85 V

9.17.1.2 Verification of the automatic opening in the event of loss of the supply voltage

The RCBO is supplied on the line side with the rated voltage (or, if relevant, with a voltage having a value within its range of rated voltages) and is closed.

The supply voltage is then switched OFF.

The time interval between the switching OFF and the opening of the main contacts is measured.

Five measurements are made:

- for RCBOs opening without delay: no value shall exceed 0,5 s;
- for RCBOs opening with delay: the maximum and the minimum values shall be situated within the range indicated by the manufacturer.

In any case, the delay for opening the RCBO shall be less than 3 h.

9.17.1.3 Verification of the correct operation, in the presence of a residual current, for RCBOs opening with delay in the event of loss of the supply voltage

The RCBO is connected according to Figure 28 and is supplied on the line side with the rated voltage (or, if relevant, with any voltage having a value within its range of rated voltages).

All phases but one are then switched OFF by means of switch S_3 . S_4 is open. FE connection is not relevant for RCBOs classified according to 4.1.5 and 4.1.6.

During the opening delay indicated by the manufacturer, the RCBO is submitted to the tests of 9.9.1.2.3 but only with $I_{\Delta n}$ and $5 I_{\Delta n}$, the closing and subsequent opening of switch S_3 being required before each measurement. In the case of delay times longer than 1 min, the test is performed after approximately 90 % of the measured minimum delay time.

9.17.1.4 Verification of the reclosing function of automatically reclosing RCBOs classified according to 4.1.6

The RCBO is in open position due to automatic opening. A slowly rising supply voltage is applied so as to obtain the rated voltage or, in the case of a range of rated voltages, the lowest rated voltage starting from zero within 30 s. The RCBO shall re-close before the voltage reaches 0,85 times the rated voltage. The increase of the voltage shall be stopped at the moment of automatic reclosing of the RCBO.

At that voltage or 85 V, whichever is the higher, it shall be verified that the RCBO operates in accordance with IEC 61009-1:2024, Table 11 at $I_{\Delta n}$. The supply voltage is removed and then re-applied after 30 s and the RCBO shall not reclose automatically.

NOTE In China, the value of 50 V is required (for RCBOs with $I_{\Delta n} \leq 30$ mA) instead of 85 V

9.17.2 Verification of not opening in the event of loss of the supply voltage (RCBO classified according 4.1.2, 4.1.3 and 4.1.4)

The RCBO is supplied on the line side with the rated voltage (or, if relevant, with a voltage having a value within its range of rated voltages) and is closed.

The supply voltage is then switched OFF.

The RCBO shall not open within an observation time of 6 h.

9.18 Void

9.19 Verification of the behaviour of RCBOs in the event of current surges caused by impulse voltages

9.19.1 Current surge test for all RCBOs (0,5 μ s / 100 kHz ring wave test)

IEC 61009-1:2024, 9.19.1 applies with the following addition:

The RCBO is supplied at rated voltage.

9.19.2 Verification of the behaviour at surge currents up to 3 000 A (8/20 μ s surge current test)

9.19.2.1 Test conditions

IEC 61009-1:2024, 9.19.2.1 applies with the following addition:

The RCBO is supplied at rated voltage.

9.20 Verification of reliability

9.20.1.3 Test procedure

IEC 61009-1:2024, 9.20.1.3 applies with the following addition after b) 1):

- i) RCBOs classified according to 4.1.2, 4.1.3 and 4.1.4 shall be in the closed position and not supplied.
- ii) RCBOs classified according to 4.1.5 and 4.1.6 shall be supplied at rated voltage and in the closed position.

9.20.2 Test with temperature of 40 °C

IEC 61009-1:2024, 9.20.2 applies with the following addition:

The test is performed at any convenient voltage, the electronic components being supplied at the rated voltage. Special samples, permitting to supply the electronic components at the rated voltage may be prepared by the manufacturer for this test.

9.21 Verification of withstand against ageing

IEC 61009-1:2024, 9.21 applies with the following addition:

The test is performed at any convenient voltage, the electronic components being supplied at 1,1 times the rated voltage. Special samples, permitting to supply the electronic components may be prepared by the manufacturer for this test.

NOTE An example of the test circuit for this verification is given in Figure 22.

In the case of RCBOs classified according to 4.1.3, the following additional tests apply:

The RCBOs are supplied at 1,1 times the rated voltage and the supply neutral is then disconnected.

