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Introduction

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1	2	(3)	4	5	(6)	(7)
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



23E/917/CD

COMMITTEE DRAFT (CD)

IEC/TC or SC: SC 23E		Project number IEC 62955 Ed. 1	
Title of TC/SC: Circuit-breakers and similar equipment for household use		Date of circulation 2015-09-11	Closing date for comments 2016-01-15
Also of interest to the following committees TC64 - TC 69 - ISO TC22/SC21		Supersedes document 23E/853/NP - 23E/864/RVN	
Proposed horizontal standard ☐ Other TC/SCs are requested to indicate their interest, if any, in this CD to the TC/SC secretary			
Functions concerned: ☒ Safety ☒ EMC ☐ Environment ☐ Quality assurance			
Secretary: Italy / G. Cassinelli		THIS DOCUMENT IS STILL UNDER STUDY AND SUBJECT TO CHANGE. IT SHOULD NOT BE USED FOR REFERENCE PURPOSES. RECIPIENTS OF THIS DOCUMENT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.	

Title:

IEC 62955 Ed. 1: Residual Direct Current Monitoring Device to be used for Mode 3 charging of Electric Vehicle

(Titre) :

Introductory note

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

Residual Direct Current Monitoring Device to be used for Mode 3 charging of Electric Vehicle

FOREWORD

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

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understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

According to IEC 60364-7-722 every connecting point for mode 3 shall be individually protected by an RCD having a rated residual operating current not exceeding 30 mA. This may be a RCD type B according to IEC 62423 or a type A together with a device according to this standard.

The RCD protecting the connecting point shall be at least of type A. If the characteristics of the load regarding possible residual smooth direct currents $> 6\text{mA}$ are not known, protective measures against residual direct currents shall be taken, e.g. RCD type B, or RCD type A or type F in conjunction with an equipment detecting residual direct current to ensure proper functionality of the RCD type A or type F.

It is the purpose of this new standard to specify this type of detecting equipment to ensure that the proper functionality of the RCD type A or type F is not impaired by d.c. residual currents above 6 mA.

Residual Direct Current Monitoring Device to be used for Mode 3 charging of Electric Vehicle

1 Scope

The international standard will apply to a residual direct current monitoring device with an internal or external mechanical switching device for permanently connected a.c. Electric Vehicle charging station (Mode 3 charging of electric vehicles, according to IEC 61851-1 and IEC 60364-7-722), hereafter referred to as RDC-MD, for rated voltages not exceeding 440 V a.c. with rated frequencies of 50 Hz, 60 Hz or 50/60 Hz and rated currents not exceeding 125 A.

RDC-MDs are intended to remove or initiate removal of the supply to the EV in cases where a smooth residual direct current equal to or above 6 mA is detected.

Note The value of 6mA for smooth residual direct current was chosen to prevent impairing the correct operation of an upstream RCD type A or Type F.

This standard also covers requirements and tests for RDC-MDs with an interface to a separate protection device to verify the correct operation of the protection device according to its product standard.

This standard applies to devices performing simultaneously the functions of detection of the residual direct current, of comparison of the value of this current with the residual operating value and initiating the opening of the monitored circuit when the residual direct current exceeds 6 mA.

RDC-MDs are not required to provide isolation.

RDC-MDs are intended to be used for single-phase or multi-phase circuits in TN-, TT- and IT-systems.

RDC-MDs are intended to be used within the fixed installation.

RDC-MDs are intended to be used in a.c. circuits only. RDC-MD according to this standard are not intended for bilateral power flow between electric vehicle and fixed installation.

RDC-MDs shall be supplied from the monitored circuit.

RDC-MD are not intended for functional switching.

RDC-MD are not intended to be used either for fault protection or for additional protection according to IEC 60364-4-41.

This part of the standard is valid for RDC-MD consisting of 6 mA d.c. residual current detection, evaluation and mechanical switching device in one unit.

For RDC-MD with integrated a.c., pulsating d.c. and 6mA d.c. detection, evaluation and mechanical switching in one unit annex Y applies.

For RDC-MD with a mechanical interface to a separate protection device (circuit breaker or RCD) annex W or Z, as applicable, applies.

For modular RDC-MD with separated residual current detection and evaluation with an electrical interface to a switching device (e.g. contactor) or a protection device (circuit breaker or RCD) annex X applies.

2 Normative references

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

IEC 60038, *IEC standard voltages*

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

IEC 60060-2:1994, *High-voltage test techniques – Part 2: Measuring systems*

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

IEC 60068-3-4: 2001, *Environmental testing – Part 3-4: Supporting documentation and guidance – Damp heat tests*

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

IEC 60228:2004, *Conductors of insulated cables*

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

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

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

IEC 60417, *Graphical symbols for use on equipment*

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

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

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

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

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

IEC 60898-1:2002, *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations – Part 1: Circuit-breakers for a.c. operation*

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

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

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

Amendment 1 (2004)

Amendment 2 (2005)

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

3 Terms and definitions

For the purposes of this Technical Report, the terms and definitions given in Glossary IEC 62873-2 and the following apply:

NOTE 1 Wherever in IEC 62873-2 “RCD” is written, it is to read as “RDC-MD”

NOTE 2 For a glossary of symbols see Annex IB.

3.1 Definitions relating to RDC-MD design

3.1.1

RDC-MD

covers all components to meet the requirements of this standard including detection and evaluation of residual currents and switching the monitored circuit. This may be a stand-alone

device or a RDC-M-unit according to 3.10.1 together with a dedicated RCD or circuit breaker or one or more modules according to 3.10.3 together with a switching device.

3.1.2

RDC-M-unit

includes detection and evaluation of residual currents and provides a mechanical operation to a RCD or circuit breaker to cause switching of the monitored circuit

3.1.3

RDC-M-module

may be a detection module (e.g. core balance transformer) or a detection module to detect residual direct currents or a connection module for providing directly or indirectly a signal to a switching device to cause switching of the monitored circuit. One module may also consist out of more than one of the mentioned modules

4 Classification

4.1 RDC-MDs are classified: According to the type of construction

Note Annex U shows the overview of the following classifications.

4.1.1 RDC-MD with 6mA d.c. residual current detection only

4.1.1.1 RDC-MD capable of 6 mA d.c. residual current detection, evaluation and mechanical switching in one unit.

Note 1 This device is intended to be used with a Type A RCD according to IEC61008 or IEC61009 or a Type F RCD according to IEC62423 with all having a residual operating current rating not exceeding 30mA.

Note 2 An example of RDC-MD according to this classification is given in Figure V.1.

