

INTERNATIONAL STANDARD

GROUP SAFETY PUBLICATION

General safety requirements for residual current operated protective devices

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GROUP SAFETY PUBLICATION

General safety requirements for residual current operated protective devices

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**GENERAL SAFETY REQUIREMENTS FOR RESIDUAL CURRENT
OPERATED PROTECTIVE DEVICES**

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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International Standard IEC 60755 has been prepared by subcommittee 23E: Circuit breakers and similar equipment for household use, of IEC technical committee 23: Electrical accessories.

This first edition cancels and replaces IEC TR 60755 published in 2008 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC TR 60755:

- a) restructuration of the document, as a Group Safety Publication, in compliance with Guide 104;
- b) introduction of classification for type F RCDs;
- c) introduction of Clause 9 for tests of RCDs (operating characteristics, electrical endurance, behaviour in short-circuit conditions, trip-free mechanism, test device, surges, reliability, EMC).

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

FDIS	Report on voting
23E/1035/FDIS	23E/1036/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

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

It has the status of a group safety publication in accordance with IEC Guide 104.

The following differing practices of a less permanent nature exist in the countries indicated below:

- 5.3.3: 0,015 A, 0,05 A and 0,2 A are also considered standard values (Korea and Japan);
- 5.3.12: 1 000 A, 2 000 A, 2 500 A, 7 500 A and 9 000 A are also considered preferred values (Korea and Japan);
- 8.1.1.1: multiple settings are not allowed (Australia, Germany, Denmark, the UK and Switzerland);
- 8.1.2: the colours red and green are not used for contact position indication (US).

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

IEC 60755 has been prepared as a Group Safety Publication by subcommittee 23E in accordance with its Group Safety Function for residual current devices. It is intended for use by technical committees in the preparation of standards for residual current unit, function or devices when it is intended to provide protective measures according to IEC 60364 (all parts).

There are two basic conditions of protection against the risk of electric shock: fault protection (indirect contact) and basic protection (direct contact).

Fault protection implies that the device is used to prevent dangerous voltages persisting on accessible installation metalworks, which are earthed but become live under earth fault conditions.

Under such conditions, the risk arises not from the user making direct contact with a live conductive part, but making contact with earthed metalwork, which itself is in contact with a live conductive part.

The primary or basic function of residual current devices is to provide fault protection. However, where devices have an adequate sensitivity (i.e. units having operating residual currents not exceeding 30 mA), they provide the additional benefit of people (and livestock) protection to a user making direct contact with a live conductive part where other methods of protection failed.

The operating characteristics given in this document are therefore based on requirements, which themselves are based on the information contained in IEC 60479-1 and IEC 60479-2.

Residual current devices having rated residual operating currents not exceeding 300 mA also provide protection against the risk of fire resulting from earth fault currents which can exist for lengthy periods without operating the overcurrent protective device.

GENERAL SAFETY REQUIREMENTS FOR RESIDUAL CURRENT OPERATED PROTECTIVE DEVICES

1 Scope

This document provides general minimum requirements, recommendations and information for the drafting of standards on residual current operated protective devices (hereinafter referred to as residual current devices, "RCDs"). It applies to any device providing residual current protection intended primarily for protection against electric shock hazard.

NOTE 1 Residual current monitors (RCMs) according to IEC 62020, whose purpose is to monitor an electrical installation and not to provide protection, are not covered by this document and cannot be considered similar or equivalent to RCDs.

NOTE 2 RCDs for DC supply system are under consideration.

NOTE 3 For the relationship between this document and the RCD product standards, see Annex D.

This document is primarily intended to be used as a reference for drafting product safety standard for devices identified as "RCD" or "residual current device" either for general use or incorporated or embedded in equipment.

This document is also intended to be used as a reference for defining the design requirements and the applicable testing procedure for an RCD incorporated or embedded in an equipment.

This group safety publication is primarily intended for use by technical Committees in the preparation of standards in accordance with the principles laid down in IEC Guide 104 and ISO/IEC Guide 51. It is not intended for use by manufacturers or certification bodies.

One of the responsibilities of a technical committee is, wherever applicable, to make use of group safety publications in the preparation of its publications. The requirements, test methods or test conditions of this group safety publication will not apply unless specifically referred to or included in the relevant publications.

2 Normative references

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

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

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

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

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

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

IEC 60364-4-41, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

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

IEC 60479 (all parts), *Effects of current on human beings and livestock*

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

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

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity standard for residential, commercial and light-industrial environments*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

IEC 61140, *Protection against electric shock – Common aspects for installation and equipment*

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

IEC 61543:1995/AMD1:2004

IEC 61543:1995/AMD2:2005

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

IEC GUIDE 104, *The preparation of safety publications and the use of basic safety publications and group safety publications*

ISO/IEC Guide 51, *Safety aspects – Guidelines for their inclusion in standards*

CISPR 14-1, *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 terms and definitions given in IEC 62873-2 and the following apply.

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

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

3.1

supplementary protection

measure to further reduce the risk of electric shock without replacing fault and/or additional protection according to IEC 60364-4-41

4 Classification

4.1 According to the method of operation

Classification is given in the relevant product standard.

4.2 According to the type of installation

4.2.1 RCD for fixed installation and fixed wiring

NOTE RCDs according to this classification are designed to be used to provide protection against electric shock according to IEC 60364-4-41.

4.2.2 Portable RCDs with corded connection

NOTE RCDs according to this classification are designed to be used to provide supplementary protection only.

4.3 According to the possibility of adjusting the residual operating current

4.3.1 RCD with a single value of rated residual operating current

4.3.2 RCD with multiple settings of residual operating current by fixed steps

4.3.3 RCD whose rated residual operating current is continuously adjustable

4.4 According to their operating characteristics and behaviour in presence of DC components

4.4.1 RCD of type AC

4.4.2 RCD of type A

4.4.3 RCD of Type F

4.4.4 RCD of Type B

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

4.5.1 RCD without time-delay

4.5.2 RCD with time-delay

4.5.2.1 RCD of type S with time-delay of 0,06 s;

4.5.2.2 RCD with other time-delay.

4.6 According to the protection against external influences

4.6.1 Enclosed-type RCD (not requiring an appropriate enclosure)

4.6.2 Unenclosed-type RCD (for use with an appropriate enclosure)

4.7 According to the method of mounting

4.7.1 Surface-type RCD

4.7.2 Flush-type RCD

4.7.3 Panel board type RCD, also referred to as distribution board type

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

4.8 According to the method of connection

4.8.1 RCD, the electrical connections of which are not associated with the mechanical mounting

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

4.9 According to the type of terminals

4.9.1 RCD with screw-type terminals for external copper conductors

4.9.2 RCD with screwless type terminals for external copper conductors

NOTE The requirements for RCDs equipped with these types of terminals are given in IEC 62873-3-1.

4.9.3 RCD with flat quick-connect terminals for external copper conductors

NOTE The requirements for RCDs equipped with these types of terminals are given in IEC 62873-3-2.

4.9.4 RCD with screw-type terminals for external aluminium conductors

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

4.10 According to the number of poles and current paths

4.10.1 Single-pole RCD with two current paths

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

4.10.2 Two-pole RCD

4.10.3 Two-pole RCD with three current paths

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

4.10.4 Three-pole RCD

4.10.5 Three-pole RCD with four current paths

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

4.10.6 Four-pole RCD

4.11 According to the instantaneous tripping current

This classification applies to RCD with integral overcurrent protection and shall be defined in the relevant product standard.

4.12 According to the I^2t characteristics

This classification applies to RCD with integral overcurrent protection and is defined in the relevant product standard.

4.13 According to overcurrent protection

4.13.1 RCD without integral overcurrent protection

4.13.2 RCD with integral overcurrent protection (comprising overload and short-circuit protection)

4.13.3 RCD with integral overload protection only

4.13.4 RCD with integral short-circuit protection only

4.14 According to the method of construction

4.14.1 RCD completely assembled by the manufacturer as one unit (stand-alone RCD)

4.14.2 RCD comprised of a circuit breaker and an r.c. unit to be assembled on site to create a single unit

4.14.3 Any association of devices, in separate units, acting together in order to accomplish the three main functions of an RCD – detection of a residual current, comparison to a reference value and opening the contacts or poles when the residual current exceeds this reference value

NOTE The current sensing means and/or the processing device can be mounted separately from the current breaking device.

4.15 According to the intended use

4.15.1 RCD intended for general use

NOTE 1 These devices can be incorporated in an equipment provided that the conditions of use comply with the conditions and requirements of the RCD standard (e.g. IEC 61008-1).

NOTE 2 RCDs intended to be used in low voltage switchgear and controlgear assemblies according to IEC 61439 (all parts) or enclosures according to IEC 60670-24 are covered by this classification.

4.15.2 RCD specifically intended to be incorporated in a specific item of equipment

NOTE In this case, the RCD can be removed from the equipment and tested separately.

4.15.3 RCD embedded in an equipment

NOTE In this case, the RCD is part of the equipment and cannot be separated.

4.16 According to the range of ambient air temperature

4.16.1 RCD intended for use between $-5\text{ }^{\circ}\text{C}$ and $+40\text{ }^{\circ}\text{C}$

4.16.2 RCD intended for use between $-25\text{ }^{\circ}\text{C}$ and $+40\text{ }^{\circ}\text{C}$

4.16.3 RCD intended for use in more severe conditions to be defined.

5 Characteristics of residual current devices

5.1 Summary of characteristics

The characteristics of the RCD are given in the relevant RCD standard in accordance with this group safety standard.

In case an RCD is incorporated or embedded in equipment, the characteristics of the equipment are given in the relevant equipment standard, if any.