RCBOs classified according to 4.1.3.1 are reclosed. Under the conditions of 9.9.1.2.3, the RCBO shall trip with a test current equal to $1,25 I_{\Delta n}$. Only one test is carried out without measurement of the break time.

RCBOs classified according to 4.1.3.2 are reclosed and shall trip automatically.

9.22 Electromagnetic compatibility (EMC)

RCBOs shall be tested according to the test sequences H, I and J listed in Annex A.

9.24 Verification of the behaviour of the RCBO under temporary overvoltage (TOV) condition

IEC 61009-1:2024, 9.24 applies with the following addition:

9.24.200 Additional tests for RCBOs with a terminal intended to be connected to the FE

The tests of IEC 61009-1:2024, 9.24.3 apply with the additional voltage U_{TOV} applied between the neutral and the FE-wire or terminal.

The tests of this Subclause 9.24.200 are not applicable for single-pole RCBOs with two current paths and for three-pole RCBOs with four current paths.

After the test, samples shall be verified according to IEC 61009-1:2024, 9.24.4.

9.200 Test of the maximum connecting capacity of FE terminal

9.200.1 Test procedure

The test shall be carried out using the appropriate gauge form A or form B specified in Table 200.

Terminals are tested using gauges number 1 and 2.

The measuring section of the gauges shall not be able to be inserted into the terminal.

9.200.2 Construction of gauges

The construction of the gauges is shown in Figure 26.

Details of dimensions a and b and their permissible deviations are shown in Table 200.

The measuring section of the gauge shall be made from gauge steel.

9.201 Verification of the limitation of the standing current in the FE

9.201.1 Test circuit

The RCBO is installed as for normal use.

The test circuit shall correspond to Figure 31.

The instruments for the measurement of the voltage across R_e shall show (or permit to determine) the true RMS value.

The FE current can be measured by alternative means provided that the R_e value is not exceeded.

The supply voltage during the test shall be $1,1 U_e$.

9.201.2 Verification of the standing current in the FE under normal conditions

The switch S_1 in the neutral conductor is closed.

The voltage across R_e is measured. The value shall not exceed 1 mV.

9.201.3 Verification of the standing current in the FE when the RCBO is supplied from just one phase chosen at random and FE

The switch S_1 in the neutral conductor is opened and the RCBO may trip.

The voltage across R_e is measured after 1 s, and the measured value shall not exceed 2 mV.

The test circuit is shown in Figure 31.

Table 33 – Requirements for RCBOs classified according to 4.1.2 to 4.1.6

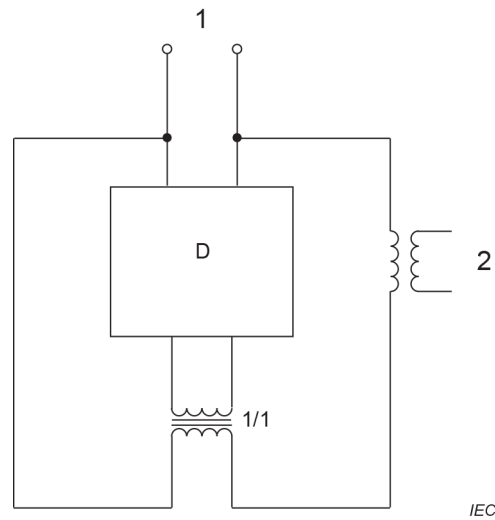
Classification of the device according to 4.1.2 to 4.1.6		Behaviour in the event of loss of the line voltage
RCBOs opening automatically in the event of loss of the line voltage (4.1.5 and 4.1.6)	Without delay	Opening without delay, according to the conditions stated in 9.17.1.2 a)
	With delay	Opening with delay, according to 9.17.1.2 b). Correct operation during the delay shall be verified according to 9.17.1.3
RCBOs which do not open automatically in the event of loss of the line voltage (4.1.2, 4.1.3, 4.1.4)		No opening

Table 200 – Gauges for the verification of the rated connecting capacity of the FE terminal

Gauge					
Form A			Form B		Permissible deviation for a and b
Gauge number	Diameter a mm	Width b mm	Gauge number	Diameter a mm	
1	3,6	3,1	2	3,0	0 -0,06

Table 201 – Additional withstand values and duration of temporary overvoltages for RCBOs classified according to 4.1.3

TOV		
Occurrence	Voltage	Duration
Between FE and all poles including neutral, if any ^a	$1\,200\text{ V} + U_0$	5 s
Between FE and all poles including neutral, if any ^a	$250\text{ V} + U_0$	1 h
^a Not applicable for single-pole RCBOs with two current paths and three-pole RCBOs with four current paths.		