4.1.1.2 RDC-MD capable of 6mA d.c. residual current detection and evaluation, and mechanically coupled to a separate switching device as follows:

- a) Type A RCBO or
- b) Type A RCCB or
- c) Circuit Breaker

Note 1 In case c) with circuit breaker, for AC and pulsating DC protection, this device is intended to be used with a Type A RCD according to IEC61008 or IEC61009 or a Type F RCD according to IEC62423 with all having residual operating current rating not exceeding 30mA.

Note 2 This classification is covered by Annex W.

Note 3 An example of RDC-MD according to this classification is given in Figure V.2.

4.1.1.3 RDC-MD capable of 6mA d.c. residual current detection and evaluation, and electrically coupled to a separate switching device as follows:

- a) Type A RCBO or
- b) Type A RCCB or
- c) Circuit breaker
- d) Contactor or relay

Note 1 For AC and pulsating DC protection, this RDC_MD is intended to be used with a Type A RCD according to IEC61008 or IEC61009 or a Type F RCD according to IEC62423 with residual operating current rating not exceeding 30mA.

Note 2 The switching device may be an RCD or a circuit breaker or a contactor or a relay and may be actuated by using under-voltage or shunt trip operation

Note 3 This classification is covered by Annex X.

Note 4 An example of RDC-MD according to this classification is given in Figure V.3.

4.1.2 RDC-MD with a.c., pulsating d.c. and 6mA d.c. residual current detection

4.1.2.1 RDC-MD with integrated a.c., pulsating d.c. and 6mA d.c. detection, evaluation and mechanical switching in one unit

Note 1 This classification is covered by Annex Y.

Note 2 An example of RDC-MD according to this classification is given in Figure V.1.

4.1.2.2 RDC-MD with integrated a.c., pulsating d.c. and 6mA d.c. detection, evaluation and mechanically coupled to a separate circuit breaker

Note 1 This classification is covered by Annex Z.

Note 2 An example of RDC-MD according to this classification is given in Figure V.4.

4.2 According to the number of poles

- two-pole RDC-MD;
- three-pole RDC-MD;
- four-pole RDC-MD

Note For RDC-MD classified according to 4.1.1.3 the number of poles refers to the number of poles of the switching device.

4.3 According to the method of connection

- RDC-MDs, the electrical connections of which are not associated with the mechanical mounting;
- RDC-MDs, the electrical connections of which are associated with the mechanical mounting.

NOTE Examples of this type are:

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

Some RDC-MDs may be of bolt-on type on the line side only, the load terminals being usually suitable for wiring connection.

4.4 According to the type of terminals

- RDC-MDs with screw-type terminals for external copper conductors;
- RDC-MDs with screwless type terminals for external copper conductors;

NOTE 1 The requirements for RDC-MDs equipped with this type of terminals are given in Annex J.

- RDC-MDs with flat quick-connect terminals for external copper conductors;

NOTE 2 The requirements for RDC-MDs equipped with these types of terminals are given in Annex K.

4.5 According to range of ambient air temperature

4.5.1 Ambient air temperature range -5°C up to 40°C

4.5.2 Ambient air temperature range -25°C up to 40°C

5 Characteristics of RDC-MDs

5.1 Summary of characteristics

The characteristics of an RDC-MD shall be stated in the following terms:

- rated current I_n (see 5.2.2);
- rated d.c. residual operating current $I_{\Delta dc}$ (see 5.2.3);
- rated d.c. residual non-operating current (see 5.2.4);
- rated voltage U_n (see 5.2.1);
- rated frequency (see 5.2.5);

- rated making and breaking capacity I_m (see 5.2.6);
- rated residual making and breaking capacity $I_{\Delta m}$ (see 5.2.7);
- degree of protection (see IEC 60529);
- rated conditional short-circuit current I_{nc} (see 5.4.2);
- rated conditional residual short-circuit current $I_{\Delta c}$ (see 5.4.3);

5.2 Rated quantities and other characteristics

5.2.1 Rated voltage (U_n)

5.2.1.1 Rated operational voltage (U_e)

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

NOTE The same RDC-MD may be assigned a number of rated voltages.

5.2.1.2 Rated insulation voltage (U_i)

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

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

5.2.1.3 Rated impulse withstand voltage (U_{imp})

The rated impulse withstand voltage of an RDC-MD shall be equal to or higher than the standard values of rated impulse withstand voltage given in Table 4.

5.2.2 Rated current (I_n)

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

5.2.3 Rated d.c. residual operating current ($I_{\Delta dc}$)

The value of residual operating current, assigned to the RDC-MD by the manufacturer, at which the RDC-MD shall operate under specified conditions.

5.2.4 Rated d.c. residual non-operating current ($I_{\Delta odc}$)

The value of residual non-operating current, assigned to the RDC-MD by the manufacturer, at which the RDC-MD does not operate under specified conditions.

5.2.5 Rated frequency

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

NOTE The same RDC-MD may be assigned a number of rated frequencies.

5.2.6 Rated making and breaking capacity (I_m)

The r.m.s. value of the a.c. component of prospective current, assigned by the manufacturer, which an RDC-MD can make, carry and break under specified conditions.

The conditions are those specified in 9.11.2.2.

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

The r.m.s. value of the a.c. component of residual prospective current, assigned by the manufacturer, which an RDC-MD can make, carry and break under specified conditions.

The conditions are those specified in 9.11.2.3.

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage (U_n)

Preferred values of rated voltage are given in table 1:

Table 1 – Preferred values of rated voltages

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

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

5.3.2 Preferred values of rated current (I_n)

Preferred values of rated current are

$$16 - 32 - 63 \text{ A.}$$

5.3.3 Standard value of rated d.c. residual operating current ($I_{\Delta dc}$)

Standard value of rated residual operating current is 0,006 A.

5.3.4 Standard value of d.c. residual non-operating current ($I_{\Delta odc}$)

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

5.3.5 Preferred values of rated frequency

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

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

5.3.6 Minimum value of the rated making and breaking capacity (I_m)

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

The associated power factors are specified in Table 17.

5.3.7 Minimum value of the rated residual making and breaking capacity ($I_{\Delta m}$)

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

The associated power factors are specified in Table 17.

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

5.3.8.1 Values up to and including 10 000 A

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

3 000 – 4 500 – 6 000 – 10 000 A.

The associated power factors are specified in Table 17.

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

5.3.8.2 Values above 10 000 A

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

The associated power factors are specified in Table 17.

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

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

5.3.9.1 Values up to and including 10 000 A

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

3 000 – 4 500 – 6 000 – 10 000 A.

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

The associated power factors are specified in Table 17.

