BRITISH STANDARD

BS EN 62020:1999
IEC 62020:1998

Incorporating Amendment No.1

Electrical accessories — Residual current monitors for household and similar uses (RCMs)

The European Standard EN 62020:1998, with the incorporation of amendment A1:2005, has the status of a British Standard

ICS 29.120.50

National foreword

This British Standard is the official English language version of EN 62020:1998 including amendment A1:2005. It is identical with IEC 62020:1998, including amendment 1:2003.

The start and finish of text introduced or altered by amendment is indicated in the text by tags [A1) (A1]. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by [A1) (A1].

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags [C) (C]. Where a common modification has been introduced by amendment, the tags carry the number of the amendment. For example, the common modifications introduced by CENELEC amendment A11 are indicated by [C11) (C11].

The UK participation in its preparation was entrusted by Technical Committee ISE/NFE/4, Mechanical testing of metals, to Subcommittee ISE/NFE/4/5, Indentation hardness testing, which has the responsibility to:

— aid enquirers to understand the text;
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— monitor related international and European developments and promulgate them in the UK.

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Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Search" facility of the BSI Electronic Catalogue or of British Standards Online.

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Descriptors: Electrical household accessory, low-voltage equipment, residual current monitor, definition, characteristics, construction, tests

English version

Electrical accessories Residual current monitors for household and similar uses (RCMs)

(IEC 62020:1998)

Petit appareillage électrique
Contrôleurs d'isolement à courant différentiel résiduel (RCM) pour usages domestiques et analogues
(CEI 62020:1998)

Elektrisches Installationsmaterial
Differenzstrom-Überwachungsgeräte für Hausinstallationen und ähnliche Verwendungen (RCMs)
(IEC 62020:1998)

This European Standard was approved by CENELEC on 1998-10-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

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CENELEC

European Committee for Electrotechnical Standardization
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Foreword

The text of document 23E/337/FDIS, future edition 1 of IEC 62020, prepared by SC 23E, Circuit-breakers and similar equipment for household use, of IEC TC 23, Electrical accessories, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 62020 on 1998-10-01.

The following dates were fixed:

— latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1999-07-01

— latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2001-07-01

Annexes designated "normative" are part of the body of the standard.

In this standard, Annex ZA is normative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62020:1998 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 23E/531/FDIS, future amendment 1 to IEC 62020:1998, was prepared by SC 23E, Circuit-breakers and similar equipment for household use, of IEC TC 23, Electrical accessories, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 62020:1998 on 2005-03-01.

A draft amendment, aiming to improve subclause 8.18.1 of EN 62020:1998, prepared by the Technical Committee CENELEC TC 23E, Circuit breakers and similar devices for household and similar applications, was submitted to the Unique Acceptance Procedure and was approved by CENELEC on 2005-03-01 for inclusion into amendments A1 to EN 62020:1998.

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— latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2005-12-01

— latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2008-03-01

Annex ZB has been added by CENELEC.

Endorsement notice

The text of amendment 1:2003 to the International Standard IEC 62020:1998 was approved by CENELEC as an amendment to the European Standard with agreed common modifications.

Contents

Introduction

The purpose of a residual current monitor (hereinafter referred to as RCM) is to monitor an electrical installation or circuit for the presence of an unbalanced earth fault current and to indicate, by means of an alarm, the presence of such a residual current when it exceeds a predetermined level.

An RCM may be used in conjunction with protective devices (see IEC 60364-4).

Installation and application rules are given in IEC 60364.

1 Scope

This International Standard applies to residual current monitors having rated voltages not exceeding 440 V a.c. and rated currents not exceeding 125 A for household and similar purposes.

These devices are intended to monitor the residual current of the installation and to give a warning if the residual current between a live part and an exposed conductive part or earth exceeds a predetermined level.

[A1) RCMs covered by this standard are not intended to be used as protective devices. (A1]

RCMs detect residual alternating currents and residual pulsating direct currents whether suddenly applied or slowly rising (see **8.16**).

This standard applies to monitors performing simultaneously the functions of detection of the residual current, of comparison of the value of this current with the residual operating current of the device and of providing the prescribed warning signal(s) when the residual current exceeds this value.

RCMs having internal batteries are not covered by this standard.

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

This standard does not cover Insulation Monitoring Devices (IMDs) which are covered by the scope of IEC 61557-8.

NOTE An RCM is distinguished from an IMD in that it is passive in its monitoring function and only responds to an unbalanced fault current in the installation being monitored. An IMD is active in its monitoring and measuring functions in that it can measure the balanced and unbalanced insulation resistance or impedance in the installation (see IEC 61557-8).

2 Normative references

The following normative documents contain requirements which, through reference in this text, form an integral part of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and product committees using this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60038:1983, *IEC standard voltages.*

IEC 60050-101:1998, *International Electrotechnical Vocabulary (IEV) — Part 101: Mathematics.*

IEC 60050(151):1978, *International Electrotechnical Vocabulary (IEV) — Chapter 151: Electrical and magnetic devices.*

IEC 60050(441):1984, *International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, controlgear and fuses.*

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

IEC 60068-2-28:1990, *Environmental testing — Part 2: Tests — Guidance for damp heat tests.*

IEC 60068-2-30:1980, *Environmental testing — Part 2: Tests — Test Db and guidance: Damp heat, cyclic (12 + 12-hour cycle).*

IEC 60364-4-443:1995, *Electrical installations of buildings — Part 4: Protection for safety — Chapter 44: Protection against overvoltages —Section 443: Protection against overvoltages of atmospheric origin or due to switching.*

IEC 60364-5-53:1994, *Electrical installations of buildings — Part 5: Selection and erection of electrical equipment — Chapter 53: Switchgear and controlgear.*

IEC 60417-2:1998, *Graphical symbols for use on equipment — Part 2: Symbol originals.*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code).*

IEC 60664-1:1992, *Insulation coordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests.*

[A1] IEC 60664-3:2003, *Insulation coordination for equipment within low-voltage systems — Part 3: Use of coating, potting or moulding for protection against pollution* [A1].

IEC 60695-2-1/0:1994, *Fire hazard testing — Part 2: Test methods — Section 1/sheet 0: Glow-wire test methods — General.*

IEC 60755:1983, *General requirements for residual current operated protective devices.*

IEC 61008-1:1996, *Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) — Part 1: General rules.*

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

IEC 61557-8:1997, *Electrical safety in low-voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. — Equipment for testing, measuring or monitoring of protective measures — Part 8: Insulation monitoring devices for IT systems.*

ISO/IEC Guide 2:1991, *General terms and their definitions concerning standardization and related activities.*

[A1] CISPR 14-1:2002, *Electromagnetic compatibility — Requirements for household appliances, electric tools and similar apparatus — Part 1: Emission* [A1].

3 Definitions

For the purpose of this standard, the following definitions apply.

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

3.1 Definitions relating to currents flowing from live parts to earth

3.1.1
earth fault current

current flowing to earth due to an insulation fault

3.1.2
earth leakage current

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

3.1.3
pulsating direct current

current of pulsating wave form (IEV 101-14-31) which assumes, in each period of the rated power frequency, the value 0 or a value not exceeding 0,006 A d.c. during one single interval of time, expressed in angular measure, of at least 150°

3.1.4
current delay angle α

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

3.2 Definitions relating to the energization of an RCM

3.2.1
energizing quantity

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

3.2.2
energizing input-quantity

energizing quantity by which the RCM is activated when it is applied under specified conditions these conditions may involve, for example, the energizing of certain auxiliary elements

3.2.3
residual current (I_Δ)

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

3.2.4
residual operating current

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

3.2.5
residual non-operating current ($I_{\Delta no}$)

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

3.3 Definitions relating to the operation and to the functions of residual current monitors

3.3.1
residual current monitor (RCM)

device or association of devices which monitors the residual current in an electrical installation, and which activates an alarm when the residual current exceeds the operating value of the device

3.3.2
RCMs functionally independent of line voltage

RCMs for which the functions of detection, evaluation and actuation do not depend on the line voltage

3.3.3
RCMs functionally dependent on line voltage

RCMs for which the functions of detection, evaluation or actuation depend on the line voltage

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

3.3.4
limiting non-actuating time

maximum delay during which a value of residual current higher than the residual [A1) operating (A1] current can be applied to the RCM without causing it to operate

3.3.5
time-delay RCM

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

3.3.6
main circuit (of a RCM)

all the conductive parts of a RCM included in the current paths (see **4.3**)

3.3.7
control and auxiliary circuit (of a RCM)

all the conductive parts of a RCM intended to be included in a circuit other than the main circuit of the RCM

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

3.3.8
RCM type A

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

3.3.9
test device

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

3.3.10
alarm state

alarm state indicates that the residual current in the installation monitored has exceeded the preset level of the RCM

3.3.11
non-alarm state

non-alarm state indicates that the residual current in the installation monitored is less than the preset level of the RCM

3.3.12
actuating time

time taken for an RCM to change from the non-alarm state to the alarm state in response to the sudden appearance of a residual current which exceeds the preset level

[A1) **3.3.13**
functional earth connection (FE)

electrical connection between RCM and earth which is provided to ensure:

— a reference point for RCMs having a discriminating function (see **4.11**) and/or

— continued operation in the event of loss of supply neutral.

3.3.14 maximum actuating time (T_{max})

the maximum actuating time for residual currents greater than or equal to $I_{\Delta n}$ for RCMs with adjustable time delay

3.3.15 minimum non-actuating time (T_{min})

the minimum non-actuating time for residual currents greater than or equal to $I_{\Delta n}$ for RCMs with adjustable time delay (A1]

3.4 Definitions relating to values and ranges of energizing quantities

3.4.1
rated value

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

3.4.2
non-operating overcurrents in the main circuit

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

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

3.4.2.1
limiting value of overcurrent in case of a load through a RCM with two current paths

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

3.4.2.2
limiting value of overcurrent in case of a single-phase load through a RCM

maximum value of a single-phase overcurrent which in the absence of any fault to frame or to earth, and in the absence of an earth leakage current, can flow through a RCM without causing it to switch to the alarm state

3.4.3
residual short-circuit withstand current

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

3.4.4
prospective current

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

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

3.4.5
conditional short-circuit current

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

3.4.6
conditional residual short-circuit current

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

3.4.7
I^2t (Joule integral)

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

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

3.5 Definitions relating to values and ranges of influencing quantities

3.5.1
influencing quantity

any quantity likely to modify the specified operation of a RCM

3.5.2
reference value of an influencing quantity

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

3.5.3
reference conditions of influencing quantities

collectively, the reference values of all influencing quantities

3.5.4
range of an influencing quantity

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

3.5.5
extreme range of an influencing quantity

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

3.5.6
ambient air temperature

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

3.6 Definitions relating to terminals

3.6.1
terminal

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

NOTE For examples of designs of terminals, see informative Annex IC in IEC 61008-1.