Key

D Device under test

1 Supply at 1,1 U_e

2 Current supply

Figure 22 – Example for test circuit for verification of ageing of electronic components

Dimensions in millimetres

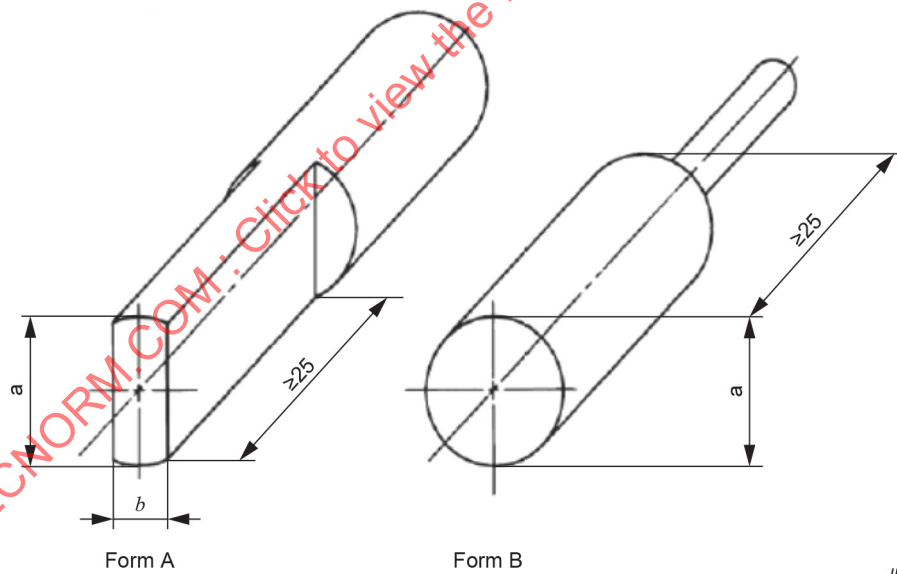
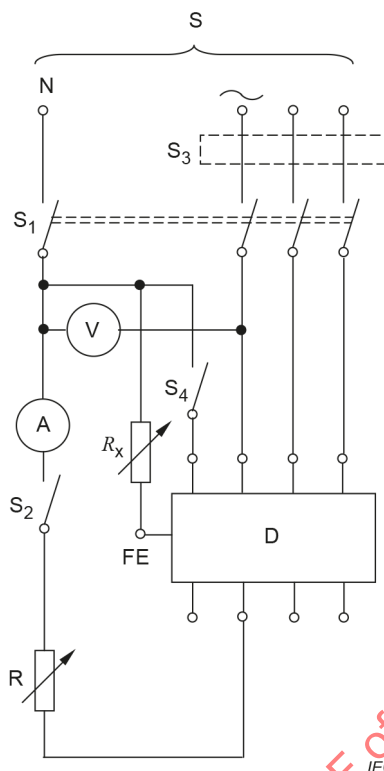


Figure 26 – Gauges of Form A and Form B

**Key**

N Neutral conductor

S Supply

V Voltmeter

A Ammeter

 S_1 All pole switch S_2 Single-pole switch S_3 Switch operating all phases but one S_4 Single-pole switch