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

- rated voltages (see 5.2.1);
- rated current I_n (see 5.2.2);
- rated frequency (see 5.2.3);
- rated making and breaking capacity I_m (see 5.2.4);
- rated residual operating current $I_{\Delta n}$ (see 5.2.5);
- rated residual non-operating current $I_{\Delta no}$ (see 5.2.6);
- rated residual making and breaking capacity $I_{\Delta m}$ (see 5.2.7);
- time-delay, if applicable (see 5.3.7.2);
- operating characteristics in case of residual currents with DC components (see 5.2.10);
- rated conditional short-circuit current I_{nc} (see 5.2.8);
- rated conditional residual short-circuit current $I_{\Delta c}$ (see 5.2.9);
- degree of protection (see IEC 60529).

5.2 Rated quantities and other characteristics

5.2.1 Rated voltages

5.2.1.1 Rated operational voltage (U_e)

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

5.2.1.2 Rated insulation voltage (U_i)

The rated insulation voltage of an RCD 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 operational voltage of the RCD. In no case shall the maximum rated operational voltage exceed the rated insulation voltage.

5.2.1.3 Rated impulse withstand voltage (U_{imp})

The rated impulse withstand voltage of an RCD is defined in the relevant product standard taking into account the overvoltage category and the rated operational voltage, according to IEC 60664-1.

5.2.1.4 Minimum operating voltage (U_x)

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

5.2.2 Rated current (I_n)

A current assigned by the manufacturer as the current which the RCD can carry in uninterrupted duty (see IEC 62873-2), at a specified reference ambient air temperature.

5.2.3 Rated frequency

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

NOTE The same RCD can be assigned a number of rated frequencies.

5.2.4 Rated making and breaking capacity (I_m)

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

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

The value of residual operating current (see IEC 62873-2), assigned to the RCD by the manufacturer, at which the RCD shall operate under specified conditions.

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

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

The value of residual non-operating current (see IEC 62873-2), assigned to the RCD by the manufacturer, at which the RCD does not operate under specified conditions.

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

The RMS value of the AC component of residual prospective current (see IEC 62873-2), assigned by the manufacturer, which an RCD can make, carry and break under specified conditions.

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

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

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

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

5.2.10 Operating characteristics in case of residual currents with DC components

5.2.10.1 RCD type AC

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

5.2.10.2 RCD type A

An RCD for which tripping is ensured:

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

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

NOTE 1 According to IEC 61140, pluggable electrical equipment with a rated input ≤ 4 kVA are designed to have protective conductor current with a smooth superimposed DC current component limited to 6 mA.

NOTE 2 Operation in case of alternating current superimposed with smooth DC residual current is assumed to be covered by the test of pulsating DC superimposed with smooth DC residual current.

5.2.10.3 RCD type F

An RCD for which tripping is ensured:

- as for type A;
- for composite residual currents which may result from circuits supplied between phase and neutral or phase and earthed middle conductor; and
- for residual pulsating direct currents superimposed on smooth direct current of 0,01 A.

The above specified residual currents may be suddenly applied or slowly rising.

NOTE Operation in case of alternating current superimposed with smooth DC residual current is assumed to be covered by the test of pulsating DC superimposed with smooth DC residual current.

5.2.10.4 RCD type B

An RCD for which tripping is ensured as for type F and, in addition:

- for residual sinusoidal alternating currents up to 1 000 Hz;
- for residual alternating currents superimposed on a smooth direct current of 0,4 times the rated residual current ($I_{\Delta n}$) or 10 mA whichever is the highest value;
- for residual pulsating direct currents superimposed on a smooth direct current of 0,4 times the rated residual current ($I_{\Delta n}$) or 10 mA, whichever is the highest value;
- for residual direct currents which may result from rectifying circuits, i.e.
 - two-pulse bridge connection line to line for two-, three- and four-pole devices;
 - three-pulse star connection or six-pulse bridge connection for three- and four-pole devices;
- for residual smooth direct currents.

The above specified residual currents may be suddenly applied or slowly increased independently of polarity.

5.3 Standard and preferred values

5.3.1 Values of rated operational voltage (U_o)

The values of rated operational voltage shall be defined in the relevant product standard.

5.3.2 Values of rated current (I_n)

The values of rated current shall be defined in the relevant product standard.

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

Standard values of rated residual operating current are:

0,006 A – 0,01 A – 0,03 A – 0,1 A – 0,3 A – 0,5 A – 1 A – 2 A – 3 A – 5 A – 10 A – 20 A – 30 A

NOTE In Korea and Japan, 0,015 A, 0,05 A and 0,2 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 .

5.3.5 Preferred values of rated frequency

The values of rated frequency shall be defined in the relevant product standard.

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

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

The standard values of rated impulse withstand voltages, as a function of the nominal voltage of the installation, shall be given in the relevant product standard.

5.3.7 Standard values of operating time

5.3.7.1 Standard values of maximum break time for non time-delay type RCDs

Standard values of maximum break time for non time-delay type RCDs are given in Table 4, Table 5, Table 6 and Table 7, as applicable.

5.3.7.2 Standard values of actuating and non-actuating times for time-delay type residual current devices

For time-delay type RCDs, the non-actuating time at $2 I_{\Delta n}$ shall be declared by the manufacturer.

Preferred values of minimum non-actuating time at $2 I_{\Delta n}$:

0,06 s – 0,1 s – 0,2 s – 0,3 s – 0,4 s – 0,5 s – 1 s

Type S RCDs shall have a rated time-delay equal to 0,06 s.

Time-delay type RCDs are permitted only for $I_{\Delta n}$ higher than 0,03 A.

Standard values of actuating and non-actuating times for time-delay type RCDs are given in Table 8, Table 9 and Table 10, as applicable.

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

The standard minimum value of non-operating overcurrent in case of a load through a two-pole or two-current-paths RCD shall be defined in the relevant product standard.

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

The standard minimum value of non-operating overcurrent in case of a single-phase load through a three- or four-pole or four-current-paths RCD shall be defined in the relevant product standard.

NOTE For RCDs with integral overcurrent protection, this minimum value can be lower, depending on the characteristics of the overcurrent protection.

5.3.10 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.

This applies to RCDs without integral short-circuit protection.

The minimum value is reduced to 250 A for PRCDs and SRCDs.

5.3.11 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 preferred values of the rated residual making and breaking capacity are:

500 A – 1 000 A – 1 500 A – 3 000 A – 4 500 A – 6 000 A – 10 000 A – 20 000 A – 50 000 A

The minimum value is reduced to 250 A for PRCDs and SRCDs.

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

The preferred values of the rated conditional short-circuit current for RCDs without integral short-circuit protection are:

1 500 A – 3 000 A – 4 500 A – 6 000 A – 10 000 A – 20 000 A – 50 000 A

NOTE In Korea and Japan, the values of 1 000 A, 2 000 A, 2 500 A, 7 500 A, 9 000 A are also considered preferred values.

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

The preferred values of the rated conditional short-circuit current for RCDs without integral short-circuit protection are:

1 500 A – 3 000 A – 4 500 A – 6 000 A – 10 000 A – 20 000 A – 50 000 A

5.4 Coordination with short-circuit protective devices (SCPDs)

RCDs 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 (all parts).

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

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

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

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

Coordination between RCDs and the SCPD is verified according to the relevant test clauses which are designed to verify that there is an adequate protection of the RCDs against short-circuit currents up to the conditional short-circuit current I_{nc} and up to the conditional residual short-circuit current $I_{\Delta C}$.

6 Marking and other product information

6.1 Information and marking for RCDs according to 4.15.1

The information given in column 2 of Table 2 shall be provided. The position of marking shall be specified in the relevant product standard (e.g. visible after installation, on the product, in the leaflet or manufacturer's catalogue).

In addition, for r.c. units,

- they shall be marked with the maximum rated current of the circuit-breaker with which it can be assembled or associated, and
- information shall be given to indicate on which circuit-breaker the r.c. unit can be assembled or associated.

All relevant information for the correct assembly, if any, installation and use of the product shall be provided.

Compliance is checked by visual inspection and by the tests in the relevant product standard.

For RCDs other than those operated by means of push-button, the open position shall be indicated by the symbol "O" and the closed position by the symbol "|" (a short straight line). Additional national symbols are allowed for this indication. Provisionally, the use of national indications only is allowed. These indications shall be readily visible when the RCD is installed.

For RCDs 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 RCD.

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

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

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

NOTE The symbol $\frac{1}{\equiv}$ (IEC 60417-5017:-2006-08) can be progressively superseded by the preferred symbol IEC 60417-5019:2006-08, given above.

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

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 RCD or, if the space available is not sufficient, on the smallest package unit or in the technical information.

6.2 Information and marking for RCDs according to 4.15.2 and 4.15.3

Information and marking for RCDs according to 4.15.2 and 4.15.3 are given in Table 3.

The equipment incorporating or integrating an RCD classified according to 4.15.2 and 4.15.3 shall be marked with the symbol:



Additionally, a description may be used for example "This product is incorporated with residual current operated protective device".

The equipment manufacturer shall provide adequate instructions and information in a leaflet or data sheet, provided with the equipment, covering at least the following:

- detailed description and explanation about the objective of the declared RCD use;
- reference to the RCD relevant standard, to the type of RCD, trade mark, catalogue number(s) and commercial reference (if any) of the declared RCD;
- instruction for wiring and installation of the equipment integrating the RCD for normal use;
- method for checking operation to verify the correct operation of the RCD and using the test device;
- instruction for correct use of the equipment incorporating an RCD;
- test procedure to test the equipment after maintenance in case of RCDs embedded in equipment according to 4.15.3;
- information that RCDs embedded in equipment are not intended to be used as a means for fault and/or additional protection according to IEC 60364-4-41.

NOTE Usual switchboards according to IEC 60364 (all parts) or IEC 61439 (all parts), integrating RCDs, are not considered as equipment within this document.