3.6.2
screw-type terminal

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

3.6.3
pillar terminal

screw-type terminal in which the conductor is inserted into a hole or cavity, where it is clamped under the shank of the screw(s). The clamping pressure may be applied directly by the shank of the screw or through an intermediate clamping element to which pressure is applied by the shank of the screw

3.6.4
screw terminal

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

3.6.5
stud terminal

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

3.6.6
saddle terminal

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

3.6.7
lug terminal

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

3.6.8
screwless terminal

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

3.6.9
tapping screw

screw manufactured from a material having high resistance to deformation, when applied by rotary insertion to a hole in a material having less resistance to deformation than the screw. The screw is made with a tapered thread, the taper being applied to the core diameter of the thread at the end section of the screw. The thread produced by application of the screw is formed securely only after sufficient revolutions have been made to exceed the number of threads on the tapered section

3.6.10
thread forming screw

tapping screw having an uninterrupted thread; it is not a function of this thread to remove material from the hole

3.6.11
thread cutting screw

tapping screw having an interrupted thread; it is a function of this thread to remove material from the hole

3.7 Conditions of operation

3.7.1
operation

alteration of the state of the RCM from the non-alarm state to the alarm state or vice versa

3.7.2
clearance (see Annex B)

shortest distance in air between two conductive parts

NOTE For the purpose of determining a clearance to accessible parts, the accessible surface of insulating enclosure shall be considered conductive as if it was covered by a metal foil wherever it can be touched by hand or by the standard test finger according to Figure 1.

3.7.3
creepage distance (see Annex B)

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

NOTE For the purpose of determining a creepage distance to accessible parts, the accessible surface of insulating enclosure shall be considered conductive as if it was covered by a metal foil wherever it can be touched by hand or by a standard test finger according to Figure 1.

3.8 Test

3.8.1
type test

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

3.8.2
routine tests

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

4 Classification

RCMs are classified:

4.1 According to the method of operation

4.1.1 RCM functionally dependent on line voltage

4.1.2 RCM functionally dependent on an energy source other than line voltage

4.2 According to the type of installation

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

4.3 According to the number of current paths

— two current paths RCM;
— three current paths RCM;
— four current paths RCM.

4.4 According to the ability to adjust the residual operating current

— RCM with a non-adjustable residual operating current;

NOTE Some RCMs with non-adjustable residual operating current may include a pre-warning level.

— RCM with adjustable residual operating current.

4.5 According to the possibility of adjusting the time-delay

— RCM without adjustable time-delay;

— RCM with adjustable time-delay.

4.6 According to the protection against external influences

— enclosed-type RCM (not requiring an appropriate enclosure);

— unenclosed-type RCM (for use with an appropriate enclosure).

4.7 According to the method of mounting

— surface-type RCM;

— flush-type RCM;

— panel board type RCM, also referred to as distribution board type.

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

4.8 According to the method of connection

— RCMs the connections of which are not associated with the mechanical mounting;

— RCMs the connections of which are associated with the mechanical mounting, for example: plug-in type, bolt-on type.

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

4.9 According to the type of connection of the load conductors

A1 **4.9.1** ***RCM to which the monitored line is not directly connected***

See Figure 22a.

4.9.2 ***RCM to which the monitored line is directly connected***

See Figure 22b. A1

4.10 According to fault indicating means

— visual, non-resettable during fault condition (minimum requirement);

— visual and audible; the audible means may be disabled by the user during fault condition;

— visual, with relay output; the relay may be disabled by the user during fault condition;

— visual, with other output signal.

4.11 According to ability to directionally discriminate between supply side and load side residual currents

— directionally discriminating (applicable in IT systems);

— directionally non-discriminating.

5 Characteristics of RCMs

5.1 Summary of characteristics

The characteristics of a RCM shall be stated in the following terms:

— type of installation (see **4.2**);
— number of current paths (see **4.3**);
— rated current I_n (see **5.2.2**);
— rated residual operating current $I_{\Delta n}$ (see **5.2.3**);
— rated residual non-operating current $I_{\Delta no}$ (see **5.2.4**);
— rated voltage U_n (see **5.2.1**);
— rated frequency (see **5.2.5**);
— time-delay, if applicable;
— operating characteristics in case of residual currents with d.c. components (see **5.2.6**);
— insulation coordination including clearances and creepage distances (see **5.2.7**);
— degree of protection (see IEC 60529);
— rated conditional short-circuit current I_{nc} (only for RCMs according to **4.9.2**);
— rated conditional residual short-circuit current $I_{\Delta c}$ (only for RCMs according to **4.9.2**);
— behaviour of the RCM in case of failure of the line voltage (see **4.1.1**);
— behaviour of the RCM in case of failure of the energy source other than the line voltage (see **4.1.2**).

5.2 Rated quantities and other characteristics

5.2.1 *Rated voltage*

5.2.1.1 *Rated operational voltage (U_e)*

The rated operational voltage (hereafter referred to as rated voltage U_n) of a RCM is the value of voltage, assigned by the manufacturer, to which its performance is referred.

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

5.2.1.2 *Rated insulation voltage (U_i)*

The rated insulation voltage of a RCM 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 RCM. In no case shall the maximum rated voltage exceed the rated insulation voltage.

5.2.2 *Rated current (I_n)*

The value of current, assigned to the RCM by the manufacturer, which the RCM can carry in uninterrupted duty. [A1) *Text deleted* (A1]

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

The value of residual operating current (see **3.2.4**), assigned to the RCM by the manufacturer, at which the RCM shall operate under specified conditions.

NOTE For a RCM having multiple settings of residual operating current the highest setting is used to designate it.

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

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

5.2.5 *Rated frequency*

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

NOTE The same RCM may be assigned a number of rated frequencies.

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

Actuation is ensured by RCM for residual sinusoidal alternating currents and residual pulsating direct currents, whether suddenly applied or slowly rising.

NOTE This operating characteristic corresponds to type A of IEC 61008-1.

5.2.7 ***Insulation coordination including clearances and creepage distances***

Under consideration.

NOTE For the time being clearances and creepage distances are given in **8.1.3**.

5.3 Standard and preferred values

5.3.1 ***Preferred values of rated voltage (U_n)***

The voltages 230 V and 400 V are standardized according to IEC 60038. These values shall progressively replace the values 220 V and 240 V, 380 V and 415 V, respectively.

Wherever in this standard there is a reference to 230 V and 400 V, they may be read as 220 V or 240 V, 380 V or 415 V, respectively.

For single-phase three-wire systems the standardized voltages are 120/240 V.

5.3.2 ***Preferred values of rated current (I_n)***

Preferred values of rated current are (only for RCMs according to **4.9.2**)

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

NOTE For RCMs according to **4.9.1** the rated current is limited by the physical size of the current transformer, external or internal to the RCM itself.

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

[A1) Preferred (A1] values of rated residual operating current are

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

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

[A1) *Note deleted* (A1]

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

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

NOTE For residual pulsating direct currents residual non-operating currents depend on the current delay angle α (see **3.1.4**).

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

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

5.3.6 ***Standard minimum value of the non-operating overcurrent through a RCM (see 3.4.2.2)***

The standard minimum value of the non-operating overcurrent through a RCM is 6 I_n.

This clause does not apply to RCMs classified according to **4.9.1**. The minimum value of the non-operating overcurrent through a RCM classified according to **4.9.1** shall be taken into account to declare the rated current (see note to **5.3.2**). For this purpose RCMs according to **4.9.1** with adjustable residual operating current shall be set at the lowest value appropriate to each current transformer.

5.3.7 ***Preferred values of rated frequency***

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

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

5.3.8 ***Standard and preferred values of the rated conditional short-circuit current (I_{nc}) (only applicable to RCMs classified according to 4.9.2)***

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. They are:

3 000 – 4 500 – 6 000 – 10 000 A.

The associated power factors are specified in Table 13.

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 13.

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

5.3.9 ***Maximum actuating time (T_{max})***

The actuating time for residual currents equal to or greater than $I_{\Delta n}$ shall not exceed 10 s.

[A1] **5.3.10** ***Minimum non-actuating time (T_{min})***

For RCMs with minimum non-actuating time according to **3.3.15**, this time shall be declared by the manufacturer. [A1]

5.4 Coordination with short-circuit protective devices (SCPDs) (only valid for RCMs classified according to 4.9.2)

5.4.1 ***General***

RCMs 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 RCMs and the SCPD shall be verified under the general conditions of **9.11.2.1**, by means of the tests described in **9.11.2.2** which are designed to verify that there is an adequate protection of the RCMs 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 a RCM, protected by a SCPD, can withstand under specified conditions without undergoing alterations impairing its functions.

The conditions are those specified in **9.11.2.2** a).

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

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

The conditions are those specified in **9.11.2.2** b).

6 Marking and other product information

[A1⟩ Each RCM and external devices of RCMs, if applicable, shall be marked in a durable manner with the following data: ⟨A1]

a) the manufacturer's name or trade mark;

b) type designation, catalogue number or serial number;

c) rated voltage(s);

d) rated frequency, if the RCM is designed for frequencies other than 50 Hz and/or 60 Hz (see **5.3.7**);

e) rated current;

f) rated residual operating current;

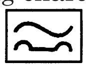
g) settings of residual operating current in case of RCMs with multiple residual operating current settings;

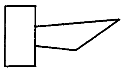
h) the degree of protection (only if different from IP20);

j) the position of use (symbol according to IEC 60051), if necessary;

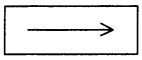
k) operating means of the test device, by the letter T;

l) wiring diagram;

m) operating characteristic in presence of residual currents with d.c. components with the symbol: 

n) disabling means for the audible signal, by the symbol: 

o) installation instructions, including identification of current transformer(s) which may be used with the RCM;

p) directionally discriminating RCM by the symbol: 

[A1⟩ q) the maximum actuating time (see **5.3.9**);

r) the minimum non-actuating time (see **5.3.10**);

s) the FE-terminal shall be marked "FE".