5.3.9.2 Values above 10 000 A

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

The associated power factors are specified in Table 17.

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

5.3.10 Limiting values of break time and non-operating time

5.3.10.1 Limiting values of break time and non-operating time at sudden appearance of direct current

Limiting values of break time for residual direct currents are given in Table 2.

Table 2 – Maximum values of break times for residual direct currents

Standard values of maximum break time at a residual direct current equal to		
s		
6 mA	60 mA	200 mA
10,0	0,3	0,1

5.3.10.2 Limiting values of break time and non-operating time at sudden appearance of direct current

Minimum values of delay time for alternating residual currents (r.m.s. values) for classification 4.1.1.1, 4.1.1.2c), 4.1.1.3c) and 4.1.1.3d) are given in Table 3

Table 3 – Minimum values of non-operating time for alternating residual currents (r.m.s. values)

Minimum values of non-operating time (s) in event of alternating residual currents (r.m.s. values) equal to			
up to 30 mA	60 mA	150 mA	5 A
no tripping	0,3	0,08	0,08

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

Table 4 gives the standard value of rated impulse withstand voltages as a function of the nominal voltage of the installation.

Table 4 – Rated impulse withstand voltage as a function of the nominal voltage of the installation

Rated impulse withstand voltage U_{imp} kV	Nominal voltage of the installation	
	Three-phase systems V	Single-phase system with mid-point earthed V
2,5 ^a		120/240 ^b
4 ^a	230/400	120/240, 240 ^c
NOTE For test voltages to check the insulation, see Table 14.		
^a void ^b For installation practice in Japan. ^c For installation practice in North American countries.		

5.4 Coordination with short-circuit protective devices (SCPDs)

5.4.1 General

This clause applies to RDC-MDs classified according to 4.1.1.1, 4.1.1.2b), 4.1.1.3 b) and d) and 4.1.2.1.

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

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

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

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

The conditions are those specified in 9.11.2.4 a).

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

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

The conditions are those specified in 9.11.2.4 c).

6 Marking and other product information

RDC-MD shall provide indication in case it has tripped or it has provided a tripping signal or tripping action. These indications shall be readily visible after the RDC-MD is installed.

Due to physical reasons for pulsating d.c. residual currents only limited selectivity to upstream RCD type A or type F with rated residual current 30 mA can be achieved. For this reason information shall be provided in the manufacturer's information.

Each RDC-MD or its associated switching device shall be marked in a durable manner with all or, for small apparatus, part of the following data:

- a) the manufacturer's name or trade mark;
- b) type designation, catalogue number or serial number;
- c) rated voltage(s);
- d) rated frequency; RDC-MDs with more than one rated frequency (e.g. 50/60 Hz) shall be marked accordingly;
- e) rated current;
- f) rated residual d.c. operating current as $I_{\Delta dc} = 0,006A$;
- g) ambient air temperature range -25°C up to 40°C (Snow flake), if applicable
- h) rated making and breaking capacity, if applicable;
- j) the degree of protection (only if different from IP20);
- k) the position of use, if necessary;
- l) rated residual making and breaking capacity, if different from rated making and breaking capacity, if applicable;
- m) void
- n) void
- o) operating means of the test device, by the letter T;
- p) wiring diagram;
- q) void

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

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

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

The manufacturer shall state the Joule integral I^2t and the peak current I_p withstand capabilities for RDC-MD according to classifications 4.1.1.1. Where these are not stated, minimum values as given in Table 16 apply.

For RDC-MD according to classification 4.1.1.1 the manufacturer shall give the reference of one or more suitable SCPDs in his catalogues and in a sheet accompanying each device.

RDC-MD shall provide indication in case it has tripped..

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

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

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

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

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

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

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

Compliance is checked by inspection and by the test of 9.3

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

- no marking.

For non-universal terminals:

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

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

7 Standard conditions for operation in service and for installation

7.1 Standard conditions

RDC-MDs complying with this standard shall be capable of operating under the standard conditions shown in Table 5.

Table 5 – Standard conditions for operation in service

Influencing quantity	Standard range of application	Reference value	Test tolerances ⁶⁾
Ambient temperature ^{1) 7)}	–5 °C to +40 °C ²⁾ –25 °C to +40 °C	20 °C	±5 °C
Altitude	Not exceeding 2 000 m		
Relative humidity maximum value 40 °C	50 % ³⁾		
External magnetic field	Not exceeding 5 times the earth's magnetic field in any direction	Earth's magnetic field	⁴⁾
Position	As stated by the manufacturer, with a tolerance of 2° in any direction ⁵⁾	As stated by the manufacturer	2° in any direction
Frequency	Reference value ±5 % ⁶⁾	Rated value	±2 %
Sinusoidal wave distortion	Not exceeding 5 %	Zero	5 %

¹⁾ The maximum value of the mean daily temperature is +35 °C.

²⁾ Values outside the range are admissible where more severe climatic conditions prevail, subject to agreement between manufacturer and user.

³⁾ Higher relative humidities are admitted at lower temperature (for example 90 % at 20 °C).

⁴⁾ When an RDC-MD is installed in proximity of a strong magnetic field, supplementary requirements may be necessary.

⁵⁾ The device shall be fixed without causing deformation liable to impair its functions.

⁶⁾ The tolerances given apply unless otherwise specified in the relevant test.

⁷⁾ Extreme limits of –20 °C and +60 °C are admissible during storage and transportation, and should be taken into account in the design of the device.

7.2 Conditions of installation

RDC-MDs shall be installed in accordance with the manufacturer's instructions.

7.3 Pollution degree

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

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 General

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

It shall not be possible to alter the operating characteristics of the RDC-MD by means of external interventions.

The protective conductor of the installation shall not become live in such a way that a dangerous touch voltage is created when the RDC-MD is operated. A standing current in the PE up to the limit of 1 mA is accepted with a touch voltage limited not exceeding dangerous levels according to IEC 60364 and IEC 60479 series of standards.

Compliance is checked by inspection and verification at rated voltage, if applicable.

The protection means with which the RDC-MD is declared to be used in conjunction with, shall pass all relevant test of its own product standard with the RDC-MD connected and in use.

8.1.2 Mechanism

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

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

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

RDC-MDs shall have a trip-free mechanism.

The RDC-MD shall have a tripping indication showing that tripping was initiated.

The RDC-MD shall have a reset function. The reset function may be activated locally or remotely. This remote reset may also be initiated by activating the charging process.

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

NOTE 1 In the US, the colours red and green are not used for contact position indication.

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

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

When an indicator light is used, this shall be lit when the RDC-MD is in a closed position and be of a bright colour.