7 Conditions for operation in service and for installation

7.1 Preferred ranges of application, reference values of influencing quantities/factors and the associated test tolerances

RCDs complying with this document shall be capable of operating under the standard conditions shown in Table 1.

7.2 Conditions of installation

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

7.3 Pollution degree

RCDs shall be intended for an environment with pollution degree 2 as a minimum, i.e. normally, only non-conductive pollution occurs; occasionally, however, a temporary conductivity caused by condensation may be expected.

The product standard may specify a higher value of pollution degree.

7.4 Additional standard conditions for operation in service and for installation when an RCD is incorporated or embedded in an equipment

If equipment incorporates an RCD according to classification 4.15.2, the standard conditions for operation in service and for installation of the incorporated RCD apply to the equipment.

If the standard conditions of the equipment are more stringent than the standard conditions provided in this document, an assessment shall be fulfilled in order to verify that the RCD can be used safely within the conditions for operation in service of the equipment. This assessment requires a special additional testing procedure (see Clause 9).

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 General

8.1.1.1 Requirements for any type of RCDs

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

RCDs shall cover the three following functions:

- detection of a residual current;
- comparison to a reference value;
- opening of the contacts or poles when the residual current exceeds this reference value.

Any accessory, device or equipment intended for accomplishing only one or two of the above three functions or not completely fulfilling all parts of this document cannot be called an RCD or refer to "RCD" either as an acronym or full text "residual current device". These accessories, devices or equipment cannot be marked RCD either on the product or in the documentation.

The residual current detection and the residual current release may be located in different components, but the consequences of possible disconnection of the components shall be considered.

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

For RCDs which may be accessible to uninstructed persons after installation, changing from one setting to another shall not be possible without a tool, and it shall not be possible to disable or inhibit the RCD function by any means.

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

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.1.1.2 Additional general requirements for RCDs according to 4.15.2 and 4.15.3

The equipment shall not impair the operating characteristics of the declared RCD(s).

Equipment declared with embedded RCD according to 4.15.3 or making reference to the acronym RCD or equivalent shall meet the requirements and testing procedures of an IEC published RCD standard based on this document. Any reference to RCD is forbidden if the requirements from this document have not been applied.

For RCD(s) intended to be incorporated in an equipment according to 4.15.2, the manufacturer of the equipment shall declare which RCD(s) is(are) (or can be) incorporated within the equipment. RCDs shall comply with the relevant IEC product standard. The equipment and the RCD shall fit together readily in the correct manner, and the design shall be such as to prevent an incorrect incorporation.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

The equipment shall be designed so that:

- a) the equipment shall not impair the ability of the RCD to be manually switched OFF;
- b) a fault in or a failure affecting the normal use of the RCD does not result in a non-fulfilment of the basic requirements;
- c) it shall not be possible to energize the circuit on the load side of the RCD by operating the equipment when the RCD is manually switched OFF and connected as in normal use;
- d) it shall not be possible to alter the isolation capability of the RCD, if any, whatever the status of the equipment;
- e) tripping time and tripping current of the RCD shall continue to comply with the requirements of this document; and
- f) for the purpose of switching OFF the RCD, a residual current to earth shall not be used to operate the RCD. This requirement is considered satisfied if:
 - no fault is introduced in the installation that induces the RCD to function as a disconnector by a fault; and
 - the protective conductor of the equipment or installation shall not become live (the touch current and/or the touch voltage shall be limited below the dangerous levels according to IEC 60364 (all parts) and IEC 60479 (all parts)) when the equipment is operated. A standing current in the PE up to the limit of 1 mA is accepted.

RCDs embedded in equipment (see 4.15.3) shall be designed and constructed so that the maintenance of the equipment shall not impair the proper functioning of the RCDs.

The load current introduced by the equipment in the RCD shall not be greater than the current rating of the RCD.

The prospective short-circuit current within the equipment shall not be higher than the rated short-circuit current of the RCD.

The electrical connections between the equipment (if any) and the declared RCD(s) shall form part of the equipment.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.1.1.3 R.c. unit to be assembled on site to a circuit breaker

Requirements for safe assembly and correct function shall be given in the relevant product standard.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.1.2 Mechanism

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

The neutral pole (see IEC 62873-2) of four-pole RCDs shall not close after and shall not open before the other poles (see IEC 62873-2).

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements, using any appropriate means (example: indicator lights, oscilloscope).

RCDs shall have a trip-free mechanism.

It shall be possible to switch the RCD on and off by manual operation.

RCDs shall be so constructed that the moving contacts can come to rest only in the closed position (see IEC 62873-2) or in the open position (see IEC 62873-2), even when the operating means is released in an intermediate position.

RCDs intended to provide fault protection or additional protection shall provide in the open position (see IEC 62873-2) an isolation distance in accordance with the requirements necessary to satisfy the isolating function (see 8.3).

For RCDs with or without overcurrent protection for socket-outlets for household and similar uses, pulling out the plug from the socket-outlet is recognized as providing effective isolation.

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);
- a separate mechanical indicator.

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

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to those requirements.

8.1.3 Clearance and creepage distances

RCDs shall have clearance and creepage distances capable of withstanding the voltage stresses during their anticipated lifetime, taking into account the overvoltage category and the pollution degree of the installation for which their use is intended.

The clearances and creepage distances shall be in accordance with IEC 60664-1.

In particular, the equipment shall not impair the suitability for isolation of the RCD, if any.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.1.4 Screws, current-carrying parts and connections

8.1.4.1 Connections

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

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

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.1.4.2 Screws in engagement with a thread of insulating material

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to those requirements.

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

8.1.4.3 Electrical connections

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

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

8.1.4.4 Current-carrying parts

Current-carrying parts 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.

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.1.5 Terminals for external conductors

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

NOTE For the purpose of defining requirements and tests, IEC 60999 (all parts) can be referred to.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.2 Protection against electric shock

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

A part is considered to be "accessible" if it can be touched by the jointed test finger, according to IEC 60529.

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

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.

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.3 Dielectric properties and isolating capability

RCDs shall have adequate dielectric properties.

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

When drafting product standards, consideration shall be given to the requirements for isolation capability included in IEC 61140 and IEC 60364-4-41.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.4 Temperature rise

The RCD shall not suffer damage impairing its functions and its safe use taking into account the ambient temperature at which it is intended to be used.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.5 Operating characteristics

8.5.1 General

RCDs shall operate according to the requirements of 8.5.2 to 8.5.4, as applicable.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.5.2 Operation in response to the type of residual current

8.5.2.1 Alternating residual current

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

RCDs shall operate in response to a steady increase of alternating residual current of rated frequency within the limits of the non-operating current $I_{\Delta no}$ and the rated residual operating current $I_{\Delta n}$ in accordance with Table 13.

8.5.2.2 Pulsating DC residual current

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

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

NOTE The wave shape of pulsating direct residual currents can be seen in Annex B.

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

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

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

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

RCDs of type F shall operate in response to a steady increase of pulsating direct residual current of rated frequency within specified limits of the non-operating current and the operating current in accordance with Table 14, as applicable, also when a smooth direct current of 10 mA is superimposed.

RCDs of type B shall operate in response to a steady increase of alternating or pulsating direct residual current of rated frequency within specified limits of the non-operating current and the operating current in accordance with Table 13 or Table 14, as applicable, also when a smooth direct current of 0,4 times $I_{\Delta n}$, or 10 mA, whichever is the highest value, is superimposed. For RCDs of type B with rated residual current of 0,006 A, respectively 0,01 A, the value of 3 mA, respectively 5 mA, is used for this test.

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

8.5.2.5 Single phase composite residual current

RCDs of type F and type B shall operate in case of a steadily increased residual current.

Table 15 provides frequency component values for calibration purposes as well as the starting current values. Table 17 provides the limit operating values of the composite residual current.

The test frequency shall have a maximum tolerance of $\pm 2\%$.

To verify the operation of the RCD in the presence of composite currents, the starting composite residual current value given in Table 15 shall be increased at a linear rate. The RCD shall trip within the limits of Table 16.

In any case the ratios of the different frequencies shall be maintained from the initial value up to the operating value.

8.5.2.6 Residual currents having frequencies which differ from the rated frequency

RCDs of type B shall comply with the values given in Table 17, in case of residual current having frequencies which differ from the rated frequency.

8.5.2.7 Smooth DC residual current

RCDs type B shall operate in response to a steady increase of smooth direct residual current within specified limits of the non-operating current and the operating current in accordance with Table 18.

The limits shall be kept independent of the polarity of the smooth direct residual current.

NOTE The wave shape of smooth direct residual currents can be seen in Annex B.

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

8.5.3.1 RCDs without time-delay

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

The operation of RCDs to a suddenly applied residual current shall be in accordance with Table 4, Table 5, Table 6 and Table 7, as applicable, and whatever the polarity, if any.

8.5.3.2 RCDs with time-delay

The operation and non-operation of RCDs to a suddenly applied residual current shall be in accordance with Table 8, Table 9 and Table 10, as applicable, and whatever the polarity, if any.

8.5.4 Additional requirements for RCDs according to 4.15.2 and 4.15.3

The operating characteristics of the RCD incorporated or embedded in an equipment shall not be impaired by the equipment, under specified conditions of residual current, according to the RCD relevant standard.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.6 Mechanical and electrical endurance

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.7 Performance at short-circuit currents

RCDs 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.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.8 Resistance to mechanical shock and impact

RCDs shall have adequate mechanical behaviour so as to withstand the stresses imposed during installation and use.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.9 Resistance to heat

RCDs shall be sufficiently resistant to heat.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.10 Resistance to abnormal heat and to fire

External parts of RCDs 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 document.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.11 Test device

RCDs 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 RCD 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 RCDs supplied at rated voltage or at the highest value of the voltage range shall be defined in the relevant product standards.