If, for small devices, the space available does not allow all the above data to be marked, at least the information under e), f), k) and, as applicable, o) and p) shall be marked and visible when the device is installed. The remaining information shall be given in the manufacturer's catalogues. ⟨A1]

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

Table 1 — Standard conditions for operation in service

Influencing quantity	Standard range of application	Reference value	Test tolerances[f]
Ambient temperature [ag]	– 5 °C to + 40 °C[b]	20 °C	± 5 °C
Altitude	Not exceeding 2 000 m		
Relative humidity maximum value at 40 °C	50 %[c]		
External magnetic field	Not exceeding 5 times the earth's magnetic field in any direction	Earth's magnetic field	[d]
Position	As stated by the manufacturer, with a tolerance of 2° in any direction[e]	As stated by the manufacturer	2° in any direction
Frequency	Reference value ± 5 %	Rated value	± 2 %
Sinusoidal wave distortion	Not exceeding 5 %	Zero	5 %

[a] The maximum value of the mean daily temperature is + 35 °C.

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

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

[d] When a RCM is installed in proximity of a strong magnetic field, supplementary requirements may be necessary.

[e] The device shall be fixed without causing deformation liable to impair its functions.

[f] The tolerances given apply unless otherwise specified in the relevant test.

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

Additional components, e.g. separate warning units, shall be marked according to a), b), c), d) and n) (if applicable).

If, for small devices, the space available does not allow all the above data to be marked, at least the information under e), f), k) and n) shall be marked and visible when the device is installed. The information under a), b), c), j), l) and 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 l) 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 catalogue.

The manufacturer shall give the reference of one or more suitable SCPDs in his catalogues and in a sheet accompanying each RCM classified under **4.9.2**.

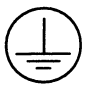
Red shall not be used for the test button nor for the resetting means, if any, of the RCM.

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 on the RCM for connecting the current transformer shall be clearly identified.

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 60417-2-5019 a)].

NOTE The symbol  [IEC 60417-2-5017 a)], previously recommended, shall be progressively superseded by the preferred symbol IEC 60417-2-5019 a), 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****.*

7 Standard conditions for operation in service and for installation

7.1 Standard conditions

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

7.2 Conditions of installation

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

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 *General*

A RCM may provide for remote indication of the fault condition.

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

Where RCMs are fitted with an internal current transformer (CT), but have the capability of selecting an optional external CT, all relevant tests shall be carried out using the internal CT. The proper function of the external CT shall, however, be confirmed by testing it once according to **9.9.4**.

8.1.2 *Features*

[A1) The RCM shall be provided with a visual "Power on" indicator which shall neither be red, yellow nor blue. (A1]

The RCM shall be provided with means for indicating a fault condition when the residual current exceeds the preset operating value, the primary indicating means being visual. The visual indicating means shall be an integral part of the RCM and shall be easily discernible from the front of the RCM when installed as for normal use. This visual indicating means shall not be coloured green. It shall not be possible to override the visual alarm whilst the fault is present.

NOTE A visual alarm may also be part of a remote alarm unit, where it shall be clearly visible when installed.

Where an audible alarm is provided in addition, the audible signal shall be easily perceptible by persons with normal hearing and may have adjustable sound level. It is permissible to switch off the audible alarm whilst the fault is present.

The audible alarm, if any, shall be automatically self-resetting on removal of the fault. In the event of a subsequent fault following removal of the first fault, the audible alarm shall be reactivated.

RCMs may be fitted with a resetting means to manually reset the RCM to the non-alarm state after removal of the fault. RCMs not fitted with a resetting means shall reset automatically after removal of the fault.

Where means are provided for adjustment of the residual operating current or of the delay time, such adjustment shall only be possible by the use of a tool.

Compliance with the above paragraphs is checked by inspection during the tests according to ***9.9***.

[A1) 8.1.3 *Clearances and creepage distances (see also Annex B)*

Clearance and creepage distances applicable to the RCM and its external components, e.g. current transformers etc., with the exception of printed circuit boards, shall comply with the requirements of Table 2 when the RCM is mounted as for normal use.

The above requirements shall also apply to active conductors (phases and neutral) connected directly to the printed circuit board.

Creepage distances applicable to printed circuit boards of the RCM shall comply with the requirements of Table 4 of IEC 60664-1, "Creepage distances to avoid failure due to tracking", Pollution degree 2, Material group III.

Table 4 of IEC 60664-1 includes requirements for uncoated printed circuit boards. IEC 60664-3 provides for reduced clearance and creepage distances for printed circuit boards using a protective coating, potting or moulding. Such printed circuit boards may therefore be verified for compliance in accordance with IEC 60664-3 instead of Table 4 or IEC 60664-1. (A1]

Table 2 — Clearances and creepage distances

Description	Distance mm
Clearances[a]	
— between live parts of different polarity[bc]	3
— between live parts and	
• metal resetting means	3
• metal test button	3
• screws or other means for fixing covers which have to be removed when mounting the RCM	3
• the surface on which the base is mounted[d]	6 (3)
• screws or other means for fixing the RCM[d]	6 (3)
• metal covers or boxes[d]	6 (3)
• other accessible metal parts[e]	3
• metal frames supporting flush-type RCMs	3
Creepage distances[a]	
— between live parts of different polarity[bc]	
• for RCMs having a rated voltage not exceeding 250 V	3
• for other RCMs	4
— between live parts and	
• metal resetting means	3
• metal test button	3
• screws or other means for fixing covers which have to be removed when mounting the RCM	3
• screws or other means for fixing the RCMs[d]	6 (3)
• accessible metal parts[e]	3

[a] Clearances and creepage distances of the secondary circuit and between the primary windings of the RCM transformer are not considered.

[b] Care should be taken for providing adequate spacing between live parts of different polarity of RCMs of the plug-in type mounted close to one another. Values are under consideration.

[c] In some countries greater distances between terminals are used in accordance with national practices.

[d] If clearances and creepage distances between live parts of the device and the metallic screen or the surface on which the RCM is mounted are dependent on the design of the RCM only, so that they cannot be reduced when the RCM is mounted in the most unfavourable position (even in a metallic enclosure), the values in brackets are sufficient.

[e] Including a metal foil in contact with the surfaces of insulating material which are accessible after installation as for normal use. The foil is pushed into corners, grooves, etc., by means of a straight jointed test finger according to **9.6**.

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 RCM during installation shall not be of the thread-cutting type.

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

*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 **9.21**.

8.1.4.2 For screws in engagement with a thread of insulating material and which are operated when mounting the RCM 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 with respect to the stability of the dimensions.

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

— copper;

— an alloy containing at least 58 % copper for parts worked cold, or at least 50 % copper for other parts;

— other metal or suitably coated metal, no less resistant to corrosion than copper and having mechanical properties no less suitable.

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

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

8.1.5 ***Terminals for external conductors***

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

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

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

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

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

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

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

8.1.5.2 RCMs according to classification **4.9.2** shall be provided with terminals which shall allow the connection of copper conductors having nominal cross-sectional areas as shown in Table 3.

NOTE For conductors of signalling circuits smaller cross-sections and smaller terminals are permitted.

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.

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 wires 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**.*

Table 3 — Connectable cross-sections of copper conductors for screw-type terminals

Rated current A		Range of nominal cross-section to be clamped[a] mm^2	
Greater than	**Up to and including**	**Rigid (solid or stranded) conductors**	**Flexible conductors**
—	13	1 to 2,5	1 to 2,5
13	16	1 to 4	1 to 4
16	25	1,5 to 6	1,5 to 6
25	32	2,5 to 10	2,5 to 6
32	50	4 to 16	4 to 10
50	80	10 to 25	10 to 16
80	100	16 to 35	16 to 25
100	125	24 to 50	24 to 35

NOTE For correspondence between ISO and AWG cross-sections see Annex ID of IEC 61008-1.

[a] 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 mm^2 up to 6 mm^2 be designed to clamp solid conductors only.

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* ***9.5.2****.*

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

This requirement does not apply to lug terminals.

Compliance is checked by the test of ***9.5.3****.*

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, common designs of terminals provide sufficient resilience to comply with this requirement; for some 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

RCMs 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 RCMs 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**).

[A1) The continuous current through the protective conductor shall not exceed 1 mA under normal supply conditions. (A1]

For RCMs other, than those of the plug-in type, external parts, other than screws or other means for fixing covers and labels, which are accessible when the RCMs 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 RCMs. 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 RCMs external parts other than screws or other means for fixing covers, which are accessible for normal use, shall be of insulating material.

Metallic resetting means and metallic test buttons 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 resetting means of several current paths.

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

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

[A1) *Compliance is checked by measurement, by inspection and by the test of* ***9.6****.* (A1]

8.3 Dielectric properties

RCMs shall have adequate dielectric properties.

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

Compliance is checked by the tests of ***9.7*** *and* ***9.18****.*

8.4 Temperature rise

This subclause is applicable to RCMs classified under **4.9.2**. The temperature rise of RCMs classified under **4.9.1** is verified only by the test of **9.10.2.2**.

8.4.1 *Temperature-rise limits*

The temperature rises of the parts of a RCM specified in Table 4, measured under the conditions specified in **9.8.2**, shall not exceed the limiting values stated in Table 4.

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

8.4.2 *Ambient air temperature*

The temperature-rise limits given in Table 4 are applicable only if the ambient air temperature remains between the limits given in Table 1.

8.5 Operating characteristic

The operating characteristic of RCMs shall comply with the requirements of **9.9**.

8.6 Directional discrimination

[A1] **8.6.1** [A1] For RCMs which are declared by the manufacturer to be able to discriminate between residual fault currents due to faults on the supply, side and faults on the load side, compliance is checked by the tests of **9.9.5**.

Table 4 — Temperature-rise values

Parts[a]	Temperature rise K
Terminals for external connections[b]	65
External parts liable to be touched during manual operation of the RCM	40
External metallic parts of resetting means and of test button	25
Other external parts, including that face of the RCM in direct contact with the mounting surface	60

[a] 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 RCM shall not be impaired.
[b] For plug-in type RCMs the terminals of the base on which they are installed.

[A1] **8.6.2** The internal impedance between line terminal and the FE terminal shall have a value not less than 10 MΩ at 50/60 Hz. At higher frequencies the impedance may be reduced proportionately, however to not less than 1 MΩ.

*Compliance is checked by the tests under **9.9.5**e).* [A1]

8.7 Operational endurance

The test circuit and the functions activated by the test device shall endure a prescribed number of operations, and the visible signal and the audible signal (if any) shall be able to operate in the alarm state for a prescribed period of time.

*Compliance is checked by the tests of **9.10**.*

8.8 Performance at short-circuit currents

RCMs shall be capable of withstanding a specified number of short-circuits during which they shall neither endanger persons or surroundings nor initiate flashovers between live parts or between such parts and earth.