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

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

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

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

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

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

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

8.1.3 Clearances and creepage distances (see Annex B)

The minimum required clearances and creepage distances are given in Table 6 which is based on the RDC-MD being designed for operating in an environment with pollution degree 2 and overvoltage category III.

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

NOTE 1 Accessible surface after installation means any surface accessible by the user when the RDC-MD is installed according to the manufacturer's instructions. The test finger can be applied to determine whether a surface is accessible or not.

In above case, after the humidity treatment described in 9.7.1, compliance for items 1, 2, 4 and 5 and arrangements of 9.7.2 items b), c), d) and e) is checked in the following order:

- Tests according to 9.7.2 to 9.7.6 as applicable,
- Test according to 9.7.7.2 is applied with test voltages given in Table 14 with test arrangements of 9.7.2 items b), c), d), e).

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

Compliance for item 3 in Table 6 is checked by measurement.

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

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

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

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

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

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

Table 6 – Minimum clearances and creepage distances

	Minimum clearances mm			Minimum creepage distances ^{e, f} mm											
				Group IIIa ^h (175 V ≤ CTI < 400 V) ^d				Group II (400 V ≤ CTI < 600 V) ^d				Group I (600 V ≤ CTI) ^d			
	Rated voltage V			Working voltage ^e V											
	<i>U_{imp}</i>														
	2,5 kV	4 kV	4 kV												
Description	120/240 120	120/240 240	230/400 230 400	>25 ≤50 ⁱ	120	250	400	>25 ≤50 ⁱ	120	250	400	>25 ≤50 ⁱ	120	250	400
1. Between live parts which are separated when the main contacts are in the open position ^{a, k}	1,5	3,0	3,0	1,2	2,0	3,0	3,0	0,9	2,0	3,0	3,0	0,6	1,2	3,0	3,0
2. Between live parts of different polarity ^a	1,5	3,0	3,0	1,2	1,5	3,0	4,0	0,9	1,5	3,0	3,0	0,6	1,5	3,0	3,0
3. Between circuits supplied from different sources, one of which being PELV or SELV ^g	3,0	6,0	8,0		3,0	6,0	8,0		3,0	6,0	8,0		3,0	6,0	8,0
				Rated voltage V											
				120 / 240		230 / 400		120 / 240		230 / 400		120 / 240		230 / 400	
4. Between live parts and - accessible surfaces of operating means - screws or other means for fixing covers which have to be removed when mounting the RDC-MD - surface on which the RDC-MD is mounted ^b - screws or other means for fixing the RDC-MD ^b - metal covers or boxes ^b - other accessible metal parts ^c - metal frames supporting flush-type RDC-MDs	1,5	3,0	3,0	1,5	4,0	1,5	3,0	1,5	3,0	1,5	3,0				
NOTE 1 The values given for 400 V are also valid for 440 V.															
NOTE 2 The parts of the neutral path, if any, are considered to be live parts.															
NOTE 3 Care should be taken to provide adequate clearances and creepage distances between live parts of different polarity of RDC-MDs. If the clearance and creepage distances requirements are not fulfilled to all the surfaces adjacent to the RDC-MD, appropriate information will be provided for installation purposes.															

Table 6 (continued)

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

8.1.4 Screws, current-carrying parts and connections

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

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

NOTE 1 Screws (or nuts) which are operated when mounting the RDC-MD include screws for fixing covers or cover-plates, but not connecting means for screwed conduits and for fixing the base of an RDC-MD.

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

NOTE 2 Screwed connections are considered as checked by the tests of 9.8, 9.11, 9.12, 9.13 and 9.20.

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

Compliance is checked by inspection and by manual test.

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

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

Compliance is checked by inspection.

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

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

Examples of suitable materials are given below:

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

In case of using ferrous alloys or suitably coated ferrous alloys, compliance to resistance to corrosion is checked by a test of resistance to rusting (9.22).

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

8.1.5 Terminals for external conductors

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

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

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

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

Compliance is checked by inspection, by the tests of 9.5 for screw-type terminals, by specific tests for plug-in or bolt-on RDC-MDs included in the standard, or by the tests of Annex J, K or L, as relevant for the type of connection.

8.1.5.2 RDC-MDs shall be provided with:

- either terminals which shall allow the connection of copper conductors having nominal cross sectional areas as shown in Table 7;

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

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

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

Table 7 – Connectable cross-sections of copper conductors for screw-type terminals

Rated current ^{a)} A		Range of nominal cross-section to be clamped ^{b)} mm ²	
Greater than	Up to and including	Rigid (solid or stranded ^{c)} conductors	Flexible conductors
–	13	1 to 2,5	1 to 2,5
13	16	1 to 4	1 to 4
16	25	1,5 to 6	1,5 to 6
25	32	2,5 to 10	2,5 to 6
32	50	4 to 16	4 to 10
50	63	10 to 25	10 to 16

NOTE Information on AWG is given in Annex ID.

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

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

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

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

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

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

Compliance is checked by inspection.

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

8.1.5.5 Terminals shall have adequate mechanical strength.

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

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

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

Compliance is checked by inspection and by the test of 9.5.2.

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

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

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

This requirement does not apply to lug terminals.

Compliance is checked by the test of 9.5.3.

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

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

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

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

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

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

Compliance is checked by manual test.

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

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

8.2 Protection against electric shock

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

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

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

For RDC-MDs external parts, other than screws or other means for fixing covers and labels, which are accessible when the RDC-MDs are mounted and wired as in normal conditions of use, shall either be of insulating material, or be lined throughout with insulating material, unless the live parts are within an internal enclosure of insulating material.

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

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

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

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

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

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

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

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

8.3 Dielectric properties

RDC-MDs shall have adequate dielectric properties.

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

Compliance is checked by the tests of 9.7.

8.4 Temperature-rise

8.4.1 Temperature-rise limits

The temperature rises of the parts of an RDC-MD specified in Table 8, measured under the conditions specified in 9.8.2, shall not exceed the limiting values stated in that table.

The RDC-MD shall not suffer damage impairing its functions and its safe use.

Table 8 – Temperature-rise values

Parts ^{a, b}	Temperature rise K
Terminals for external connections	65
External parts liable to be touched during manual operation of the RDC-MD, including operating means of insulating material and metallic means for coupling insulated operating means of several poles	40
External metallic parts of operating means	25
Other external parts, including that face of the RDC-MD in direct contact with the mounting surface	60
^a No value is specified for the contacts, since the design of most RDC-MDs is such that a direct measurement of the temperature of those parts cannot be made without the risk of causing alterations or displacement of parts likely to affect the reproducibility of the tests.	