D RCBO under test

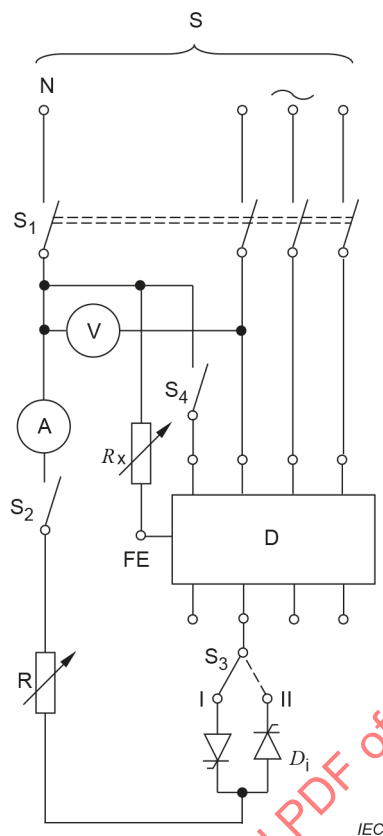
R Variable resistor

 R_x Limiting resistor, where applicable

FE Functional earth, where applicable

NOTE S_3 remains closed unless otherwise specified

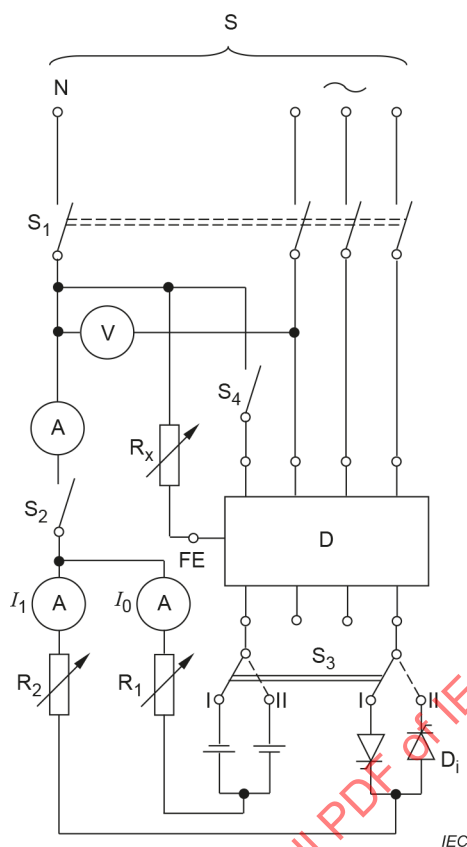
Figure 28 – Test circuit for the verification of operating characteristics and trip-free mechanism for RCBO classified according to 4.1.2 to 4.1.6



Key

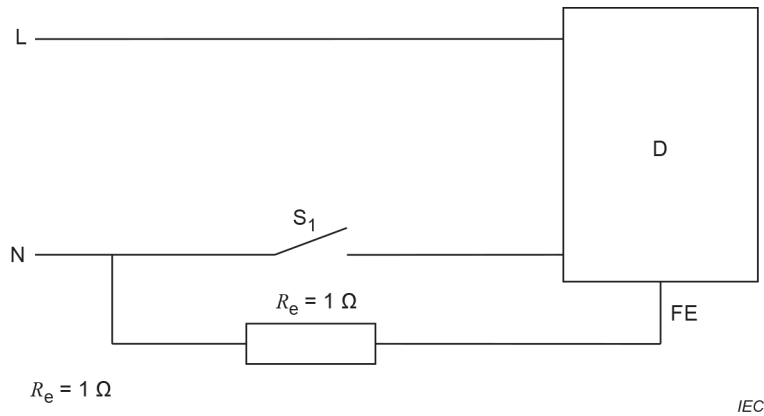
- N Neutral conductor
- S Supply
- V Voltmeter
- A Ammeter (measuring RMS values)
- D RCBO under test
- D_i Thyristors
- R Variable resistor
- S_1 Multipole switch
- S_2 Single-pole switch
- S_3 Two-way switch
- S_4 Single-pole switch
- R_x Limiting resistor, where applicable
- FE Functional earth, where applicable

Figure 29 – Test circuit for the verification of the correct operation in the event of residual pulsating direct currents

**Key**

- N Neutral conductor
- S Supply
- V Voltmeter
- A Ammeter (measuring RMS values)
- D RCBO under test
- D_i Thyristors
- R_1 Variable resistor
- R_2 Variable resistor
- S_1 Multipole switch
- S_2 Single-pole switch
- S_3 Two-way switch
- S_4 Single-pole switch
- R_x Limiting resistor, where applicable
- FE Functional earth, where applicable

Figure 30 – Test circuit for the verification of the correct operation in the event of residual pulsating direct currents in the presence of a standing smooth direct current of 0,006 A



Key

- D Device under test
- R_e Resistor ($\pm 1\%$)
- S_1 Switch
- FE Functional earth
- N Neutral conductor
- L Line conductor

Figure 31 – Test circuit for verification of the standing current in the FE

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Explanation of letter symbols used in Figure 33 and Figure 34:

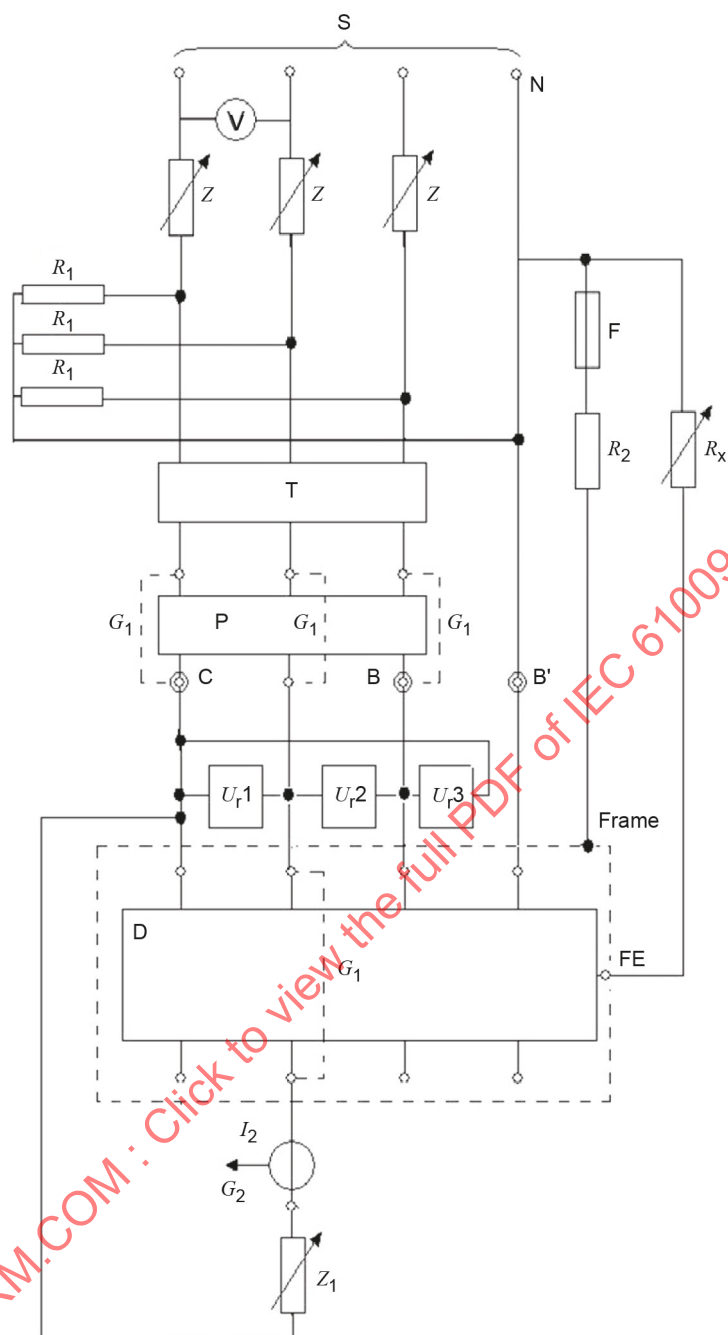
N	=	Neutral conductor
S	=	Supply (either single phase, three-phase or three-phase and neutral depending on the number of current paths of the device under test)
Z	=	Adjustable impedances
Z_1	=	Adjustable impedance to adjust the current below the rated short-circuit current
Z_2	=	Adjustable resistor for the calibration of I_{Δ}
P	=	Short-circuit protective device (SCPD). It may be connected anywhere in the phase circuit upstream of the device under test
D	=	Device under test
frame	=	All conductive parts normally earthed in service
G_1	=	Temporary connection(s) for calibration
G_2	=	Connection(s) for the test with rated conditional short-circuit current
T	=	Device making the short circuit. It may be connected anywhere in the phase circuit.
I_1, I_2, I_3	=	Current sensor(s). They may be placed before or after the device under test "D"
I_4	=	Additional residual current sensor, if needed
Ur_1, Ur_2, Ur_3	=	Voltage sensor(s)
F	=	Device for the detection of a fault current
R_1	=	Resistance drawing a current of approximately 10 A
R_2	=	Resistor limiting the current in the device F
R_X	=	Limiting impedance value (for FE terminals only)
S_1	=	Switch
B and C	=	Points of connections of the grid(s) shown in IEC 61009-1:2024, Annex C

The closing device T can alternatively be situated between the load side terminals of the device under test and current sensors I_1, I_2 and I_3 as applicable.