*Compliance is checked by the tests of **9.11**.*

8.9 Resistance to mechanical impact

RCMs 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**.*

8.10 Resistance to heat

RCMs shall be sufficiently resistant to heat.

*Compliance is checked by the test of **9.13**.*

8.11 Resistance to abnormal heat and to fire

Parts of insulating material which might be exposed to thermal stresses due to electric effects, and the deterioration of which might impair the safety of the RCM, shall not be unduly affected by abnormal heat and fire.

*Compliance is checked by the tests of **9.14**.*

8.12 Test device

RCMs shall be provided with a test device in order to allow a periodic testing of the ability of the RCM to operate. The test circuit shall be designed for continuous operation at 1,1 times the rated voltage.

NOTE 1 The test device is intended to check the actuating function, not the value at which this function is effective with respect to the rated residual operating current.

The ampere-turns produced when operating the test device of an RCM supplied at rated voltage or at the highest value of the voltage range, if applicable, shall not exceed 3,5 times the ampere-turns produced, when a residual current equal to $I_{\Delta n}$ is passed through the RCM. Alternative means of testing the RCM are acceptable, provided these confirm the correct operation of the device.

In the case of RCMs having several settings of residual operating current (see **4.4**) the highest setting for which the RCMs have been designed shall be used. The test device shall comply with the test of **9.15**.

If the test circuit is operated through the protective conductor, the current flowing through the conductor shall not exceed 1 mA.

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

The RCM may be fitted with a latching facility which retains the fault indication after the fault is cleared. Where such facility exists, the RCM must be equipped with means for resetting.

*Compliance is checked by inspection, measurement and by the test of **9.15**.*

NOTE 2 Additional requirements, taking into account the influence of the distribution system in which the RCM is installed, are under consideration.

8.13 Correct operation of RCMs within the supply voltage range

RCMs shall function reliably at any voltage between 85 % and 110 % of the rated voltage(s).

*Compliance is checked by the tests of **9.9**.*

8.14 Behaviour of RCMs in case of overcurrents in the main circuit

RCMs shall not operate under specified conditions of overcurrents.

*Compliance is checked by the test of **9.16**.*

8.15 Resistance of RCMs to unwanted tripping due to current surges caused by impulse voltages

RCMs shall adequately withstand the current surges to earth due to the loading of the capacitances of the installation.

*Compliance is checked by the test of **9.17**.*

8.16 Behaviour of RCMs in case of earth fault currents comprising d.c. components

RCMs shall adequately perform in presence of earth fault currents comprising d.c. components.

*Compliance is checked by the tests of **9.19**.*

8.17 Reliability

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

*Compliance is checked by the tests of **9.20** and **9.21**.*

[A1⟩ **8.18 Electromagnetic compatibility** (Based on IEC 61543)

Standard electromagnetic environmental conditions are those conditions which occur in installations connected to low voltage public networks or similar installations. ⟨A1]

[A1) 8.18.1 *Low frequency electromagnetic phenomena*

The type tests set out in this standard contain the EMC requirements for low frequency electromagnetic phenomena as applicable to RCMs.

NOTE Additional tests covering harmonics, interharmonics and signalling voltages are being considered (IEC SC 23E). (A1]

[C1)

Table Z.1 — Low frequency immunity test conditions

Reference (see Table 1 of IEC 61543)	Electromagnetic phenomena	Reference of basic standard for test description	Test level and test specification	Subclause including the performance criteria
T 1.1	Harmonics, inter harmonics	No requirements [a]		
T 1.2	Signalling voltages	No requirements		
T 1.3	Voltage amplitude variations			
	Voltage fluctuations (see NOTE 1)	**9.9** and **9.15**	From 0,85 U_n to 1,1 U_n	**9.15**
	Voltage dips	No requirements		
	Voltage interruptions	No requirements		
T 1.4	Voltage unbalance	Refer to T 1.3		
T 1.5	Power frequency variations	See NOTE 2		
T 1.8	Magnetic field	**9.11** and **9.16**		

NOTE 1 Tests specified in product standards do not need to be repeated. The functioning of RCMs functionally independent of line voltage is not affected by voltage amplitude variations. The tests of this standard apply only to RCMs dependent on line voltage.

NOTE 2 Immunity from power frequency variations is ensured by the fact that all performances of the device are tested at frequencies which may be subjected to variations in the range of ± 5 % of the rated frequency: see **9.2**.

[a] A study is undertaken for possible inclusion of requirements in a future revision.

(C1]

[A1) 8.18.2 *High frequency immunity*

The data for the high frequency immunity to be applied are set out in Table 15.

8.18.3 *Electrostatic discharges*

The data for the electrostatic discharge tests to be applied are set out in Table 15.

8.18.4 *Electromagnetic emission*

Emission tests are required for RCMs producing continuous or intermittent output signals. The tests shall be carried out according to CISPR 14-1.

NOTE RCMs other than those containing a continuously operating oscillator do not usually generate continuous or transient disturbances except during their switching process. The frequency, the level and the consequences of such emissions are considered as part of the normal electromagnetic environment of low-voltage installations. (A1]

A1

Table 15 — EMC Tests

Test No.	Subclause including the performance criteria	Test title	Reference of basic standard for test description	Test level and specification
T 2.1	**9.22**	Conducted high frequency test	IEC 61000-4-6	0,15 MHz to 80 MHz Z = 150 Ω 3 V for $I_{\Delta n} \geq$ 30 mA 1 V for $I_{\Delta n}$ < 30 mA
T 2.2	**9.22**[a]	Fast transients (bursts) common mode	IEC 61000-4-4	Level 4: 4 kV (peak), on power supply port, and 2 kV (peak), on control (auxiliary port) Tr/Th 5/50 ns Repetition frequency 2,5 kHz
T 2.3[b]	**9.22**[b]	Surges	IEC 61000-4-5	Tr/Th 1.2/50 μs 4 kV (peak)/12 Ω Common mode 2 kV (peak)/2 Ω Differential mode
T 2.5	**9.22**	Radiated high-frequency phenomena	IEC 61000-4-3	3 V/m, 80 MHz to 1 000 MHz
T 3.1[c]	**9.22**	Electrostatic discharge	IEC 61000-4-2	Level 3, 8 kV air, 6 kV contact

[a] The test is carried out as a single-phase test on one pole of each sample, taken at random. Three new samples are submitted to the test. If one sample does not comply with the criterion by tripping during the test, three further samples are tested, which shall fully comply with the criterion of **9.22**.

[b] Common mode and differential mode tests are carried out only at the values stated in this table.

[c] The point to which discharges shall be applied is selected by an exploration of the accessible surfaces of the RCM when installed as for normal use. The selection is made with 20 discharges per second. The selected point is tested with 10 positive and 10 negative polarity discharges with a time interval of minimum 1 s between discharges.

A1

8.19 Connection of an external current transformer (CT)

If an external CT is used, the RCM shall automatically switch to the alarm state if the CT is disconnected.

Compliance is checked by the tests of ***9.9.4****.*

9 Tests

9.1 General

9.1.1 *The characteristics of RCMs are checked by means of type tests.*

Type tests required by this standard are listed in Table 5.

Table 5 — List of type tests depending on RCM classification

Test	Subclause	Classification according to	
		4.9.1	4.9.2
— Indelibility of marking	**9.3**	X	X
— Reliability of screws, current-carrying parts and connections	**9.4**	X	X
— Reliability of terminals for external [A1⟩ conductors ⟨A1]	**9.5**	n.a.	X
— Protection against electric shock	**9.6**	X	X
— Dielectric properties	**9.7**	X	X
— Temperature rise	**9.8**	n.a.	X
— Operating characteristics	**9.9**	X	X
— Operational endurance	**9.10**	X	X
— Behaviour of RCMs under short-circuit conditions	**9.11**	n.a.	X
— Resistance to mechanical impact	**9.12**	X	X
— Resistance to heat	**9.13**	X	X
— Resistance to abnormal heat and fire	**9.14**	X	X
— Operation of the test device at the limits of rated voltage	**9.15**	X	X
— Limiting values of the non-operating current under overcurrent conditions	**9.16**	X	X
— Resistance against unwanted actuation due to an impulse voltage	**9.17**	X	X
— Resistance of the insulation against an impulse voltage	**9.18**	X	X
— Behaviour of RCMs in case of an earth fault current comprising a d.c. component	**9.19**	X	X
— Reliability	**9.20**	X	X
— Ageing of electronic components	**9.21**	X	X
— Electromagnetic compatibility (under consideration)	**9.22**	X	X
NOTE n.a. = not applicable			

Table 6 — Test copper conductors corresponding to the rated currents

Rated current I_n A	$I_n < 6$	$6 < I_n < 13$	$13 < I_n < 20$	$20 < I_n < 25$	$25 < I_n < 32$	$32 < I_n < 50$	$50 < I_n < 63$	$63 < I_n < 80$	$80 < I_n < 100$	$100 < I_n < 125$
Cross-section mm^2	1	1,5	2,5	4	6	10	16	25	35	50

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

NOTE The term "certification" denotes either a 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 RCMs in a clean and new condition, the influencing quantities having their normal reference values (see Table 1).

9.1.3 *Routine tests are to be carried out by the manufacturer on each device.*

9.2 Test conditions

The RCM is mounted individually according to the 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.
RCMs designed for installation in individual enclosures are tested in the smallest enclosure specified by the manufacturer.

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

Unless otherwise specified, the RCM is wired with the appropriate cable having the cross-section specified in Table 6 and is fixed on a dull black painted plywood board of about 20 mm thickness, the method of fixing being in compliance with the requirements relating to the indications of the manufacturer concerning mounting.

NOTE 2 For correspondence between ISO and AWG copper conductors, see Annex ID of IEC 61008-1.

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 ± 5 %.

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

*For the tests of **9.8**, **9.9**, **9.10** and **9.21**, the RCM 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 length, with a tolerance of $^{+5}_{0}$ cm, of each temporary connection from terminal to terminal is*

- *1 m for cross-sections up to and including 10 mm^2;*
- *2 m for cross-sections larger than 10 mm^2.*

The tightening torques to be applied to the terminal screws are two-thirds of those specified in Table 7.

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 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 RCM, 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 7.

The screws and nuts shall not be tightened in jerks.

The test is made with rigid conductors only, having the largest cross-sectional areas specified in Table 3, solid or stranded, whichever is the most unfavourable. The conductor is moved each time the screw or nut is loosened.

Table 7 — 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

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 RCM.