It is recommended that for household application and similar uses this value does 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 RCD.

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 RCD 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 except for RCDs providing the possibility of unplugging the protected circuit (e.g. SRCD, PRCD).

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.12 Requirements for RCDs in case of loss of supply

RCDs shall operate according to their classification in case of loss of supply.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.13 Behaviour of RCDs in case of overcurrent in the main circuit

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.14 Behaviour of RCDs in case of current surges caused by impulse voltages

RCDs shall withstand the current surges to earth due to the loading of the capacitances of the installation and the current surges to earth due to flashover in the installation. RCDs of the type S shall additionally show adequate resistance against unwanted tripping in case of current surges to earth due to flashover in the installation.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.15 Void

8.16 Reliability

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.17 Electromagnetic compatibility (EMC)

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

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

8.18 Resistance to temporary overvoltages (TOV)

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

Withstand values of alternating overvoltage levels and duration are given in Table 30, U_0 being the nominal value between line and neutral.

The relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements.

9 Preparation of test clauses for RCD product standards and of test clauses for RCD incorporated or embedded in an equipment

9.1 General

9.1.1 General test conditions

Clause 9 defines the specific rules in order to prepare the test clauses of an RCD product standard, taking into account the requirements of this document.

Clause 9 is not intended to be used as a testing procedure for RCDs, but the tests shall be specified in the relevant RCD standard, according to the requirements of this document.

A testing procedure shall be introduced in the product standard for RCDs. This testing procedure shall ensure that each requirement included in this document is fulfilled by the RCD. Product standards may require additional testing.

The test procedure of the RCD product standard shall specify the following items, as applicable:

- the ambient and electrical test conditions and tolerances, according to the standard conditions for operation in service (see Table 1);
- the supply voltage range for performing the tests;
- the conditions of installation of the RCD (see 7.2) for the tests;
- cross-section, type, length of conductors to be connected to the RCD for the tests;
- tightening torque to be applied to the terminals;
- compliance criteria.

NOTE The information for instrument accuracy limits is available at the following CTL webserver: http://www.iecee.org/ctl/sheet/pdf/CTL%20DSH%20251B%20Beijing%202009_05_15.pdf

The test sequences, number of samples and acceptance criteria shall be given by the relevant product standard.

9.1.2 Additional test conditions for preparation of standards for RCDs according to 4.15.2

Tests shall be performed with the RCD placed in the equipment.

Technical committees shall consider all the tests required by the existing product standards and, in case that it is evident that there is no influence of the equipment on the behaviour of the RCD, to avoid the repetition of these tests.

9.1.3 Additional test conditions for preparation of standards for RCDs according to 4.15.3

Tests shall be performed on the complete equipment.

9.1.4 Tests not specified in this document

The following tests are not specified in this document, but the relevant product standard shall contain a compliance clause by inspection and/or tests according to these requirements:

- terminals for external conductors;
- reliability of screws and current carrying parts;
- protection against electric shocks;
- dielectric properties;
- temperature rise;
- resistance to mechanical shocks;
- resistance to heat;
- resistance to abnormal heat and fire.

9.2 Operating characteristics

9.2.1 General requirements for operating characteristics tests

The test procedure shall define the test circuit for performing operating characteristics tests.

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

The test procedure for the RCD shall include tests based on the requirements of 9.2.2, 9.2.3, 9.2.4, 9.2.5, as applicable. Each test shall be made on one pole only, taken at random, with at least two measurements.

All tests are performed with no load, unless otherwise specified.

For RCDs having more than one rated frequency, the tests shall be carried out at the lowest and highest frequency, except for the test with load, where verification may be performed at only one frequency.

For RCDs with rated frequency different from 50 Hz, 60 Hz or 50/60 Hz, the tests shall be carried out at the rated frequency, taking into consideration the content of IEC 60479 (all parts).

For RCDs having multiple settings of residual operating current, the tests shall be made at the lowest setting, highest setting and at least at one intermediate setting.

9.2.2 Tests of RCDs of type AC

9.2.2.1 General

The test procedure for RCDs of type AC shall contain at least tests according to the requirements of 9.2.2.2, 9.2.2.3, 9.2.2.4, 9.2.2.5, 9.2.2.6, 9.2.2.7 and 9.2.2.8, as applicable. For these subclauses, all tests are performed with residual sinusoidal alternating current.

9.2.2.2 Steady increase of residual current

Correct operation of the RCD shall be tested where the RCD being in the closed position, a 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 tripping current shall be measured. The measured values shall be situated between $I_{\Delta no}$ and $I_{\Delta n}$.

9.2.2.3 Closing on a residual current

Correct operation of the RCD shall be tested where the circuit being calibrated at the rated value of the operating residual current, the RCD being in open position, the RCD is suddenly closed on the circuit. The measurements of the break time shall not exceed the value of Table 4 or Table 8, according to the type of RCD.

9.2.2.4 Sudden appearance of residual current

Correct operation of the RCD shall be tested where the circuit being calibrated at each value of residual current of Table 4 or Table 8 as applicable, the RCD being in closed position, the residual current is suddenly established. The measurements of the break time shall not exceed the value of Table 4 or Table 8, according to the type of RCD.

9.2.2.5 Residual current higher than $5 I_{\Delta n}$

Correct operation of the RCD, according to 9.2.2.4, shall be tested for values of residual current higher than $5 I_{\Delta n}$ and lower than the rated residual making and breaking capacity ($I_{\Delta m}$). The values of residual current for these tests shall be specified in the relevant RCD standard.

9.2.2.6 Tests with load

Correct operation of the RCD shall be tested, according to 9.2.2.3 and 9.2.2.4, the RCD being loaded with the rated current.

9.2.2.7 Tests at the temperature limits

Correct operation of the RCD, according to 9.2.2.4, shall be tested at the minimum ambient temperature, with no load, and successively at the maximum ambient temperature, the RCD being loaded at the rated current.

9.2.2.8 Additional test for delay type RCDs

Correct operation of delay type RCD shall be tested according to Table 8, the RCD being in the closed position, the residual current is suddenly established for periods corresponding to the relevant minimum non-actuating times. The RCD shall not trip during these tests.

9.2.3 Tests of RCDs of type A

9.2.3.1 General

The test procedure for RCDs of type A shall include the tests of 9.2.2 for RCDs of type AC.

In addition, tests according to the requirements of 9.2.3.2, 9.2.3.3, 9.2.3.4 and 9.2.3.5 shall be introduced. For these subclauses, all tests are performed with residual pulsating direct current.

9.2.3.2 Continuous rise of residual pulsating direct current

Correct operation of the RCD shall be tested where the RCD being in closed position, the residual pulsating direct current being controlled by a thyristor with current delay angle as per Table 14, the current shall be steadily increased at an approximate rate of $1,4 I_{\Delta n} / 30$ amperes per second for RCDs with $I_{\Delta n} > 0,01$ A, and at an approximate rate of $2 I_{\Delta n} / 30$ amperes per second for RCDs with $I_{\Delta n} \leq 0,01$ A, starting from zero. The tripping current shall comply with Table 14.

The test shall then be repeated with residual pulsating direct current of opposite polarity.

9.2.3.3 Suddenly appearing residual pulsating direct currents

Correct operation of the RCD shall be tested where the circuit being calibrated at each value of Table 5 or Table 9, the RCD being in the closed position, the residual current is suddenly established, with a current delay angle $\alpha = 0^\circ$. The test shall be made for residual pulsating direct current with positive and with negative polarity. The measurements of the break time shall not exceed the value of Table 5 or of Table 9, according to the type of RCD.

9.2.3.4 Tests with load

Correct operation of the RCD shall be tested, according to 9.2.3.2, the RCD being loaded with the rated current.

9.2.3.5 Tests with residual pulsating direct currents superimposed by a smooth direct current of 0,006 A

Correct operation of the RCD shall be tested with a half-wave rectified residual current (current delay angle $\alpha = 0^\circ$) superimposed by a smooth direct current of 0,006 A of the same polarity. The half-wave current, starting from zero, shall be steadily increased at an approximate rate of $1,4 I_{\Delta n} / 30$ amperes per second for RCDs with $I_{\Delta n} > 0,01$ A and $2 I_{\Delta n} / 30$ amperes per second for RCDs with $I_{\Delta n} \leq 0,01$ A and the RCD shall trip before the half-wave current reaches a value not exceeding $1,4 I_{\Delta n}$ or $2 I_{\Delta n}$ respectively. The test shall then be repeated with half-wave current and smooth direct current of negative polarity.

9.2.4 Tests of RCD of type F

9.2.4.1 General

The test procedure for RCDs of type F shall include the tests of 9.2.3 for RCDs of type A with the exception of 9.2.3.5, which is replaced by 9.2.4.4.

In addition, tests according to the requirements of 9.2.4.2, and 9.2.4.3 shall be introduced.

9.2.4.2 Steady increase of composite residual current

Correct operation of the RCD shall be tested where the RCD being in the closed position, a composite residual current according to Table 15, starting from the composite starting current value defined in Table 15, is steadily increased trying to attain the upper limit of residual operating current given in Table 16 within 30 s. The measured values shall be situated within the limits of Table 16.

For four-pole RCDs, the test above shall be repeated, the RCD being only supplied between the neutral and one-phase terminal, chosen at random.

9.2.4.3 Sudden appearance of composite residual current

Correct operation of the RCD shall be tested where the RCD being in the closed position, a composite residual current, according to Table 15, equal to 5 times the upper limit given in Table 16 is suddenly established. The measurements of the break times shall not exceed the limits of Table 4 or Table 8 as applicable for $5 I_{\Delta n}$.