The test of reliability (see 9.22) is considered to be sufficient for checking indirectly the behaviour of the contacts with respect to undue temperature-rises in service.

- ^b No value is specified for parts other than those listed, but no damage shall be caused to adjacent parts of insulating materials, and the operation of the RDC-MD shall not be impaired.

8.4.2 Ambient air temperature

The temperature-rise limits given in Table 8 are applicable only if the ambient air temperature remains between the limits given in Table 5.

8.5 Operating characteristic

The operating characteristic of RDC-MDs shall comply with the requirements of 9.9.1, 9.9.2 and 9.9.3 as applicable.

8.6 Electrical endurance

RDC-MDs shall be capable of performing an adequate number of electrical operations.

Compliance is checked by the test of 9.10

8.7 Performance at short-circuit currents

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

Compliance is checked by the tests of 9.11.

8.8 Resistance to mechanical shock and impact

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

Compliance is checked by the test of 9.12.

8.9 Resistance to heat

RDC-MDs shall be sufficiently resistant to heat.

Compliance is checked by the test of 9.13.

8.10 Resistance to abnormal heat and to fire

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

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

8.11 Test device

An RDC-MD shall be provided with a manual or an automatically initiated test function or both that checks the residual d.c. detection circuit.

Where provided the automatic test function shall be performed at every switch on and at intervals not exceeding at least once a day.

During automatic testing, it is not required to open the contacts by performing the test.

NOTE 1 The mechanical parts of the mechanism are verified by the endurance tests and the contacts are verified by the short circuit tests. For that reason these parts are expected to be high reliable and need not to be included in a periodic test.

In case of manual test, the RDC-MD shall trip.

NOTE 2 Additional requirements and testing procedure for testing the performance manually or automatically are under consideration.

In the event that a malfunction is detected during automatic testing, the RDC-MD shall cause disconnection of the supply to the EV

The protective conductor of the installation shall not become live when the test function is initiated and it shall not be possible to energize the circuit on the load side when the RDC-MD is in the open position and connected as in normal use.

For verification, the manufacturer shall provide the necessary documentation of the test function circuit.

Compliance is checked by tests of 9.16.

8.12 Behaviour of RDC-MDs in the case of current surges caused by impulse voltages

RDC-MDs shall adequately 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.

Compliance is checked by the tests of 9.18.

8.13 Reliability

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

Compliance is checked by the tests of 9.19 and 9.20.

8.14 Electromagnetic compatibility (EMC)

Residual current devices shall comply with relevant EMC requirements.

Compliance is checked by the tests of 9.21.

8.15 Behaviour of the correct operation for three- and four- pole RDC-MD powered on two poles only

Three- and four-pole RDC-MD shall be able to operate if they are powered on only two poles.

Compliance is checked by the tests of 9.17.

9 Tests

9.1 General

9.1.1 The characteristics of RDC-MDs are checked by means of type tests.

Type tests required by this standard are listed in Table 9.

Table 9 – List of type tests

Test	Subclause
– Indelibility of marking	9.3
– Reliability of screws, current-carrying parts and connections	9.4
– Reliability of terminals for external conductors	9.5
– Protection against electric shock	9.6
– Dielectric properties	9.7
– Temperature rise	9.8
– Operating characteristic	9.9
– Mechanical and electrical endurance	9.10
– Behaviour of RDC-MDs under short-circuit conditions	9.11
– Resistance to mechanical shock and impact	9.12
– Resistance to heat	9.13
– Resistance to abnormal heat and to fire	9.14

– Trip-free mechanism	9.15
– Operation of the test device at the limits of rated voltage	9.16
– Correct operation in case of three- and four- pole RDC-MD powered on two poles only	9.17
– Behaviour in case of current surges	9.18
– Reliability	9.19
– Ageing of electronic components	9.20
– Electromagnetic compatibility (EMC)	9.21
– Resistance to rusting	9.22

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

NOTE The term "certification" denotes:

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

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

Unless otherwise specified, each type test (or sequence of type tests) is made on RDC-MDs in a clean and new condition, the influencing quantities having their normal reference values (see Table 5).

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

9.2 Test conditions

The RDC-MD is mounted individually according to manufacturer's instructions and in free air, at an ambient temperature between 20 °C and 25 °C, unless otherwise specified, and is protected against undue external heating or cooling.

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

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

Unless otherwise specified, the RDC-MD is wired with the appropriate cable having the cross-section specified in Table 10 and is fixed on a dull black painted plywood board of not less than 20 mm, the method of fixing being in compliance with the requirements relating to the indications of the manufacturer concerning mounting.

Table 10 – Test copper conductors corresponding to the rated currents

Rated current I_n A	$I_n \leq 6$	$6 < I_n \leq 13$	$13 < I_n \leq 20$	$20 < I_n \leq 25$	$25 < I_n \leq 32$	$32 < I_n \leq 50$	$50 < I_n \leq 63$
S mm ²	1	1,5	2,5	4	6	10	16

NOTE 2 For AWG copper conductors, see Annex ID.

Where tolerances are not specified, type tests are carried out at values not less severe than those specified in this standard. Unless otherwise specified, tests are carried out at the rated frequency $\pm 5\%$, tolerance for voltage and current is $\pm 5\%$.

During the tests no maintenance or dismantling of the samples are allowed.

For the tests of 9.8, 9.9, 9.10, 9.19.2 and 9.20, the RDC-MD is connected as follows:

- the connections are made by means of single-core, PVC-insulated copper cables;
- the connections are in free air and spaced not less than the distance existing between the terminals;

- the minimum length of each temporary connection from terminal to terminal is:
 - 1 m for cross-sections $\leq 10 \text{ mm}^2$;
 - 2 m for cross-sections $> 10 \text{ mm}^2$.

The tightening torques to be applied to the terminal screws are two-thirds of those specified in Table 11.

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

9.3 Test of indelibility of marking

The test is made by rubbing the marking by hand for 15 s with a piece of cotton soaked with water and again for 15 s with a piece of cotton soaked with aliphatic solvent hexane (with a content of aromatics of maximum 0,1 % volume, a kauributanol value of 29, initial boiling point approximately 65°C , dry point approximately 69°C and specific gravity of $0,68 \text{ g/cm}^3$).

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

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

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

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

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

The screws or nuts are tightened and loosened

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

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

The test is made by means of a suitable test screwdriver or spanner applying a torque as shown in Table 11.

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

The test is made with rigid conductors only, having the largest cross-sectional areas specified in Table 6, solid or stranded, whichever is the most unfavourable. The conductor is moved each time the screw or nut is loosened.