Moreover, enclosures and covers shall not be damaged.

9.5 Test of reliability of terminals for external 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 3 is placed in the terminal (for nominal cross-sections exceeding 6 mm^2, a rigid stranded conductor is used; for other nominal cross-sections, a solid conductor is used), and by the tests of* ***9.5.2****,* ***9.5.2*** *and* ***9.5.3*** *using a suitable test screwdriver or spanner.*

9.5.1 *The terminals are fitted with copper conductors of the smallest and largest cross-sectional areas specified in Table 3, solid or stranded, whichever is the most unfavourable.*

The conductor is inserted into the 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 permit the solid conductor or a strand (or strands) to escape.

The clamping screws are then tightened with a torque equal to two-thirds of that shown in the appropriate column of Table 7.

Each conductor is then subjected to the pull shown in Table 8.

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

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

9.5.2 *The terminals are fitted with copper conductors of the smallest and largest cross-sectional areas specified in Table 3, 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 7.*

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 a rigid stranded copper conductor having the make-up shown in Table 9.*

Table 8 — Pulling forces

Cross-section of conductor accepted by the terminal mm^2	**Up to and including 4**	**Up to and including 6**	**Up to and including 10**	**Up to and including 16**	**Up to and including 50**
Pull *N*	50	60	80	90	100

Table 9 — Conductor dimensions

Range of nominal cross-sectionsto be clamped mm^2	**Stranded conductor**	
	Number of strands	**Diameter of strands** mm
1,0 to 2,5[a] inclusive	7	0,67
1,0 to 4,0[a] inclusive	7	0,85
1,5 to 6,0[a] inclusive	7	1,04
2,5 to 10,0 inclusive	7	1,35
4,0 to 16,0 inclusive	7	1,70
10,0 to 25,0 inclusive	7	2,14
16,0 to 35,0 inclusive	19	1,53
25,0 to 50,0 inclusive	Under consideration	Under consideration

[a] If the terminal is intended to clamp solid conductors only (see [a] of Table 3), the test is not made.

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 7.

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

9.6 Verification of protection against electric shock

This requirement is applicable to those parts of RCMs 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 RCM 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 RCM.*

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.

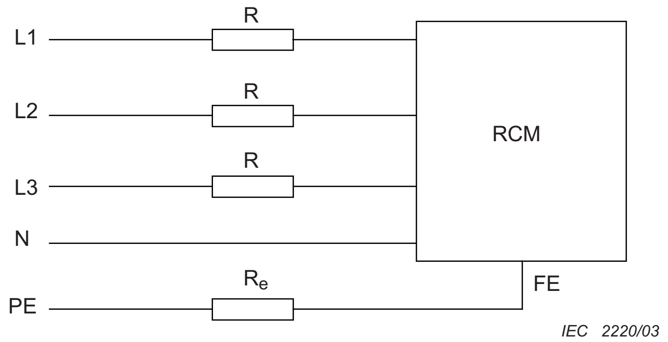
RCMs with enclosures or covers of thermoplastic material are subjected to the following additional test, which is carried out at an ambient temperature of 35 °C ± 2 °C, the RCM being at this temperature.

RCMs 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 RCM, 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 RCMs 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.

[A1⟩ *RCMs equipped with a functional earth connection (FE) shall be tested by means of the test circuit and the test description shown below.*



$R = R_e = 1\ \Omega$

The RCM is supplied at 1,1 U_n. The voltage across R_e is measured under normal conditions. This voltage shall not exceed 1 mV. ⟨A1]

9.7 Test of dielectric properties

9.7.1 *Resistance to humidity*

9.7.1.1 *Preparation of the RCM for test*

Parts of the RCM 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 and T + 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 constant circulation of the air within and to use a cabinet which is thermally insulated.

9.7.1.4 *Condition of the RCM 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** and **9.7.3**.*

9.7.2 ***Insulation resistance of the RCM***

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

After an interval between 30 min and 60 min following the treatment of ***9.7.1****, a d.c. voltage of approximately 500 V is applied for 30 s as follows:*

— *between all supply conductors connected together and any exposed metal parts including metal screws or fixing devices and any metal test button or metal reset button if any, and a metal foil in contact with the surfaces of insulating material which are accessible after installation.*

The insulation resistance is then measured and shall not be less than 5 MΩ.

NOTE 1 A terminal provided for the connection of a PE conductor is considered as a metal part for the purpose of this test.

NOTE 2 See Table 16 for test conditions.

9.7.3 ***Dielectric strength of the RCM***

A test voltage of 2 000 V at power frequency is applied for 1 min as follows:

— *between the terminals of all supply conductors and the terminals provided for external connections to any exposed metal parts including metal screws or fixing devices and any metal test button or metal reset button, if any.*

The source of the test voltage shall be capable of supplying a short circuit current of 200 mA ± 10 %. No overcurrent tripping device of the source shall operate when the current in the output circuit is less than 100 mA.

Initially not more than half the prescribed voltage is applied, then the voltage 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 ignored.

NOTE 1 A terminal provided for the connection of a PE conductor is considered as a metal part for the purpose of this test.

NOTE 2 See Table 16 for test conditions.

9.7.4 ***Capability of the RCM to withstand high d.c. voltages due to insulation measurements***

This test is applicable only for RCMs with rated voltages greater than 50 V a.c. or greater than 120 V d.c.

The test is carried out on the RCM fixed on a metal support with all external circuits including the external CT and remote alarm unit if any being connected as in service.

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

— *open circuit voltage* $500\ V^{+25\%}_{0}$

— *maximum ripple 5 %*

$$\text{where ripple} = \frac{\text{max value} - \text{min value}}{\text{mean value}} \times 100$$

— *short circuit current:* (12^{+2}_{0}) *mA*

The test voltage is applied for 1 min between each supply terminal and the other supply terminals in turn.

NOTE See Table 16 for test conditions.

After this test, the RCM shall be capable of performing satisfactorily the tests specified in ***9.9.2****a), b) and c).*

[A1⟩

Table 16 — Summary of the tests contained in 9.7.2, 9.7.3 and 9.7.4.

Sub-clause	Title of test	How or where applied	Voltage	Conditions	Required result
9.7.2	Insulation resistance of the RCM	From all supply conductors connected together to any exposed metal parts including metal test button or metal reset button if any, and a metal foil in contact with the surfaces of insulating material which are accessible after installation.	500 V d.c. for 30 s	A terminal provided for the connection of a PE conductor is considered as a metal part for the purpose of this test. The FE terminal if any is treated as a supply conductor.	Insulation resistance > 5 MΩ
9.7.3	Dielectric strength of the RCM	Between all supply conductors and terminals provided for external connections and any exposed metal parts.	2 000 V a.c., 0,2 A for 1 min	A terminal provided for the connection of a PE conductor is considered as a metal part for the purpose of this test. The FE terminal if any is treated as a supply conductor.	No flash-over or breakdown shall occur during the test. Glow discharges without drop in voltage are ignored.
9.7.4	Capability of the RCM to withstand high d.c. voltages due to insulation measurements	Only for RCMs with rated voltage 50 V a.c. or 120 V d.c. The test is carried out on the RCM with all external circuits including the external CT and remote alarm unit if any connected as in service. The test voltage is applied between each supply terminal and the other supply terminals in turn.	Source with 500 V d.c. open circuit voltage and 12 mA short circuit current for 1 min	The FE if any is treated as a supply conductor for the purposes of this test.	After this test the RCM shall be capable of performing satisfactorily the tests specified in **9.9.2**a), b) and c).

⟨A1]

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 RCM at about half its height and at a distance of about 1 min from the RCM.

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*

RCMs and all relevant parts are mounted and connected according to the manufacturer's instructions and with the rated voltage applied. A residual current greater than $I_{\Delta n}$ shall be passed through the RCM to put it into the alarm state. Alarms, if any, shall not be switched off during this test. A current equal to I_n is passed simultaneously through all current paths of the RCM 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 RCMs with four current paths the test is first made by passing the specified current through the three current paths of the phases only.

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

During these tests the temperature rise shall not exceed the values shown in Table 4.

9.8.3 *Measurement of the temperature rise of parts*

The temperature of the different parts referred to in Table 4 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*

The RCM is installed as for normal use.
The test circuit shall be of negligible inductance and correspond to Figure 2a or Figure 2b, as applicable.

The instruments for the measurement of the residual current shall be at least of class 0,5 and shall show (or permit to determine) the true r.m.s. value.

The instruments for the measurement of time shall have a relative error not greater than 10 % of the measured values.

9.9.2 *Off-load tests with residual sinusoidal alternating currents at the reference temperature of 20 °C ± 2 °C*

The RCM shall perform the following tests made on one phase only, taken at random.

The RCM is connected according to the test circuit of Figure 2a, in the case of a sudden appearance of residual current.

The supply voltage is set at 110 % of the rated voltage. In the case of more than one rated voltage the test is made at each rated voltage.

RCMs with adjustable delay times are set to their minimum delay setting.

RCMs with adjustable residual operating current are set to their minimum value.

RCMs suitable for internal or external CTs shall be set for operation with internal CT.

For the tests a), b), c) and d), S_1 is initially set to the TN position.

a) *S_2 is opened.*
Resistor R_1 is calibrated so as to provide a current of $0{,}5 \times I_{\Delta n}$ through the current transformer connected to the ammeter.
S_2 is closed for 15 s.
The RCM shall not switch to the alarm state.

b) *S_2 is opened.*

Resistor R_1 is calibrated so as to provide a current of $I_{\Delta n}$ through the current transformer connected to the ammeter.

[A1) *— For RCMs without time delay this test is not applicable.*

— For RCMs with time delay, S_2 is closed for a period of 0,3 times the maximum non-actuating time of the RCM as declared by the manufacturer. (A1]

The RCM shall not switch to the alarm state.

c) *S_2 is opened.*

Resistor R_1 is calibrated for a current of $I_{\Delta n}$ through the current transformer connected to the ammeter.

S_2 is closed for 15 s.

The RCM shall switch to the alarm state.

The time taken for the RCM to switch to the alarm state is measured. This time shall fall within the actuating time declared by the manufacturer and shall not exceed 10 s.

d) *S_2 is opened.*

Resistor R_1 is calibrated for a current of 5 $I_{\Delta n}$ through the current transformer connected to the ammeter.

S_2 is closed for 15 s.

The RCM shall switch to the alarm state.