RCDs of type S shall be additionally tested, the test current being suddenly established for the minimum non-actuating time of 0,05 s, with a tolerance of $^{+0}_{-5}$ %. The RCD shall not trip during the test.

9.2.4.4 Test of residual pulsating direct currents in presence of a standing smooth direct current of 0,01 A

Correct operation of the RCD shall be tested according to 9.2.3.5 but the smooth direct current of 0,006 A is replaced by 0,01 A.

9.2.5 Tests of RCDs of type B

9.2.5.1 General

The test procedure for RCDs of type B shall include the tests of 9.2.4 for RCDs of type F, with the exception of 9.2.4.4, which is replaced by 9.2.5.4.

In addition, tests according to the requirements of 9.2.5.2 to 9.2.5.10 shall be introduced.

9.2.5.2 Test of residual sinusoidal alternating currents up to 1 000 Hz

- a) Correct operation of the RCD shall be tested where the RCD 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 residual operating current given in Table 17 within 30 s; the tripping current shall be in compliance with Table 17. The test shall be carried out at each frequency given in Table 17.
- b) Correct operation of the RCD shall be tested where the circuit being calibrated at the residual operating current corresponding to 1 000 Hz according to Table 17, the RCD being in closed position, the residual current is suddenly established. For general type RCDs, the maximum break time shall not exceed 0,3 s. For S type RCDs, the maximum break time shall not exceed 0,5 s.

9.2.5.3 Test of a residual alternating current superimposed on a residual smooth direct current

Correct operation of the RCD shall be tested where the RCD being in closed position, a residual smooth direct current is applied through one pole chosen at random and is adjusted to $0,4 I_{\Delta n}$ or 10 mA whichever is the highest value, the residual alternating current of the rated frequency is applied to another pole and 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 tripping current being measured. The alternating tripping current shall be equal to or lower than $I_{\Delta n}$.

9.2.5.4 Test of a residual pulsating direct current superimposed on a residual smooth direct current

The test of 9.2.3.2 shall be repeated with additionally a residual smooth direct current applied to another pole and adjusted to $0,4 I_{\Delta n}$ or 10 mA whichever is the highest value. The tripping current shall comply with Table 14.

9.2.5.5 Test of residual direct currents which may result from rectifying circuits supplied from two phases

- a) The RCD shall be tested with a residual pulsating direct current resulting from a two phases rectifying circuit where the RCD is supplied by a three-phase system. The residual pulsating direct current shall be steadily increased, starting from a value not higher than $0,2 I_{\Delta n}$, trying to attain the value of $2 I_{\Delta n}$ within 30 s, the tripping current being measured. The RCD shall trip within the limits of $0,5 I_{\Delta n}$ to $2 I_{\Delta n}$.
- b) The RCD shall be tested with a residual pulsating direct current resulting from a two phases rectifying circuit where the RCD is supplied by a three-phase system. The test circuit being successively calibrated at each current value given in Table 6, the RCD being in the closed position, the residual current is suddenly established. The break times shall be in compliance with the values given in Table 6.

The tests a) and b) shall be repeated with residual pulsating direct current of the opposite polarity.

9.2.5.6 Test of residual direct currents which may result from rectifying circuits supplied from three phases

The following test shall not be introduced for two-pole type B RCDs:

- a) The RCD shall be tested with a residual direct current resulting from a three phases rectifying circuit where the RCD is supplied by a three-phase system. The RCD being in the closed position, the residual pulsating direct current is steadily increased, starting from a value not higher than $0,2 I_{\Delta n}$, trying to attain the value of $2 I_{\Delta n}$ within 30 s, the tripping current being measured. The RCD shall trip within the limits of $0,5 I_{\Delta n}$ to $2 I_{\Delta n}$.
- b) The RCD shall be tested with a residual direct current resulting from a three phases rectifying circuit where the RCD is supplied by a three-phase system. The test circuit being successively calibrated at each current value given in Table 6, the RCD being in the closed position, the residual current is suddenly established. The break times shall be in compliance with the values given in Table 6.

The tests a) and b) shall be repeated with residual direct current of the opposite polarity.

9.2.5.7 Test of residual smooth direct current

- a) Correct operation of the RCD shall be tested, the RCD being in the closed position, the residual smooth direct current is steadily increased, starting from a value not higher than $0,2 I_{\Delta n}$, trying to attain the value of $2 I_{\Delta n}$ within 30 s, the tripping current being measured. The tripping current shall be within the limits of $0,5 I_{\Delta n}$ to $2 I_{\Delta n}$.
- b) Correct operation of the RCD shall be tested, test circuit being successively calibrated at each residual operating current value given in Table 6 or Table 10 as applicable, the RCD being in the closed position, the residual current is suddenly established. The break times shall be in compliance with the values given in Table 6 or Table 10 as applicable.

The tests a) and b) shall be repeated with smooth direct residual current of the opposite polarity.

9.2.5.8 Test of residual smooth direct current with load

The test of 9.2.5.7.a) shall be repeated, the RCD being loaded with the rated current.

9.2.5.9 Tests at the temperature limits

Correct operation of the RCD, according to 9.2.5.5 b), 9.2.5.6 b) and 9.2.5.7 b), shall be tested at the minimum ambient temperature, with no load, and successively at the maximum ambient temperature, the RCD being loaded at the rated current.

9.2.5.10 Test of three- and four-pole RCDs powered on two poles only

Tests shall be performed according to 9.2.5.2 and 9.2.5.7, but the RCD is only supplied between two phases chosen at random for three-pole devices and between two phases chosen at random plus neutral for four-pole devices.

Additionally, for household and similar applications, the tests of 9.2.5.2 and 9.2.5.7 are repeated:

- a) for three- and four-pole devices, the RCD is only supplied between two phases chosen at random;
- b) for four-pole devices, the RCD is only supplied between one phase chosen at random and the neutral terminal.

9.3 Tests of electrical endurance

The test procedure shall be specified in the relevant product standard and shall specify the test circuit for performing electrical endurance tests. The product standard shall include the following testing conditions:

- number of electrical operations;
- power factor.

The tests shall be performed at the rated current and the rated operational voltage. At least 25 % of all electrical operations shall be performed by actuating the test device and a further 25 % (at least) shall be performed by applying a residual current of $I_{\Delta n}$ to any pole.

The relevant product standard shall also specify the acceptance criteria after this test.

9.4 Tests of behaviour of the RCD under short-circuit conditions

9.4.1 General

The test procedure shall define the test circuit for performing short-circuits tests.

The test procedure for the RCD shall include tests based on requirements of 9.4.2a), 9.4.2b), 9.4.2c), 9.4.2d), 9.4.2e), 9.4.2f), as applicable. After the tests, the RCD shall be tested according to the test procedure of 9.4.3.

For residual current devices with integral overcurrent protection, tests 9.4.2a), 9.4.2c), 9.4.2d), 9.4.2e), 9.4.2f) need not be introduced in the test procedure. These tests and the consequent verification are replaced by specific short-circuit tests based on the relevant circuit-breaker standard.

The test procedure of the RCD product standard shall specify the following items, as applicable:

- test circuit;
- minimum $I^2 t$ and I_p values of the SCPD to be associated with the RCD for coordination tests according to 9.4.2.c), 9.4.2.d) and 9.4.2.e) (see Table 36);
- power factor of the test circuit;
- power frequency recovery voltage;
- tolerances on test quantities: current, frequency, power factor, voltage.

9.4.2 Short-circuit tests

The recommended diagram for short-circuit tests is given in Annex A.

a) Test of verification of the rated making and breaking capacity (I_m)

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

The RCD is tested in a circuit according to the general test conditions specified in 9.4.1, no SCPD being inserted in the circuit.

With a residual operating current equal to $10 I_{\Delta n}$, the following sequence of operation is performed:

$$CO - t - CO - t - CO$$

b) Test of verification of the rated residual making and breaking capacity ($I_{\Delta m}$)

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

The RCD is tested according to the general test conditions specified in 9.4.1, no SCPD being inserted in the circuit, but connected in such a manner that the short-circuit current is a residual current.

The current paths which do not carry the residual short-circuit current are connected to the supply voltage at their line terminals.

The following sequence of operations is performed:

$$O - t - CO$$

c) Test of verification of the coordination between the RCD and the SCPD at the rated conditional short-circuit current

This test is intended to verify that the RCD, protected by the SCPD, is able to withstand, without damage, the rated conditional short-circuit current. The test is made without establishing any residual current.

The short-circuit current is interrupted by the association of the RCD and the SCPD.

The following sequence of operations is performed:

$$O - t - CO$$

d) Test of verification of the coordination at the rated making and breaking capacity (I_m)

This test is intended to check that at short-circuit currents of a value corresponding to the rated making and breaking capacity I_m , the SCPD operates and protects the RCD. The test is made without establishing any residual current.

The short-circuit current is interrupted by the association of the RCD and the SCPD.

The following sequence of operations is performed:

$$O - t - CO - t - CO$$

e) Test of verification of the coordination at rated conditional residual short-circuit current ($I_{\Delta c}$)

This test is intended to check that in the case of phase-to-earth short-circuits with currents up to the value of the rated conditional residual short-circuit current $I_{\Delta c}$, the RCD is able to withstand the corresponding stresses.

The short-circuit current is interrupted by the association of the RCD and the SCPD.

The RCD shall be tested in such a manner that the short-circuit current is a residual current.

The following sequence of operations is performed:

O – t – CO – t – CO

f) Test of verification of behaviour in IT systems

This test is applicable for RCDs intended to be used in IT systems. The test is performed in the following conditions:

- at a voltage 105 % of the rated phase-to-phase voltage value for the phase poles and at a voltage of 105 % of U_0 for the pole marked N if any;
- at a current of 500 A or $10 I_n$, whichever is the greater.