Table 11 – Screw thread diameters and applied torques

Nominal diameter of thread mm		Torque Nm		
Greater than	Up to and including	I	II	III
–	2,8	0,2	0,4	0,4
2,8	3,0	0,25	0,5	0,5
3,0	3,2	0,3	0,6	0,6
3,2	3,6	0,4	0,8	0,8
3,6	4,1	0,7	1,2	1,2
4,1	4,7	0,8	1,8	1,8
4,7	5,3	0,8	2,0	2,0
5,3	6,0	1,2	2,5	3,0
6,0	8,0	2,5	3,5	6,0



8,0	10,0	–	4,0	10,0
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Column I applies to screws without heads if the screw, when tightened, does not protrude from the hole, and to other screws which cannot be tightened by means of a screwdriver with a blade wider than the diameter of the screw.

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

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

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

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

Moreover, enclosures and covers shall not be damaged.

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

Compliance with the requirements of 8.1.5 is checked by inspection, by the test of 9.4, for which a rigid copper conductor having the largest cross-section specified in Table 7 is placed in the terminal (for nominal cross-sections exceeding 6 mm², a rigid stranded conductor is used; for other nominal cross-sections, a solid conductor is used), and by the tests of 9.5.1, 9.5.2 and 9.5.3.

These last tests are made using a suitable test screwdriver or spanner.

9.5.1 The terminals are fitted with copper conductors of the same type (solid, stranded or flexible) of the smallest and largest cross-sections specified in Table 7.

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

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

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

NOTE Information on AWG is given in Annex ID.

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

The clamping screws are then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 11.

Each conductor is then subjected to a pull of the value, in newtons, shown in Table 12, according to the relevant cross-section of the tested conductor.

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

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

Table 12 – Pulling forces

Cross-section of the conductor inserted in the terminal mm ²	1 up to and including 4	Above 4 up to and including 6	Above 6 up to and including 10	Above 10 up to and including 16	Above 16 up to and including 50
Pull N	50	60	80	90	100

9.5.2 The terminals are fitted with copper conductors of the smallest and largest cross-sectional areas specified in Table 7, solid or stranded, whichever is the most unfavourable, and the terminal screws are tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 11.

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

The conductors shall show no undue damage nor severed wires.

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

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

9.5.3 The terminals are fitted with the largest cross-section area specified in Table 7, for stranded and/or flexible copper conductor.

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

The conductor is inserted into the terminal until the conductor reaches the bottom of the terminal or just projects from the far side of the terminal and in the position most likely to permit a strand (or strands) to escape. The clamping screw or nut is then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 11.

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

9.6 Verification of protection against electric shock

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

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

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

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

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

RDC-MDs with enclosures or covers of thermoplastic material are subjected to the following additional test, which is carried out at an ambient temperature of 35 °C ± 2 °C, the RDC-MD being at this temperature.

RDC-MDs are subjected for 1 min to a force of 75 N, applied through the tip of a straight unjointed test finger of the same dimensions as the standard test finger. This finger is applied to all places where yielding of insulating material could impair the safety of the RDC-MD, but is not applied to knock-outs.

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

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

9.7 Test of dielectric properties

9.7.1 Resistance to humidity

9.7.1.1 Preparation of the RDC-MD for test

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

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

9.7.1.2 Test conditions

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

The temperature of the air in which the sample is placed is maintained within ± 1 °C of any convenient value, T , between 20 °C and 30 °C.

Before being placed in the humidity cabinet, the sample is brought to a temperature between T °C and T °C + 4 °C.

9.7.1.3 Test procedure

The sample is kept in the cabinet for 48 h.

NOTE 1 A relative humidity between 91 % and 95 % may be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate (Na_2SO_4) or potassium nitrate (KNO_3) in water having a sufficiently large surface in contact with the air.

NOTE 2 In order to achieve the specified conditions within the cabinet, it is recommended to ensure a constant circulation of the air within and to use a cabinet which is thermally insulated.

9.7.1.4 Condition of the RDC-MD after the test

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

9.7.2 Insulation resistance of the main circuit

The RDC-MD having been treated as specified in 9.7.1 is then removed from the cabinet.

After an interval of between 30 min and 60 min following this treatment, the insulation resistance is measured 5 s after application of a d.c. voltage of approximately 500 V, successively as follows:

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

The measurements a), b) and c) are carried out after having connected all auxiliary circuits to the frame.

The term "frame" includes

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

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

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

The insulation resistance shall not be less than

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

9.7.3 Dielectric strength of the main circuit

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

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

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

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

The values of the test voltage shall be as follows:

- 2 000 V for a) to d) of 9.7.2;
- 2 500 V for e) of 9.7.2.

Initially, no more than half the prescribed voltage is applied, then it is raised to the full value within 5 s.

No flashover or breakdown shall occur during the test.

Glow discharges without drop in voltage are neglected.

9.7.4 Insulation resistance and dielectric strength of auxiliary circuits

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

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

- b) The measurements of the insulation resistance are carried out
 - between the auxiliary circuits connected to each other and to the frame;
 - between each of the parts of the auxiliary circuits which might be isolated from the other parts in normal service and the whole of the other parts connected together, at a voltage of approximately 500 V d.c. after this voltage has been applied for 1 min.

The insulation resistance shall be not less than 2 MΩ.

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

The voltage values to be applied are specified in Table 13.

Table 13 – Test voltage of auxiliary circuits

Rated voltage of auxiliary circuits (a.c. or d.c.) V		Test voltage V
Greater than	Up to and including	
0	30	600
30	50	1 000
50	110	1 500
110	250	2 000
250	500	2 500

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

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

NOTE 1 Discharges which do not correspond to a voltage drop are disregarded.

NOTE 2 In the case of RDC-MDs in which the auxiliary circuit is not accessible for verification of the requirements given in b), the tests shall be made on samples specially prepared by the manufacturer or according to his instructions.

NOTE 3 Auxiliary circuits do not include the control circuit of RDC-MDs functionally dependent on line voltage.

NOTE 4 Control circuits other than those of secondary circuit of detection transformers and control circuits connected to the main circuit are submitted to the same tests as the auxiliary circuits.

9.7.5 Secondary circuit of detection transformers

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

9.7.6 Capability of control circuits connected to the main circuit withstanding high d.c. voltages due to insulation measurements

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

A d.c. voltage source is used with the following characteristics:

- open voltage: 600 V $^{+25}_0$ V

NOTE This value is provisional.

- maximum ripple : 5 %

where

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

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

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

After this treatment, the RDC-MD shall be capable of performing satisfactorily the tests specified in 9.9.2.3.