The time taken for the RCM to switch to the alarm state is measured. This time shall fall within the actuating time declared by the manufacturer shall not exceed 10 s.

e) *Test a), b), c) and d) are repeated at 0,85 U_n.*

f) *Tests a), b), c), d) and e) are repeated with S_1 in the TT position.*

g) *For RCMs with adjustable delay time the tests a), b), c), d) and e) are repeated at their maximum setting of time delay.*

h) *For RCMs with adjustable residual operating current the tests a), b), c), d) and e) are repeated at their maximum setting of residual operating current.*

9.9.3 *Verification of the correct operation with load at the reference temperature*

*The tests of **9.9.2** are repeated, the RCMs being loaded with rated current and rated supply voltage as in normal service for a sufficient time so as to reach steady-state conditions.*
In practice these conditions are reached when the variation of temperature rise does not exceed 1 K per hour.

9.9.4 *Verification of the connection and the function of an external current transformer (CT)*

This test is only applicable to RCMs with facility for connection of an external CT.

a) *The external CT is connected to the RCM as in normal use as prescribed by the manufacturer.*

The RCM is connected according to the test circuit of Figure 2a and is supplied with rated supply voltage.

S_1 is in the TT position and S_2 is opened.

RCMs with adjustable time delay shall be set at their maximum time delay-setting.

RCMs with adjustable residual operating current shall be set to their lowest level.

There shall be no fault current flowing in the CT and the test circuit shall not be activated.

The external CT is disconnected and the RCM shall switch to the alarm state within 10 s.

This test is repeated twice, by re-connecting and subsequently disconnecting the CT.

Following this test the resistor R_1 is adjusted so as to provide a current of $I_{\Delta n}$ through the external CT which is connected to the ammeter.

S_2 is closed for 15 s.

The RCM shall switch to the alarm state.

The time taken for the RCM to switch to the alarm state is measured. This time shall fall within the actuating time declared by the manufacture and shall not exceed 10 s.

b) *For RCMs with multiple settings of rated residual operating current, the test of* ***9.9.4*** *a) is made at the lowest and highest settings.*

9.9.5 ***Verification of directional discrimination for RCMs classified according to 4.11***

The RCM is connected according to the test circuit of Figure 2b. For RCMs having multiple settings of residual operating current, the tests are made at the maximum and at the minimum settings.

a) *Fault on the load side of the RCM:*

S_1 is opened, S_2 is in position 1, S_3 is closed, S_4 is opened.

[A1) *Text deleted* (A1]

S_4 is closed for 15 s.

The RCM shall switch to the alarm state within the actuating time specified by the manufacturer.

b) *Fault on the supply side of the RCM:*

S_1 is opened, S_2 is in position 2, S_3 is closed, S_4 is opened.

The resistor R_1 [A1) *is* (A1] *adjusted to practically 0 Ω.*

S_4 is closed for 15 s.

The RCM shall not switch to the alarm state.

c) *Discrimination against transient faults on the supply side of the RCM:*

S_1 is opened, S_2 is in position 2, S_3 is closed, S_4 is opened.

With the same adjustments and settings as under b) above, switch S_4 is closed for approximately two times the declared actuating time of the RCM and then opened for approximately 5 s.

For an RCM with adjustable time delay the test shall be conducted at the lowest setting of the time delay.

The RCM shall not switch to the alarm state.

This test is made 20 times.

d) *Discrimination against transient double faults on the supply side of the RCM when used in IT-systems.*

S_1 is closed, S_2 is in position 2, S_3 is closed, S_4 is closed.

Resistor R is calibrated for a current of 2 $I_{\Delta n}$.

S_4 is opened.

The procedure described under c) is repeated with S_1 closed and S_2 in position 2.

The RCM shall not switch to the alarm state.

NOTE The main difference between the tests under c) and d) is that under c) the fault current is 90° leading in phase with respect to the voltage, while under d) the main part of the fault current is resistive and flows back to the supply side.

[A1) e) *Value of the internal impedance for directionally discriminating RCMs.*

The requirements under ***8.6.1*** *shall be verified.* (A1]

9.10 Verification of operational endurance

The tests in this subclause are made to verify the operational endurance of the test circuits and the alarm(s) of the RCM.

9.10.1 ***General test conditions***

The RCM and its remote alarm accessories, if any, are mounted as for normal operation, supplied with 1,1 times rated voltage.

9.10.2 ***Test procedure***

9.10.2.1 *Circuit for the cycling test*

The RCM shall undergo 500 test cycles as follows:

The test device is operated and maintained in the ON position until the alarm is activated.

For RCMs provided with manual reset, the test device is released as soon as the RCM alarm is activated. The RCM is then reset within 5 s.

For RCMs not provided with manual reset, the test cycle is repeated after a time interval between 1 s and 2 s.

After all the test cycles are completed, the test circuit, and the alarm(s) shall function satisfactorily, and no changes shall have occurred which may adversely affect the further use of the RCM.

9.10.2.2 *Endurance of alarm(s)*

The RCM is brought to the alarm state and maintained there for 48 h. All alarm functions shall remain switched on and they shall function properly during and after this test and no temperatures shall exceed those listed in Table 4.

9.11 Verification of short-circuit withstand capability

9.11.1 ***List of the short-circuit tests***

The tests to verify the withstand capability of RCMs under short-circuit conditions are the following:

— *withstand at rated conditional short-circuit current I_{nc},* ***9.11.2.2*** *a)*

— *withstand at rated conditional residual short-circuit current $I_{\Delta c}$* ***9.11.2.2*** *b).*

9.11.2 ***Short-circuit tests***

9.11.2.1 *General conditions for test*

The conditions of ***9.11.2*** *are applicable to all tests intended to verify the behaviour of the RCMs under short-circuit conditions.*

NOTE 1 For RCMs having multiple settings of the residual operating current the tests are made at the lowest setting.

a) *Test circuit (applies only to RCMs classified according to* ***4.9.2*** *and* ***4.3****).*

Figure 5, Figure 6 and Figure 7 respectively give diagrams of the circuits to be used for the tests concerning

— *RCM with two current paths;*

— *RCM with three current paths;*

— *RCM with four current paths.*

The supply S feeds a circuit including resistors R, reactors L, the SCPD (if any) (see ***3.4.5****), the RCM under test (D), and the additional resistors R_2 and/or R_3, 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 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 taking approximately 0,6 % of the current through the reactor, unless otherwise agreed between manufacturer and user.

In each test circuit the resistors R and reactors L are inserted between the supply source S and the RCM.

The SCPD is inserted between the resistors R and the RCM.

The additional resistors R_3, if used, shall be inserted on the load side of the RCM.

*For the tests of **9.11.2.2** a) and b) the RCM shall be connected with cables having a length of 0,75 m per phase and the maximum cross-section corresponding to the rated current according to Table 3.*

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 RCM.

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.

R_2, suitably calibrated, is a resistance used to obtain the rated conditional residual short-circuit current $I_{\Delta c}$.

S_1 is an auxiliary switch.

The SCPD, if any, may be a circuit-breaker or a fuse, having Joule integral I^2t and peak current I_p not exceeding the I^2t and peak current I_p withstand capabilities stated by the manufacturer for the RCM.

For the purpose of verifying the minimum I^2t and I_p values to be withstood by the RCM, in order to obtain reproducible test results, the SCPD, if any, shall be embodied by a silver wire using the test apparatus shown in Figure 8.

The silver wire shall have at least 99,9 % purity and a diameter as given in Table 11, according to the rated current I_n and the short-circuit currents I_n and $I_{\Delta c}$.

The corresponding approximate values of let-through energy I^2t and peak current are given in Table 12 and are considered conventionally as minimum values of reference.

The silver wire shall be inserted in the appropriate position of the test apparatus, horizontally and stretched. The silver wire shall be replaced after each test.

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

For coordination with circuit-breakers, tests with the appropriate circuit-breaker are necessary.

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

This connection shall include a copper wire F of 0,1 mm diameter and not less than 50 mm in length for the detection of the fault current and, if necessary, a resistor R_1 limiting the value of the prospective fault current to about 100 A.

The current sensors O_1 are connected on the load side of the RCM.

The voltage sensors O_2 are connected:

- *— across the terminals of one phase, for RCMs with two current paths;*
- *— across the supply terminals, for RCMs with three or four current paths.*

Unless otherwise stated in the test report, the resistance of the measuring circuits shall be at least 100 Ω per volt of the power-frequency recovery voltage.

RCMs functionally dependent on line voltage are supplied on the line side with the rated voltage (or, if relevant, with a voltage having the lower value of its range of rated voltages).

b) *Tolerances on test quantities*

All the tests concerning the verification of the correct coordination between RCMs and SCPDs shall be performed at values of influencing quantities and factors as stated by the manufacturer.

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

- *Current:* $^{+5}_{0}$ %;
- *Frequency:* ± 5 %;
- *Power factor:* $^{0}_{-0,05}$;
- *Voltage (including recovery voltage):* ± 5 %.

c) *Power factor of the test circuit*

The power factor of each phase of the test circuit shall be determined according to a recognized method which shall be stated in the test report.

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

The power factor shall be in accordance with Table 13.

Table 11 — Silver wire diameter as a function of rated current and short-circuit currents

All currents are in amperes.

I_{nc} and $I_{\Delta c}$ A	Silver wire diameter[a] (mm) corresponding to					
	I_n < 16	16 < I_n < 32	32 < I_n < 40	40 < I_n < 63	63 < I_n < 80	80 < I_n < 125
500	0,30	0,35				
1 000	0,30	0,50				
1 500	0,35	0,50	0,65	0,85		
3 000	0,35	0,50	0,60	0,80	0,95	1,15
4 500	0,35	0,50	0,60	0,80	0,90	1,15
6 000	0,35	0,50	0,60	0,75	0,90	1,00

[a] The silver wire diameter values are essentially based on peak current (I_p) considerations (see Table 12).

d) *Calibration of the test circuit*

The RCM and the SCPD or silver wire are replaced by temporary connections G_1 having a negligible impedance compared with that of the test circuit. If the RCM has no terminals for the main current, i.e. the cables are going through a current transformer core, the cables are routed outside this core during the calibration.

For the test of ***9.11.2.2*** *a) the load terminals of the RCM being short-circuited by means of the connections G_2 of negligible impedance, the resistors R and the reactors L are adjusted so as to obtain a current equal to the rated conditional short-circuit current at the prescribed power factor; the test circuit is energized simultaneously in all phases and the current curve is recorded with the current sensor O_1.*

For the test of **9.11.2.2** *b), only one cable is conducted through the RCM (or the current transformer), the magnitude of the residual conditional short-circuit current being adjusted by means of the resistance R and the reactor L.*

e) *Sequence of operations*

The short circuit is established by the switch T, with the SCPD or silver wire in the closed position.