Each pole is subjected individually to a test.

The test sequence is:

O – t – CO

9.4.3 Behaviour of the RCD during and after the tests

During these tests, it shall be verified that the indicating means show the open position when the contacts are in the open position and show the closed position when the contacts are in the closed position.

After each of the tests applicable, carried out in accordance with 9.4.2a), 9.4.2b), 9.4.2c), 9.4.2d), 9.4.2e), 9.4.2f), the RCD shall show no damage impairing its further use and shall be capable, without maintenance, of withstanding the following tests:

- leakage current across open contacts, not higher than 6 mA at 1,1 times the rated voltage. For RCDs for household and similar uses this value is replaced by 2 mA;
- dielectric strength tests after the short-circuit test at a voltage at least equal to twice the rated voltage, for 1 min;
- making and breaking its rated current at its rated voltage.

Under the test conditions of 9.2.2.4, the RCD shall trip with a test current of $1,25 I_{\Delta n}$. One test only is made on one pole taken at random, without measurement of break time.

9.5 Test of the trip-free mechanism

A test procedure shall be introduced in the relevant RCD standard in order to verify the trip-free mechanism. The test procedure shall verify that when the operating means is held in the closed position, the RCD trips when a residual current is applied. This test is performed with a residual current greater than $I_{\Delta n}$.

9.6 Verification of the operation of the test device

A test procedure shall be introduced in the relevant RCD standard covering at least the following:

- a) the RCD being supplied with a voltage equal to 0,85 times the rated voltage, the test device is momentarily actuated 25 times at intervals of 5 s, the RCD being reclosed before each operation;
- b) test a) is then repeated at 1,1 times the rated voltage;
- c) test b) is then repeated, but only once, the operating means of the test device being held in the closed position for 30 s.

In case of RCDs with unidentified line and load terminals, the supply shall be connected to each set of terminals in turn or alternatively to both sets of terminals simultaneously.

For each test, the RCD shall operate. After the test, the sample shall show no change impairing its further use.

For devices for household and similar use, it shall be verified that the ampere-turns due to the operations of the test device are less than the defined value. For example, the impedance of the circuit of the test device may be measured and the test current calculated, taking into account the configuration of the circuit of the test device.

9.7 Tests of behaviour of RCDs in case of current surges caused by impulse voltages

9.7.1 Current surge test for all RCDs (0,5 µs/100 kHz ring wave test)

A test procedure shall be introduced in the relevant RCD standard covering at least the following.

The RCD is tested using a surge generator capable of delivering a damped oscillator current wave as shown in Figure 16. One pole of the RCD, chosen at random, shall be submitted to 10 applications of the surge current. The polarity of the surge wave shall be inverted after every two applications. The interval between two consecutive applications shall be about 30 s.

The current impulse flowing through the RCD shall be measured by appropriate means to meet the following requirements:

- peak value: to be chosen by the technical committee from the following values: 25 A, 200 A with a tolerance of 0_{+10} %. For RCDs classified according to 4.2.1, a value of 200 A is recommended.
- virtual front time: $0,5 \mu\text{s} \pm 30 \%$
- period of the following oscillatory wave: $10 \mu\text{s} \pm 20 \%$
- each successive reverse peak: about 60 % of the preceding peak

During the tests, the RCD shall not trip.

Technical committees shall define the appropriate operating characteristics tests to be performed after the ring-wave test.

9.7.2 Verification of behaviour at surge currents (8/20 µs surge current test)

For RCDs according to 4.2.1, technical committees shall include the following test.

This test is not required for RCDs according to 4.2.2 and to RCDs incorporated in or specifically intended for use with socket-outlets.

The RCD is tested using a current generator capable of delivering a damped surge current of $8/20 \mu\text{s}$ according to IEC 60060-1 and IEC 60060-2.

One pole of the RCD chosen at random shall be submitted to 10 applications of the surge current. The polarity of the surge current wave shall be inverted after every two applications. The interval between two consecutive applications shall be about 30 s.

The current impulse flowing through the RCD shall be measured by appropriate means to meet the following requirements:

- peak value: $250 \text{ A} \begin{smallmatrix} 0 \\ +10 \end{smallmatrix} \%$ minimum, with no tripping
or $3\,000 \text{ A} \begin{smallmatrix} 0 \\ +10 \end{smallmatrix} \%$, with tripping allowed

Technical committees shall select the value to be used for tests. For RCDs for household and similar uses, the value of 3 000 A is required:

- virtual front time: $8 \mu\text{s} \pm 20 \%$
- virtual time to half value: $20 \mu\text{s} \pm 20 \%$
- peak of reverse current: less than 30 % of peak value

During the test, the RCD may trip, depending on the peak value chosen. After the test, the correct function of the RCD shall be verified.

Technical committees shall define the appropriate operating characteristics tests to be performed after the surge current test.

9.8 Tests of reliability

9.8.1 Climatic test

A test procedure shall be introduced in the relevant RCD standard covering at least the following requirements.

The test is carried out according to IEC 60068-2-30, taking into account IEC 60068-3-4.

The chamber shall be constructed as stated in Clause 4 of IEC 60068-2-30:2005. Condensed water shall be continuously drained from the chamber and not used again until it has been re-purified. Only distilled water having a resistivity of not less than $500 \Omega\text{m}$ and a pH value of $7,0 \pm 0,2$ shall be used for the maintenance of chamber humidity.

The upper temperature shall be $55 \text{ }^\circ\text{C} \pm 2 \text{ }^\circ\text{C}$ (variant 1) and the number of cycles shall be:

- 6 for $I_{\Delta n} > 1 \text{ A}$;
- 28 for $I_{\Delta n} \leq 1 \text{ A}$.

At the end of the cycles the RCD shall be capable of complying with the tests of 9.2.2.4, but with a residual operating current of $1,25 I_{\Delta n}$ and without measurement of break time.

9.8.2 Test with temperature of $40 \text{ }^\circ\text{C}$

For standards covering RCDs for household and similar applications, a test procedure shall be introduced in the relevant RCD standard covering at least the following requirements.

The RCD is mounted as for normal use on a dull black painted plywood wall, about 20 mm thick.

The assembly is placed in a heating cabinet.

The RCD is loaded with a current equal to the rated current at any convenient voltage and is subjected, at a temperature of $40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$, to 28 cycles, each cycle comprising 21 h with current passing and 3 h without current. The current is interrupted by an auxiliary switch, the RCD being not operated.

For four-pole RCDs, only three poles are loaded.

At the end of the last period of 21 h with current passing, a temperature rise test of terminals shall be required by the product standard.

After this test, the RCD in the cabinet is allowed to cool down to approximately room temperature without current passing.

The RCD shall be capable of complying with the tests of 9.2.2.4, but with a residual operating current of $1,25 I_{\Delta n}$ and without measurement of break time.

9.8.3 Verification of the resistance to ageing

For standards covering RCD for household and similar applications, a test procedure shall be introduced in the relevant RCD standard covering at least the following requirements.

The RCD is placed for a period of 168 h in an ambient temperature of $40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ and loaded with the rated current at any convenient voltage.

However, if the RCD contains electronic components supplied between phases or phase and neutral, the supply voltage shall be 1,1 times the rated voltage.

After this test, the RCD in the cabinet is allowed to cool down to approximately room temperature without current passing. The electronic parts shall show no damage.

The RCD shall be capable of complying with the tests of 9.2.2.4, but with a residual operating current of $1,25 I_{\Delta n}$ and without measurement of break time.

9.9 Tests of electromagnetic compatibility (EMC)

9.9.1 General

Technical committees shall introduce EMC tests based on the intended use of the RCD and on the possible environmental influences that may affect the correct operation of the RCD.

When drafting standards, technical committees shall at least consider the requirements of the following IEC generic standards:

IEC 61000-6-1, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61000-6-3, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*

IEC 61000-6-4, *Electromagnetic compatibility (EMC) – Part 6-4: Generic standards – Emission standard for industrial environments*

Test levels and acceptance criteria shall be defined by the technical committees taking into account that RCDs are used to protect people against electric shock. Higher test levels than those specified in the generic standards may be appropriate.

9.9.2 Specific requirements for RCDs for household and similar uses

For RCDs for household and similar uses, technical committees shall introduce EMC tests according to IEC 61543 (see Table 45).

For devices containing a continuously operating oscillator, the test of CISPR 14-1 shall be carried out on the samples prior to the tests of IEC 61543.

Table 1 – Values of influencing quantities

Influencing quantity	Preferred range of application	Reference value	Test tolerances ^f
Ambient air temperature ^{a g}	- 5 °C to + 40 °C - 25 °C to + 40 °C ^{a b}	As stated by the relevant product standard	As permitted by the test requirements in the relevant product standard
Altitude	Not exceeding 2 000 m		
Relative humidity maximum value at 40°C	50 % ^c		
External magnetic field	Not exceeding 5 times the earth's magnetic field in any direction	Earth's magnetic field	^d
Mounting orientation	As stated by the manufacturer, with a tolerance of 5° in any direction ^e	As stated by the manufacturer	2° in any direction
Frequency	Reference value ±5 %	Rated value	± 5 %
Sinusoidal wave distortion	Not exceeding 5 %	Zero	5 %
Alternating component in DC (for external auxiliary source)		Zero	3 %
^a The maximum value of the mean daily temperature is + 35 °C. ^b Values outside the range are admissible where more severe climatic conditions prevail, subject to agreement between manufacturer and user. ^c Higher relative humidities are admitted at lower temperatures (for example 90 % at 20 °C). ^d When an RCD is installed in proximity to a strong magnetic field, supplementary requirements may be necessary. ^e The device shall be fixed in such a way that it does not cause deformation liable to impair its functions. ^f The tolerance given applies unless otherwise specified in the relevant test. ^g 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.			