9.7.7 Verification of impulse withstand voltages (across clearances and across solid insulation) and of leakage current across open contacts

9.7.7.1 General testing procedure for the impulse withstand voltage tests

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

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

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

When performing the impulse voltage test on complete RDC-MD the attenuation or amplification of the test voltage shall be taken into account. It needs to be assured that the required value of the test voltage is applied across the terminals of the equipment under test.

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

NOTE 1 In 9.7.7.2, for the verification of clearances within the basic insulation, on complete RDC-MD, a very low impedance of the generator is needed for the test. For this purpose, a hybrid generator with a virtual impedance of 2 Ω is appropriate if internal components are not disconnected before testing. However, in any case, a measurement of the correct test voltage directly at the clearance is needed.

The shape of the impulses is adjusted with the RDC-MD under test connected to the impulse generator. For this purpose, appropriate voltage dividers and voltage sensors shall be used. It is recommended to disconnect surge protective components before testing.

NOTE 2 For RDC-MDs with incorporated surge arresters that cannot be disconnected, the shape of the impulses is adjusted without connection of the RDC-MD to the impulse generator.

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

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

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

NOTE 3 It is recommended that an oscilloscope be used to observe the impulse voltage in order to detect disruptive discharge.

9.7.7.2 Verification of clearances with the impulse withstand voltage

This test is carried out immediately after the measurement of the insulation resistance in 9.7.4.

This test applies if the measurement of clearances of items 2 and 4 of Table 5 shows a reduction of the stated distances.

NOTE The measurement of the clearances of table 6 can be replaced by this test.

The test is carried out on a RDC-MD fixed on a metal support and being in the closed position.

The test impulse voltage values shall be chosen in Table 14 in accordance with the rated impulse withstand voltage of the RDC-MD as given in Table 4. These values are corrected for barometric pressure and/or altitude at which the tests are carried out, according to Table 14.

A first series of tests is made applying the impulse voltage between:

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

A second series of tests is made applying the impulse voltage between:

- the phase pole(s), connected together,
- and the neutral pole (or path) of the RDC-MD, as applicable.

Additional tests are made applying the impulse voltage as described in 9.7.2 b), c), d) and e) and not tested during the two first sequences described above.

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

No further disruptive discharge shall occur.

Table 14 – Test voltage for verification of impulse withstand voltage

Rated impulse withstand voltage U_{imp} kV	Test voltages at corresponding altitude $U_{1,2/50}$ a.c. peak kV				
	Sea level	200 m	500 m	1 000 m	2 000 m
2,5	2,9	2,8	2,8	2,7	2,5
4	4,9	4,8	4,7	4,4	4,0

9.7.7.3 Verification of resistance of the insulation of open contacts and basic insulation against an impulse voltage in normal conditions

9.7.7.3.1 General

These tests are not preceded by the humidity treatment described in 9.7.1.

NOTE The tests in 9.7.7.3, as stated in requirements of 8.1.3, will be carried out before 9.7.1 on three samples of Test sequence B.

The test impulse voltage values shall be chosen from Table 14 in accordance with the rated voltage of the installation for which the RDC-MD is intended to be used as given in Table 4. These values are corrected for barometric pressure and/or altitude at which the tests are carried out.

9.7.7.3.2 RDC-MD in closed position

The series of tests is carried out on a RDC-MD fixed on a metal support, wired as in normal use and being in closed position.

The test voltages of table 14 apply

All components bridging the basic insulation have to be disconnected.

NOTE If necessary, separate samples can be prepared by the manufacturer.

A first series of tests is made, the impulses being applied between:

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

A second series of tests is made, the impulses being applied between:

- the phase pole(s), connected together
- and the neutral pole (or path) of the RDC-MD.

There shall be no disruptive discharge. If, however, only one such disruptive discharge occurs, ten additional impulses having the same polarity as that which caused the disruptive

discharge are applied, the connections being the same as those with which the failure occurred.

No further disruptive discharge shall occur.

Afterwards, a new sample is tested according to 9.7.7.4.

9.7.7.4 Verification of the behaviour of components bridging the basic insulation

A new RDC-MD sample is tested in order to check that components bridging the basic insulation would not reduce safety with respect to short term temporary overvoltages.

NOTE 1 Afterward, it is necessary to ensure that components, bridging the basic insulation and having been disconnected during the impulse voltage test for testing the basic insulation, would not impair the behaviour or the safety of the basic insulation of the equipment during normal use.

The test voltage has a frequency of 50 Hz/60 Hz. In accordance with IEC 60364-4-44:2007, Table 44.A.2, and to IEC 60664-1, the r.m.s. value of the test voltage for the basic insulation is $1\,200\text{ V} + U_0$. U_0 being the nominal voltage value between line and neutral.

NOTE 2 This test is performed only on RCBOs, where components bridging the basic insulation have been disconnected during the impulse voltage test of 9.7.7.3.2.

NOTE 3 As an example, for an RDC-MD having a rated voltage of $U_0 = 250\text{ V}$, the value of the a.c. test voltage for basic insulation is $1\,200\text{ V} + 250\text{ V}$, thus the r.m.s. test voltage is $1\,450\text{ V}$.

The voltage is applied during 5 s between:

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

The equipment is then visually inspected; no component bridging the basic insulation should show a visible alteration.

NOTE 4 It is accepted to replace a fuse before connecting the equipment to the mains. If a fuse protecting a surge arrester has blown, it is accepted to replace the surge arrester too.

Then, the equipment is connected to the mains in accordance with the manufacturer's instruction.

Under the condition of 9.9.2.3, the RDC-MD shall trip with a test current of $1,25\text{ }I_{\Delta dc}$. One test only is made on one pole, taken at random, without measurement of break time.

9.8 Test of temperature-rise

9.8.1 Ambient air temperature

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

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

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

9.8.2 Test procedure

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

For four-pole RDC-MDs the test is first made by passing the specified current through the three phase poles only.

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

During these tests the temperature rise shall not exceed the values shown in Table 8.

9.8.3 Measurement of the temperature of parts

The temperature of the different parts referred to in Table 8 shall be measured by means of fine wire thermocouples or by equivalent means at the nearest accessible position to the hottest spot.

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

9.8.4 Temperature rise of a part

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

9.9 Verification of the operating characteristics

9.9.1 Test circuit and test procedure

The RDC-MD is installed as for normal use.

The test circuit shall be of negligible inductance.

The tests are carried out at 0,85 times and 1,1 times rated voltage also in case where supplied between any two poles.

For tests according to 9.9.2, the test circuit shall correspond to Figure 3. For tests according to 9.9.3, the test circuit shall correspond to Figure 2.