The SCPD or the silver wire opens the circuit.

f) *Behaviour of the RCM under test*

During the test the RCM shall not endanger the operator.

g) *Condition of the RCM after test*

After each of the tests applicable and carried out in accordance with ***9.11.2.2*** *a) and* ***9.11.2.2*** *b) the RCM shall show no damage impairing its further use and shall be capable, without maintenance, of complying with the requirements of* ***9.7.3****, without previous humidity treatment.*

Under the test conditions of ***9.9.2.1*** *a) the RCM shall operate with a test current of 1,25 $I\Delta_n$. One test only is made at one phase taken at random, without measurement of actuating time.*

Table 12 — Minimum values of I^2t and I_p

I_{nc} and $I_{\Delta c}$		$I_n < 16$	$16 < I_n < 32$	$32 < I_n < 40$	$40 < I_n < 63$	$63 < I_n < 80$	$80 < I_n < 125$
500	I_p kA	0,45	0,57				
	I^2t kA^2s	0,40	0,68				
1 000	I_p kA	0,65	1,18				
	I^2t kA^2s	0,50	2,7				
1 500	I_p kA	1,02	1,5	1,9	2,1		
	I^2t kA^2s	1	4,1	9,75	22		
3 000	I_p kA	1,1	1,85	2,35	3,3	3,7	3,95
	I^2t kA^2s	1,2	4,5	8,7	22,5	36	72,5
4 500	I_p kA	1,15	2,05	2,7	3,9	4,8	5,6
	I^2t kA^2s	1,45	5	9,7	28	40	82
6 000	I_p kA	1,3	2,3	3	4,05	5,1	5,8
	I^2t kA^2s	1,6	6	11,5	25	47	65

NOTE 1 At the request of the manufacturer a silver wire of a larger diameter may be used to verify coordination at values of I^2t and I_p higher than the minimum.

NOTE 2 For intermediate values of short-circuit test currents the silver wire diameter should be that corresponding to the next higher current in the table.

NOTE 3 If another protective device gives the same results as the relevant silver wire in this test apparatus, it may be used for the test; for example, a fuse may be used for the test with the agreement of the manufacturer, if the corresponding I^2t and I_p values are nearly the same, but in any case not smaller than those of the silver wire used with the test apparatus. In case of doubt, the test should be repeated with the test apparatus.

Table 13 — Power factors for short-circuit tests

Short-circuit current I_c A	Power factor
$I_c <$ 500	0,95 to 1,00
$500 < I_c < 1\,500$	0,93 to 0,98
$1\,500 < I_c < 3\,000$	0,85 to 0,90
$3\,000 < I_c < 4\,500$	0,75 to 0,80
$4\,500 < I_c < 6\,000$	0,65 to 0,70
$6\,000 < I_c < 10\,000$	0,45 to 0,50
$10\,000 < I_c < 25\,000$	0,20 to 0,25

9.11.2.2 *Verification of the coordination between the RCM and the SCPD*

These tests are intended to verify that the RCM, protected by the SCPD, is able to withstand, without damage, short-circuit currents up to its rated conditional short-circuit current (see ***5.3.8****).*

The short-circuit current is interrupted by the SCPD.

The SCPD is renewed after each operation, if required.

The following tests are made under the general conditions of ***9.11.2.1****:*

— *a test [see* ***9.11.2.2*** *a)] to verify that at the rated conditional short-circuit current* I_{nc} *the SCPD protects the RCM.*

— *a test [see* ***9.11.2.2*** *b)] to verify that in the case of phase-to-earth short circuits with currents up to the value of the rated conditional residual short-circuit current* $I_{\Delta c}$*, the RCM is able to withstand the corresponding stresses.*

a) *Verification of the coordination at the rated conditional short-circuit current* (I_{nc})

1) *Test conditions*

The connections G_1 *of negligible impedance are replaced by the RCM and by the SCPD.*

The auxiliary switch S_1 *remains open: no residual current is established.*

2) *Test procedure*

The switch T is closed and the SCPD operates. After opening of T and reclosing or renewing the SCPD the switch is closed once more.

b) *Verification of the coordination at rated conditional residual short-circuit current* ($I_{\Delta c}$)

1) *Test conditions*

The RCM is connected in such a manner that the short-circuit current is a residual current.

The test is performed on one phase only. The other phases are not connected.

The connections G_1 *of negligible impedance are replaced by the RCM and by the SCPD.*

The auxiliary switch S_1 *remains closed.*

2) *Test procedure*

The switch T is closed and the SCPD operates. After opening T and reclosing or renewing the SCPD the procedure is repeated twice.

3) *Condition of the RCM after the tests*

After the tests RCM shall not have suffered damages leading to non-compliance with this standard.

9.12 Verification of resistance to mechanical impact

Compliance is checked on those exposed parts of the RCM and remote alarm units, if any, mounted as for normal conditions of use, which may be subjected to mechanical impact in normal use, by the test of ***9.12.1****, for all types of RCM and, in addition, by the tests of*

— ***9.12.2*** *for RCMs intended to be mounted on a rail;*

— ***9.12.3*** *for plug-in type RCMs.*

NOTE RCMs only intended to be totally enclosed are not submitted to this test.

9.12.1 *The samples are subjected to blows by means of an impact-test apparatus as shown in Figure 9 to Figure 11.*

The head of the striking element has a hemispherical face of radius 10 mm and is of polyamide having a Rockwell hardness of HR 100. The striking element has a mass of 150 g ± 1 g and is rigidly fixed to the lower end of a steel tube with an external diameter of 9 mm and a wall thickness of 0,5 mm, which is pivoted at its upper end in such a way that it swings only in a vertical plane.

The axis of the pivot is 1 000 mm ± 1 mm above the axis of the striking element.

For determining the Rockwell hardness of the polyamide of the head of the striking element, the following conditions apply:

- *diameter of the ball: 12,7 mm ± 0,025 mm;*
- *initial load: 100 N ± 2 N;*
- *overload: 500 N ± 2,5 N.*

NOTE Additional information concerning the determination of the Rockwell hardness of plastics is given in ASTM specification D 785-65 (1970).

The design of the test apparatus is such that a force of between 1,9 N and 2,0 N has to be applied to the face of the striking element to maintain the tube in the horizontal position.

Surface-type RCMs are mounted on a sheet of plywood, 175 mm ° 175 mm, 8 mm thick, secured at its top and bottom edges to a rigid bracket, which is part of the mounting support, as shown in Figure 11.

The mounting support shall have a mass of 10 kg ± 1 kg and shall be mounted on a rigid frame by means of pivots. The frame is fixed to a solid wall.

Flush-type RCMs are mounted in a device, as shown on Figure 12, which is fixed to the mounting support.

Panel-mounting type RCMs are mounted in a device, as shown in Figure 13, which is fixed to the mounting support.

Plug-in type RCMs are mounted in their appropriate sockets, which are fixed on the sheet of plywood or in the devices according to Figure 12 or Figure 13, as applicable.

RCMs for rail mounting are mounted on their appropriate rail which is rigidly fixed to the mounting support.

The design of the test apparatus is such that

- *the sample can be moved horizontally and turned about an axis perpendicular to the surface of the plywood;*
- *the plywood can be turned about a vertical axis.*

The RCM with its covers, if any, is mounted as in normal use on the plywood or in the appropriate device, as applicable, so that the point of impact lies in the vertical plane through the axis of the pivot of the pendulum.

Cable entries which are not provided with knock-outs are left open. If they are provided with knock-outs, two of them are opened.

Before applying the blows, fixing screws of bases, covers and the like are tightened with a torque equal to two-thirds of that specified in Table 7.

The striking element is allowed to fall from a height of 10 cm on the surfaces which are exposed when the RCM is mounted as for normal use.

The height of fall is the vertical distance between the position of a checking point when the pendulum is released and the position of that point at the moment of impact. The checking point is marked on the surface of the striking element where the line through the point of intersection of the axis of the steel tube of the pendulum and that of the striking element, and perpendicular to the plane through both axes, meets the surface.

NOTE 1 Theoretically, the centre of gravity of the striking element should be the checking point. As the centre of gravity is difficult to determine, the checking point is chosen as specified above.

Each RCM is subjected to 10 blows evenly distributed over the parts of the sample likely to be subjected to impact.

The blows are not applied to knock-out areas or to any openings covered by a transparent material.

In general, one blow is applied on each lateral side of the sample after it has been turned as far as possible, but not through more than 60°, about a vertical axis, and two blows each approximately midway between the side blow on a lateral side and the blows on the resetting means.

The remaining blows are then applied in the same way, after the sample has been turned through 90° about its axis perpendicular to the plywood.

If cable entries or knock-outs are provided, the sample is so mounted that the two lines of blows are as nearly as possible equidistant from these entries.

After the test, the samples shall show no damage within the meaning of this standard. In particular, covers which, when broken, make live parts accessible or impair the further use of the RCM, linings or barriers of insulating material and the like, shall not show such a damage.

In case of doubt, it is verified that removal and replacement of external parts, such as enclosures and covers, is possible without these parts or their lining being damaged.

NOTE 2 Damage to the appearance, small dents which do not reduce the creepage distances or clearances below the values specified in **8.1.3** and small chips which do not adversely affect the protection against electric shock are disregarded.

When testing RCMs designed for screw fixing as well as for rail mounting, the test is made on two sets of RCMs, one of them being fixed by means of screws and the other being mounted on a rail.

9.12.2 *RCMs designed to be mounted on a rail are mounted as for normal use on a rail rigidly fixed on a vertical rigid wall, but without cables being connected and without any cover or cover-plate.*

A downward vertical force of 50 N is applied without jerks for 1 min on the forward surface of the RCM, immediately followed by an upward vertical force of 50 N for 1 min (Figure 14).

During this test the RCM shall not become loose and after the test the RCM shall show no damage impairing its further use.

9.12.3 ***Plug-in type RCMs***

NOTE Additional tests are under consideration.

9.13 Test of resistance to heat

9.13.1 *The samples, without removable covers, if any, are kept in a heating cabinet at a temperature of 100 C ± 2 C; removable covers, if any, are kept for 1 h in the heating cabinet at a temperature of 70 C ± 2 C.*

During the test the samples shall not undergo any change impairing their further use, and sealing compound, if any, shall not flow to such an extent that live parts are exposed.

After the test and after the samples, have been allowed to cool down to approximately room temperature, there shall be no access to live parts which are normally not accessible when the samples are mounted as for normal use, even if the standard test finger is applied with a force not exceeding 5 N.