Table 2 – Marking for RCDs according to 4.15.1

	Marking or information item
A	the manufacturer's name or trade mark
B	type designation, catalogue number or serial number
C	rated voltage(s)
D	rated current
E	rated frequency; RCDs with more than one rated frequency (e.g. 50/60 Hz) shall be marked accordingly
F	rated residual operating current
G	settings of residual operating current for RCDs with multiple residual operating currents
H	Void
I	Void
J	rated residual making and breaking capacity
K	the degree of protection (only if different from IP 20)
L	the position of use, if necessary
M	the symbol  (S in a rectangle) for type S devices
N	Void
O	operating means of the test device, by the letter T
P (2)	wiring diagram
Q (1)	operating characteristic in presence of residual currents with DC components
R	value for U_x (if any) for devices according to the method of operation
S	number of the product standard e.g. IEC 61008 (all parts)
T	Void
	rated residual non-operating current if different from the preferred value
	rated time-delay if applicable
	rated conditional short-circuit current if applicable, and in such a case characteristics for the associated short-circuit protective device, according to 5.2.8
	range of operating temperature
	means shall be provided to distinguish between the open and closed states of the device
	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)
	terminals specifically intended for the connection of the neutral shall be indicated by the symbol N

	Marking or information item
1)	One of the following markings applies:
–	RCDs of type AC with the symbol (IEC 60417-6148:2012-01)
–	RCDs of type A with the symbol (IEC 60417-6149:2012-01)
–	RCDs of type F with the symbol (IEC 60417-6149:2012-01 + 6160:2012-04)
	Alternatively the following symbol may be used
–	RCDs of type B with the symbol (IEC 60417-6149:2012-01 + 6160:2012-04 + 6297:2014-11)
	Alternatively the following symbol may be used
2)	This information may be on the inside of any cover which has to be removed in order to connect the supply wires.



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Table 3 – Marking for RCDs according to 4.15.2 and 4.15.3

	Marking or Information item
E	rated frequency; RCDs with more than one rated frequency (e.g. 50/60 Hz) shall be marked accordingly
G	settings of residual operating current for RCDs with multiple residual operating currents
J	rated residual making and breaking capacity
M	the symbol  (S in a rectangle) for type S devices
O	operating means of the test device, by the letter T
Q (1)	operating characteristic in presence of residual currents with DC components
R	value for U_x (if any) for devices according to the method of operation
	rated time-delay if applicable
	rated conditional short-circuit current if applicable, and in such a case characteristics for the associated short-circuit protective device, according to 5.2.8
	means shall be provided to distinguish between the open and closed states of the device
One of the following markings applies: – RCDs of type AC with the symbol (IEC 60417-6148:2012-01)  – RCDs of type A with the symbol (IEC 60417-6139:2012-01)  – RCDs of type F with the symbol (IEC 60417-6139:2012-01 + 6160:2012-04)  Alternatively the following symbol may be used  – RCDs of type B with the symbol (IEC 60417-6139:2012-01 + 6160:2012-04 + 6297:2014-11)  Alternatively the following symbol may be used 	

Table 4 – Standard values of maximum break time of non time-delay type RCDs for AC residual current

$I_{\Delta n}$ A	Standard values of maximum break time at			
	s			
	$I_{\Delta n}$	$2 I_{\Delta n}$	$5 I_{\Delta n}^a$	$> 5 I_{\Delta n}^b$
Any value	0,3	0,15	0,04	0,04

^a For RCDs with $I_{\Delta n} \leq 0,030$ A, the value 0,25 A may be used as an alternative to $5 I_{\Delta n}$.

^b To be specified in the relevant product standard.

Table 5 – Standard values of maximum break time of non time-delay type RCDs for half-wave pulsating DC residual current

$I_{\Delta n}$ A	Standard values of maximum break time at							
	s							
	1,4 $I_{\Delta n}$	2 $I_{\Delta n}$	2,8 $I_{\Delta n}$	4 $I_{\Delta n}$	7 $I_{\Delta n}^a$	10 $I_{\Delta n}^b$	> 7 $I_{\Delta n}^c$	> 10 $I_{\Delta n}^c$
< 0,030		0,3		0,15		0,04		0,04
0,030	0,3		0,15		0,04		0,04	
> 0,030	0,3		0,15		0,04		0,04	
^a For RCDs with $I_{\Delta n} = 0,030$ A, the value 0,35 A may be used instead of 7 $I_{\Delta n}$. ^b For RCDs with $I_{\Delta n} \leq 0,010$ A, the value 0,5 A may be used instead of 10 $I_{\Delta n}$. ^c To be specified in the relevant product standard.								

Table 6 – Standard values of maximum break time of non time-delay type RCDs for residual direct currents which result from rectifying circuits and/or smooth DC residual current

$I_{\Delta n}$ A	Standard values of maximum break time at			
	s			
	2 $I_{\Delta n}$	4 $I_{\Delta n}$	10 $I_{\Delta n}$	> 10 $I_{\Delta n}^a$
Any value	0,3	0,15	0,04	0,04
^a To be specified in the relevant product standard.				

Table 7 – Acceptable alternative standard values of maximum break times for RCDs with a rated residual current of 6 mA and non time-delay type intended to be used in bi-phase system 120 V with middle point

$I_{\Delta n}$ A	Standard values of maximum break time at			
	s			
	$I_{\Delta n}$	2 $I_{\Delta n}$	5 $I_{\Delta n}$	> 5 $I_{\Delta n}^a$
0,006	5	2	0,04	0,04
^a To be specified in the relevant product standard.				

Table 8 – Standard values of break time for AC residual current for time-delay type residual current devices

Classification of time-delay		Standard values of break and non-actuating time at			
		s			
		$I_{\Delta n}$	2 $I_{\Delta n}$	5 $I_{\Delta n}$	> 5 $I_{\Delta n}$
Type S (rated time-delay of 0,06 s)	Maximum break time	0,5	0,2	0,15	0,15
	Minimum non-actuating time	b	0,06	b	b
Other time- delay (e.g. for industrial purposes)	Maximum break time	a, b	b	b	b
	Minimum non-actuating time	b	rated delay	b	b
^a To ensure fault protection, the maximum operating time shall be in accordance with IEC 60364-4-41.					
^b Defined either by the relevant product standard or by the manufacturer.					

Table 9 – Standard values of break time for pulsating DC residual current for time-delay type residual current devices

Classification of time-delay		Standard values of break and non-actuating time at s			
		$1,4 I_{\Delta n}$	$2,8 I_{\Delta n}$	$7 I_{\Delta n}$	$>7 I_{\Delta n}$
Type S (rated time-delay of 0,06 s)	Maximum break time ^c	0,5	0,2	0,15	0,15
	Minimum non-actuating time	b	0,06	b	b
Other time-delay (e.g. for industrial purposes)	Maximum break time ^c	a, b	b	b	b
	Minimum non-actuating time	b	rated delay	b	b

^a To ensure fault protection, the maximum operating time shall be in accordance with IEC 60364-4-41.

^b Defined either by the relevant product standard or by the manufacturer.

^c For residual current devices with $I_{\Delta n} \leq 0.03$ A, the value for the maximum break time is given in Table 4, Table 5, Table 6, as applicable.

Table 10 – Standard values of break time for rectifying circuits and smooth DC residual current for time-delay type residual current devices

Classification of time-delay		Standard values of break and non-actuating time at s			
		$2 I_{\Delta n}$	$4 I_{\Delta n}$	$10 I_{\Delta n}$	$> 10 I_{\Delta n}$
Type S (rated time-delay of 0,06 s)	Maximum break time ^c	0,5	0,2	0,15	0,15
	Minimum non-actuating time	b	0,06	b	b
Other time-delay (e.g. for industrial purposes)	Maximum break time ^c	a, b	b	b	b
	Minimum non-actuating time	b	rated delay	b	b

^a To ensure fault protection, the maximum operating time shall be in accordance with IEC 60364-4-41.

^b Defined either by the relevant product standard or by the manufacturer.

^c For residual current devices with $I_{\Delta n} \leq 0.03$ A, the value for the maximum break time is given in Table 4, Table 5, Table 6, as applicable.

Table 11 – Void

Table 12 – Void

Table 13 – Tripping current limits

Current shape	Tripping current	
	Lower limit	Upper limit
AC	$0,5 I_{\Delta n}$	$I_{\Delta n}$

NOTE For the given current shape, the lower limit corresponds to the non-operating current, and the upper limit corresponds to the operating current.

Table 14 – Tripping current limits for pulsating DC

Current shape	Tripping current		
	Lower limit	Upper limit	
		$I_{\Delta n} < 30 \text{ mA}$	$I_{\Delta n} \geq 30 \text{ mA}$
Single-pulse DC			
0°	$0,35 I_{\Delta n}$	$2 I_{\Delta n}$	$1,4 I_{\Delta n}$
90°	$0,25 I_{\Delta n}$	$2 I_{\Delta n}$	$1,4 I_{\Delta n}$
135°	$0,11 I_{\Delta n}$	$2 I_{\Delta n}$	$1,4 I_{\Delta n}$
NOTE For the given current shape, the lower limit corresponds to the non-operating current, and the upper limit corresponds to the operating current.			

Table 15 – Different frequency component values of test currents and starting current values (I_{Δ}) for verifying the operating in case of steady increased residual current

Different frequency component values of test currents for calibration (RMS)			Composite starting current value (RMS)
$I_{\text{at rated frequency}}$	$I_1 \text{ kHz}$	$I_{\text{F motor (10 Hz)}}$	I_{Δ}
$0,138 I_{\Delta n}$	$0,138 I_{\Delta n}$	$0,035 I_{\Delta n}$	$0,2 I_{\Delta n}$
NOTE 1 $I_{\Delta n}$ corresponds to the rated residual operating current of the device at the rated frequency.			
NOTE 2 For test purposes, the values of 10 Hz and 1 kHz have been used for the output and clock frequency respectively representing the most severe condition.			