The instruments for the measurement of the a.c. residual current shall display (or allow to determine) the true r.m.s. value.

NOTE The information for instrument measurement is available at the following CTL webserver:

http://www.iecee.org/ctl/sheet/pdf/CTL%20DSH%20251B%20Beijing%202009_05_15.pdf

Unless otherwise specified, the tests are performed with no load at the reference temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$.

The RDC-MD shall perform the tests of 9.9.2 and 9.9.3, as applicable. Each test is made on one pole only, taken at random, with five measurements, unless otherwise specified.

For RDC-MDs having more than one rated frequency, the tests shall be carried out at the lowest and highest frequency.

9.9.2 Verification of correct operation of RDC-MDs with smooth d.c. residual current

9.9.2.1 Verification of correct operation in case of a steady increase of smooth d.c. residual current

The test switches S1 and S2 and the RDC-MD being in the closed position, the residual current is steadily increased, starting from a value not higher than 2 mA, trying to attain the value of 6 mA within 30 s, the tripping current being measured each time. The test is repeated five times.

The auxiliary switch S3 shall be in position I for the first two measurements and in position II for the remaining measurements.

All five measured values shall be between 3 mA and 6 mA d.c..

9.9.2.2 Verification of correct operation on closing on a smooth d.c. residual current

The test circuit shall be calibrated at the value of 6 mA d.c. and the test switches S₁ and S₂ being closed, the RDC-MD is closed on the circuit so as to simulate service conditions as closely as possible. The break time is measured five times.

The auxiliary switch S3 shall be in position I for the first two measurements and in position II for the remaining measurements.

No measurement shall exceed the limiting value specified for the values given in Table 8.

9.9.2.3 Verification of correct operation in case of sudden appearance of smooth d.c. residual current

The test circuit being successively calibrated at each of the values of residual current specified in Table 1, the test switch S2 and the RDC-MD being in the closed position, the test voltage is suddenly established by closing the test switch S1. The break time is measured five times.

The auxiliary switch S3 shall be in position I for the first two measurements and in position II for the remaining measurements.

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

No break time shall exceed the relevant specified values given in Table 2.

9.9.2.4 Verification of correct operation with load

The tests of 9.9.2.2 and 9.9.2.3 are repeated, the pole under test and one other pole of the RDC-MD being loaded with rated current I_n , this current being established shortly before the test.

For the test of 9.9.2.3, the switch S1 and RDC-MD are in closed position. The residual current is established by closing S2.

NOTE The loading with rated current is not shown in Figure 3.

9.9.2.5 Tests at the temperature limits

The RDC-MD shall perform the tests specified in 9.9.2.3 at 1,1 U_n under the following conditions, successively:

a) ambient temperature:

- I) $-5\text{ }^{\circ}\text{C}$, off-load for RDC-MD classified according to 4.5.1 or
- II) $-25\text{ }^{\circ}\text{C}$, off-load for RDC-MD classified according to 4.5.2

b) ambient temperature: $+40\text{ }^{\circ}\text{C}$, the RDC-MD having been previously loaded with the rated current, until it attains thermal steady-state conditions.

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

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

NOTE Preheating may be carried out at any convenient voltage at either 50 Hz or 60 Hz but auxiliary circuits shall be connected to their normal operating voltage (particularly for components depending on line voltage).

9.9.3 Verification of non-operating time for alternating residual currents

A first test is made with switch S1 and S2 and RCD-MD in the closed position. The alternating residual current is steadily increased, starting from a value not higher than 6 mA trying to attain the value of 30 mA within 30 s. The current of 30 mA shall be kept for 10 s.

The RDC-MD shall not trip.

The following tests shall be made with the test circuit being successively calibrated at each of the remaining values of alternating residual current specified in Table 3, the test switch S1 and the RDC-MD being in the closed position, the residual current is suddenly established by closing the test switch S2 for periods corresponding to the relevant minimum non-operating

time, with a tolerance of -5% .

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

The RDC-MD shall not trip during any of the tests.

9.10 Verification of mechanical and electrical endurance

9.10.1 General test conditions

The RDC-MD is fixed to a metal support.

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

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

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

The current shall have substantially sine-wave form and the power factor shall be between 0,85 and 0,9.

The RDC-MD is connected to the circuit with conductors of the sizes indicated in Table 11.

9.10.2 Test procedure

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

The RDC-MD shall be operated as for normal use.

The opening operations shall be effected as follows:

- for the first 1 000 operating cycles by using the manual operating means;
- for the following 500 operating cycles by using the test device, if applicable
- for the last 500 or 1000 if no test device, operating cycles by passing through one pole a residual operating current of 60 mA d.c..

9.10.3 Condition of the RDC-MD after test

Following the test of 9.10.2 the RDC-MD shall not show

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

Under the test condition of 9.9.2.3 the RDC-MD shall trip with a test current of $1,25 I_{\Delta dc}$. One test only is made without measurement of break time.

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

9.11 Verification of the behaviour of the RDC-MD under short-circuit conditions

9.11.1 List of the short-circuit tests

The various tests to verify the behaviour of the RDC-MD under short-circuit conditions are shown in Table 15.

Table 15 – Tests to be made to verify the behaviour of RDC-MDs under short-circuit conditions

Verification of	Subclause
Rated making and breaking capacity I_m	9.11.2.2
Rated residual making and breaking capacity $I_{\Delta m}$	9.11.2.3
Coordination at rated conditional short-circuit current I_{nc}	9.11.2.4 a)

Coordination at rated making and braking capacity I_m	9.11.2.4 b)
Coordination at rated conditional residual short-circuit current $I_{\Delta c}$	9.11.2.4 c)

9.11.2 Short-circuit tests

9.11.2.1 General conditions for test

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

a) Test circuit

Figures 4, 5 and 6 respectively give diagrams of the circuits to be used for the tests concerning

- a two-pole RDC-MD,
- a three-pole RDC-MD,
- a four-pole RDC-MD.

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

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

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

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

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

In each test circuit the impedance L is inserted between the supply source S and the RDC-MD.

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

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

For the tests of 9.11.2.4 a) and c), the RDC-MD shall be connected with cables having a length of 0,75 m per pole and the maximum cross-section corresponding to the rated current according to Table 7.

NOTE 2 It is recommended that 0,5 m be connected on the supply side and 0,25 m on the load side of the RDC-MD under test.

The diagram of the test circuit shall be given in the test report. It shall be in accordance with the relevant figure.

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

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

- a residual current of $10 I_{\Delta c}$ such as to cause the operation of the RDC-MD within the appropriate minimum operating time specified in Table 2;