The voltage sensors Ur_1, Ur_2 and Ur_3 can, alternatively, be connected between phase and neutral.

The adjustable load Z may be located at the high-voltage side of the supply circuit.

According to the agreement of the manufacturer, the three resistances R_1 can be omitted.



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Figure 34 – Typical diagram for short circuit tests according to 9.11.11.1 for RCBOs according to 4.1.3

Annex A (normative)

Test sequence and number of samples to be submitted for certification¹ purposes

A.1 Test sequences

To verify compliance with the requirements of this document, the tests are carried out according to Table A.1 where the tests in each sequence are carried out in the order indicated.

Table A.1 – Test sequences

Test sequence	Clause or subclause ^a	Test (or inspection)
A ₁	6	Marking and other product information
	6.200	Additional marking
	8.1.1	General
	8.1.2	Mechanism
	9.3	Indelibility of marking
	8.1.3	Clearances, creepage distances and solid insulation (external parts only)
	8.1.6	Non-interchangeability
	9.15	Verification of the trip-free mechanism
	9.4	Test of reliability of screws, current-carrying parts and connections
	9.5	Reliability of terminals for external conductors
	9.200	Test of the maximum connecting capacity of FE terminal
	9.6	Protection against electric shock
	9.13	Resistance to heat
	8.1.3	Clearances and creepage distances (internal parts)
	9.23	Resistance to rusting
A ₂	9.24	Verification of the behaviour of the RCBO under temporary overvoltage (TOV) conditions
	9.24.200	Additional tests for RCBOs with a terminal intended to be connected to the FE
	9.14	Resistance to abnormal heat and to fire

¹ The term "certification" denotes either a declaration of conformity by the manufacturer, or a third party certification, e.g., by an independent testing station.

Test sequence		Clause or subclause ^a	Test (or inspection)
B		9.7.7.3	Verification of resistance of the insulation of open contacts against an impulse voltage (suitability for isolation)
		9.7.1	Resistance to humidity
		9.7.2	Insulation resistance of the main circuit
		9.7.3	Dielectric strength of the main circuit
		9.7.4	Insulation resistance and dielectric strength of auxiliary circuits
		9.7.7.2	Verification of clearances with the impulse withstand voltage
		9.7.	Secondary circuit of detection transformers
		9.7.6	Capability of control circuits connected to the main circuits, etc.
		9.8	Temperature-rise
		9.20.2	Reliability at 40 °C
		9.21	Verification of withstand against ageing
C	C ₁	9.201	Verification of the limitation of the standing current in the FE
		9.10	Mechanical and electrical endurance
		9.11.11.2.1	Performance at reduced short-circuit currents (test on all RCBOs)
		9.11.12	Verification of the RCBO after short-circuit test
	C ₂	9.11.11.1	Short-circuit test on RCBOs for verifying their suitability for use in IT systems
		9.11.12	Verification of the RCBO after short-circuit test
D	D ₀	9.9.1	Residual operating characteristics
	D ₁	9.17	Verification of the behaviour of RCBOs in the event of loss of the supply voltage
		9.19	Verification of the behaviour of RCBOs in the event of current surges caused by impulse voltages
		9.11.13	Performance at $I_{\Delta m}$
		9.16	Test device
E	E ₀	9.9.2	Overcurrent operating characteristics
	E ₁	9.12	Resistance to mechanical shock and impact
		9.11.11.3	Short-circuit performance at 1 500 A
		9.11.12	Verification of the RCBO after short-circuit test
F ₀		9.11.11.4 b)	Performance at service short-circuit capacity
		9.11.12	Verification of the RCBO after short-circuit test
F ₁		9.11.11.4 c)	Performance at rated short-circuit capacity
		9.11.12	Verification of the RCBO after short-circuit test
G		9.20.1	Reliability (climatic test)
H		IEC 61543:2022, Clause 4	Electromagnetic emission (if applicable)
		IEC 61543:2022, Table 1, T1	Voltage dips, short interruptions and voltage variations
		IEC 61543:2022, Table 1, T 5a and T 5b	Surges