Table 16 – Operating current ranges for composite residual current

Operating current (RMS)	
Lower limit	Upper limit
$0,5 I_{\Delta n}$	$1,4 I_{\Delta n}$
NOTE 1 $I_{\Delta n}$ corresponds to the rated residual operating current of the device at the rated frequency.	
NOTE 2 Operating currents are composed of the ratio of frequency components given in Table 15.	

Table 17 – Tripping current ranges for type B RCDs at frequencies which differ from the rated frequency 50/60 Hz

Frequency Hz	Residual non-operating current	Residual operating current
150	$0,5 I_{\Delta n}$	$2,4 I_{\Delta n}^a$
400	$0,5 I_{\Delta n}$	$6 I_{\Delta n}^a$
1 000	$I_{\Delta n}$	$14 I_{\Delta n}^{a, b}$
NOTE The waveform for the given frequencies is sinusoidal.		
^a These values are derived from ventricular fibrillation protection according to IEC 60479-1 in combination with the frequency factor for ventricular fibrillation according to IEC 60479-2.		
^b IEC 60479-2 gives no factors for frequencies above 1 kHz.		

Table 18 – Tripping current limits

Type RCD	Number of poles	Current shape	Tripping current	
			Lower limit	Upper limit
B	2, 3, 4	Double-pulse DC	0,5 $I_{\Delta n}$	2 $I_{\Delta n}$
	3, 4	Three-pulse DC		
		Six-pulse DC.		
	2, 3, 4	Smooth DC.		
NOTE For the given current shape, the lower limit corresponds with the non-operating current, and the upper limit corresponds to the operating current.				

Table 19 – Void

Table 20 – Void

Table 21 – Void

Table 22 – Void

Table 23 – Void

Table 24 – Void

Table 25 – Void

Table 26 – Void

Table 27 – Void

Table 28 – Void

Table 29 – Void

Table 30 – Withstand values and duration of temporary overvoltages

TOV		
Occurrence	Voltage	Duration
Between neutral and all other poles	$\sqrt{3} \times U_0$	1 h
Between earth and all poles including neutral, if any ^{a,b}	$1200 \text{ V} + U_0$	5 s
Between earth and all poles including neutral, if any ^{a,b}	$250 \text{ V} + U_0$	1 h
^a Only for RCD with a terminal intended to be connected to the PE.		
^b Not applicable for single-pole RCDs with two-current paths and three-pole RCDs with four-current paths.		

Table 31 – Void

Table 32 – Void

Table 33 – Void

Table 34 – Void**Table 35 – Void****Table 36 – Minimum values of I^2t and I_p**

I_{nc} and $I_{\Delta c}$ A		I_n A								
		≤ 16	≤ 20	≤ 25	≤ 32	≤ 40	≤ 63	≤ 80	≤ 100	≤ 125
500	I_p (kA)	0,45	0,47	0,5	0,57					
	I^2t (kA ² s)	0,4	0,45	0,53	0,68					
1 000	I_p (kA)	0,65	0,75	0,9	1,18					
	I^2t (kA ² s)	0,50	0,9	1,5	2,7					
1 500	I_p (kA)	1,02	1,1	1,25	1,5	1,9	2,1			
	I^2t (kA ² s)	1	1,5	2,4	4,1	9,75	22			
3 000	I_p (kA)	1,1	1,2	1,4	1,85	2,35	3,3	3,5	3,8	3,95
	I^2t (kA ² s)	1,2	1,8	2,7	4,5	8,7	22,5	26	42	72,5
4 500	I_p (kA)	1,15	1,3	1,5	2,05	2,7	3,9	4,3	4,8	5,6
	I^2t (kA ² s)	1,45	2,1	3,1	5,0	9,7	28	31	45	82,0
6 000	I_p (kA)	1,3	1,4	1,7	2,3	3	4,05	4,7	5,3	5,8
	I^2t (kA ² s)	1,6	2,4	3,7	6,0	11,5	25	31	48	65,0
10 000	I_p (kA)	1,45	1,8	2,2	2,6	3,4	4,3	5,1	6	6,4
	I^2t (kA ² s)	1,9	2,7	4	6,5	12	24	31	48	60,0

NOTE I_{nc} is the rated conditional short-circuit current.

Table 37 – Void**Table 38 – Void****Table 39 – Void****Table 40 – Void****Table 41 – Void****Table 42 – Void****Table 43 – Void****Table 44 – Void**

Table 45 – List of electromagnetic phenomena covered by IEC 61543

Reference to Tables 1, 2, 3, 4, 5 and 6 of IEC 61543:1995, IEC 61543:1995/AMD1:2004, IEC 61543:1995/AMD2:2005	Electromagnetic phenomena
T1.1	Harmonics, interharmonics
T1.2	Signalling voltage
T1.3	Voltage amplitude variations
T1.4	Voltage unbalance
T1.5	Power-frequency variations
T1.6	Induced low frequency voltages
T1.7	Direct current in AC network
T1.8	Magnetic fields
T2.1	Conducted sine-wave form voltages or currents
T2.2	Fast transients (burst) – common mode
T2.3	Surges
T2.4	Current oscillatory transients (ring wave)
T2.5	Radiated electromagnetic field
T2.6	Conducted common mode disturbances in the frequency range lower than 150 kHz
T3.1	Electrostatic discharges

Figure 1 – Void

Figure 2 – Void

Figure 3 – Void

Figure 4 – Void

Figure 5 – Void

Figure 6 – Void

Figure 7 – Void

Figure 8 – Void

Figure 9 – Void

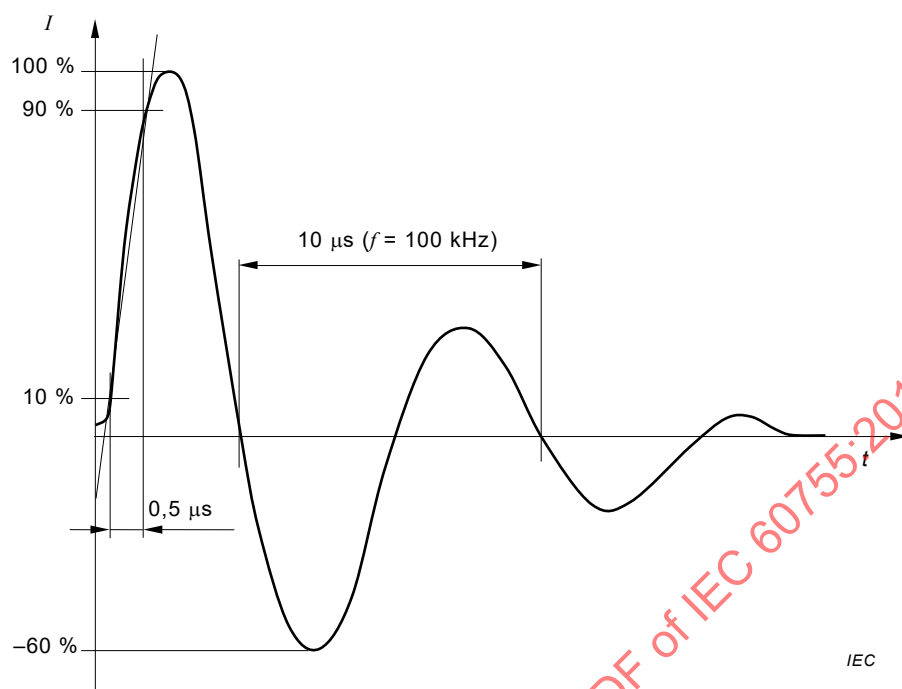
Figure 10 – Void

Figure 11 – Void

Figure 12 – Void

Figure 13 – Void

Figure 14 – Void

Figure 15 – Void

Care should be taken that the oscillating wave is guaranteed at least up to the 5th full period (50 μs).

Figure 16 – Current ring wave 0,5 μs /100 kHz

Annex A (informative)

Recommended diagram for short-circuit tests

Figure A.1 and Figure A.2 give diagrams of the circuits to be used for the short-circuit tests concerning:

- a single-pole RCD with two current paths;
- a two-pole RCD (with one or two overcurrent protected poles);
- a three-pole RCD;
- a three-pole RCD with four current paths, and
- a four-pole RCD.

The resistances and reactances of the impedances Z and Z_1 (Figure A.2) shall be adjustable to satisfy the specified test conditions. The reactors shall preferably be air-cored; they shall always be connected in series with the resistors and their value shall be obtained by series coupling of individual reactors; parallel connecting of reactors is permitted when these reactors have practically the same time-constant.

Since the transient recovery voltage characteristics of test circuits including large air-cored reactors are not representative of normal service conditions, the air-cored reactor in any phase shall be shunted by a resistor R_1 taking approximately 0,6 % of the current through the reactor.

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

In each test circuit for testing the rated short-circuit capacity, the impedances Z are inserted between the supply source S and the circuit-breaker under test.

When tests are made with current less than the rated short-circuit capacity, the additional impedances Z_1 shall be inserted on the load side of the circuit-breaker.

A resistor R_2 of about $0,5 \Omega$ is connected in series with a copper wire F as shown in Figure A.1.

Single-pole RCDs are tested in a circuit the diagram of which is shown in Figure A.1.

Two-pole RCDs are tested in a circuit, the diagram of which is shown in Figure A.1, both poles being in the circuit irrespective of the number of overcurrent protected poles.

Three-pole RCDs and four-pole RCDs with three overcurrent protected poles are tested in a circuit the diagrams of which are shown in Figure A.1.

The grid circuit shall be connected to the points B and C (see Figure A.1).