Under the test conditions of ***9.9.2.1*** *a) the RCM shall actuate with a test current of 1,25* $I_{\Delta n}$. *Only one test is made, on one pole taken at random, without measurement of actuating time.*

After the test, markings shall still be legible.

Discoloration, blisters or a slight displacement of the sealing compound are disregarded, provided that safety is not impaired within the meaning of this standard.

9.13.2 *External parts of RCMs made of insulating material necessary to retain in position current-carrying parts or parts of the protective circuit are subjected to a ball pressure test by means of the apparatus shown in Figure 15, except that, where applicable, the insulating parts necessary to retain in position terminals for protective conductors in a box, shall be tested as specified in* ***9.13.3***.

The part to be tested is placed on a steel support with the appropriate surface in the horizontal position, and a steel ball of 5 mm diameter is pressed against this surface with a force of 20 N.

The test is made in a heating cabinet at a temperature of 125 °C ± 2 °C.

After 1 h, the ball is removed from the sample which is then cooled down within 10 s to approximately room temperature by immersion in cold water.

The diameter of the impression caused by the ball is measured and shall not exceed 2 mm.

9.13.3 *External parts of RCMs made of insulating material not necessary to retain in position current-carrying parts and parts of the protective circuit, even though they are in contact with them, are subjected to a ball pressure test in accordance with **9.13.2**, but the test is made at a temperature of 70 C ± 2 C or at a temperature of 40 C ± 2 C plus the highest temperature rise determined for the relevant part during the test of **9.8**, whichever is higher.*

NOTE For the purpose of the tests of **9.13.2** and **9.13.3**, bases of surface-type RCMs are considered as external parts.

*The tests of **9.13.2** and **9.13.3** are not made on parts of ceramic material.*

*If two or more of the insulating parts referred to in **9.13.2** and **9.13.3** are made of the same material, the test is carried out only on one of these parts, according to **9.13.2** or **9.13.3** respectively.*

9.14 Test of resistance to abnormal heat and to fire

*The glow-wire test is performed in accordance with clauses **4** to **10** of IEC 60695-2-1/0 under the following conditions:*

— *for external parts of RCMs made of insulating material necessary to retain in position current-carrying parts and parts of the protective circuit, by the test made at a temperature of 960 °C ± 15 °C;*

— *for all other external parts made of insulating material, by the test made at a temperature of 650 °C ± 10 °C.*

NOTE For the purpose of this test, bases of surface-type RCMs are considered as external parts.

If insulating parts within the above groups are made of the same material, the test is carried out only on one of these parts, according to the appropriate glow-wire test temperature.

The test is not made on parts of ceramic material.

The glow-wire test is applied to ensure that an electrically heated test wire under defined test conditions does not cause ignition of insulating parts or to ensure that a part of insulating material, which might be ignited by the heated test wire under defined conditions, has a limited time to burn without spreading fire by flame or burning parts or droplets falling from the tested part.

The test is made on one sample.

In case of doubt, the test shall be repeated on two further samples.

The test is made by applying the glow-wire once.

The sample shall be positioned during the test in the most unfavourable position of its intended use (with the surface tested in a vertical position).

The tip of the glow-wire shall be applied to the specified surface of the test sample taking into account the conditions of the intended use under which a heated or glowing element may come into contact with the sample.

The sample is regarded as having passed the glow-wire test if

— *either there is no visible flame and no sustained glowing;*

— *or flames and glowing on the sample extinguish themselves within 30 s after the removal of the glow-wire.*

There shall be no ignition of the tissue paper or scorching of the pine-wood board.

9.15 Verification of the operation of the test device at the limits of rated voltage

a) *The RCM being supplied by a voltage equal to 0,85 times the rated voltage, the test device is momentarily actuated 25 times at intervals of 5 s, the RCM being reset before each operation. For RCMs with delay time up to 10 s the interval is increased to 15 s.*

b) *Test a) is then repeated at 1,1 times rated voltage.*

c) *Test b) is then repeated, but only once, the resetting means of the test device being held in the closed position for 30 s. (A revision of this test is under consideration.)*

At each test the RCM shall activate the alarm. After the test, it shall show no change impairing its further use.

In order to check that the ampere-turns due to the operation of the test device are less than 3,5 times the ampere-turns produced by a residual current equal to $I_{\Delta n}$ at the rated voltage, the impedance of the circuit of the test device is measured and the test current is calculated, taking into account the configuration of the circuit of the test device.

If, for such verification, the dismantling of the RCM is necessary, a separate sample shall be used.

Where an alternative test method is used, the above verification of the ampere-turns does not apply.

NOTE The verification of the endurance of the test device is considered as covered by the tests of **9.10**.

9.16 Verification of limiting values of the non-operating current under overcurrent conditions

[A1] *The tests of* ***9.16.1*** *and* ***9.16.2*** *are applicable only to RCMs classified under* ***4.9.2****.* [A1]

NOTE For RCMs having multiple settings, the test is made at the lowest settings.

9.16.1 *Verification of the limiting value of overcurrent in case of a load through a RCM with two current paths*

[A1] *The RCM is connected according to Figure 16a.* [A1]

The RCM is connected as for normal use with a substantially non-inductive load corresponding to a current of 6 I_n.

RCMs functionally dependent on line voltage are supplied on the line side with the rated voltage (or, if relevant, with any voltage having a value within its range of rated voltages).

The load is switched on using a two-pole test switch and then switched off after 1 s.

The test is repeated three times, the interval between two successive closing operations being at least 1 min.

The RCM shall not operate.

9.16.2 *Verification of the limiting value of overcurrent in case of a single phase load through a three-pole or four-pole RCM*

The RCM is connected according to [A1] *Figure 16a.* [A1]

RCMs functionally dependent on line voltage are supplied on the line side with the rated voltage (or, if relevant, with any voltage having a value within its range of rated voltages).

The resistance R is adjusted so as to let a current equal to 6 I_n flow in the circuit.

NOTE For the purpose of this current adjustment, the RCM may be replaced by connections of negligible impedance.

The test switch S_1, being initially open, is closed and re-opened after 1 s. [A1] *Text deleted* [A1]

The test is repeated three times for each possible combination of the current paths, the interval between two successive operations being at least 1 min.

The RCM shall not operate.

[A1] 9.16.3 *Verification of the limiting value of overcurrent in case of a single phase load through an RCM with an external detecting device (transformer)*

The RCM is connected according to Figure 16b.

RCMs functionally dependent on line voltage are supplied on the line side with the rated voltage (or if relevant, with any voltage having a value within its range of rated voltages).

The resistance R is adjusted so as to let a current equal to 6 I_n flow in the circuit.

NOTE For the purpose of this current adjustment, the RCM may be replaced by connections of negligible impedance.

The test switch S_1, being initially open, is closed and reopened after 1 s.

The test is repeated three times for each possible combination of current paths, the interval between two successive operations being at least 1 min.

The RCM shall not operate. [A1]

[A1) 9.17 Verification of resistance against unwanted operation due to current surges caused by impulse voltages (A1]

The RCM is tested using a surge generator capable of delivering a damped oscillatory current wave as shown in Figure 17. An example of circuit diagram for the connection of the RCM is shown in Figure 18.

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

The current impulse shall be measured by appropriate means and adjusted using an additional RCM of the same type with the same I_n and the same $I_{\Delta n}$, to meet the following requirements:

— *peak value:*	*200 A* $^{+10}_{0}$ *%* or *25 A* $^{+10}_{0}$ *% for RCMs with* $I_{\Delta n} < 10$ *mA*
— *virtual front time:*	*0,5 µs ± 30 %*
— *period of the following oscillatory wave:*	*10 µs ± 20 %*
— *each successive peak:*	*about 60 % of the preceding peak*

During the tests, the RCM shall not be actuated. After the ring wave test, the correct operation of the RCM is verified by a test according to ***9.9.2*** *c) at* $I_{\Delta n}$ *only with the measurement of the actuating time.*

NOTE Test procedures and relevant test circuits for RCMs with integral or incorporated overvoltage protection are under consideration.

9.18 Verification of resistance of the insulation against impulse voltages

The test is carried out on a RCM fixed on a metal support, wired as in normal use and being in the closed position.

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

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

A first series of tests is made at an impulse voltage of 6 kV peak, the impulses being applied between the phase(s), connected together, and the neutral of the RCM.

A second series of tests is made at an impulse voltage of 8 kV peak, the impulses being applied between the metal support connected to the terminal(s) intended for the protective conductor(s), if any, and the phase(s) and the neutral connected together.

[A1) NOTE 1 (A1] The surge impedance of the test apparatus should be 500 Ω ± 5 %.

In both cases, five positive impulses and five negative impulses are applied, the interval between consecutive impulses being at least 10 s.

No unintentional disruptive discharge shall occur.

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.

[A1) NOTE 2 (A1] The expression "unintentional disruptive discharge" is used to cover the phenomena associated with the failure of insulation under electric stress, which include a drop in the voltage and the flowing of current.

[A1) NOTE 3 (A1] Intentional discharges cover discharges of any incorporated surge arresters.

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

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

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

9.19 Verification of the correct operation at residual currents with d.c. components

*The test conditions of **9.9.1** and **9.9.5** apply, except that the test circuits shall be those shown in Figure 3 and Figure 4, as applicable.*

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

For non-discriminating RCMs the test shall be performed according to Figure 3.

NOTE For discriminating RCMs the test of the correct operation in case of a continuous rise of the residual direct current is under consideration.

The auxiliary switches S_1 and S_2 shall be closed. The relevant thyristor shall be controlled in such a manner that current delay angles α of 0° 90° and 135° are obtained. Each pole of the RCM shall be tested twice at each of the current delay angles, in position 1 as well as in position II of the auxiliary switch S_3.

At every test the current shall be steadily increased at an approximate rate of 1,4 $I_{\Delta n}$/30 amperes per second for RCMs with $I_{\Delta n}$ > 0,01 A, and at an approximate rate of 2 $I_{\Delta n}$/30 amperes per second for RCMs with $I_{\Delta n}$ < 0,01 A, starting from zero. The actuating current shall be in accordance with Table 14.

Table 14 — Actuating current ranges

Angle α	Tripping current A	
	Lower limit	Upper limit
0°	0,35 $I_{\Delta n}$	1,4 $I_{\Delta n}$ or 2 $I_{\Delta n}$ (subclause **5.2.6**)
90°	0,25 $I_{\Delta n}$	
135°	0,11 $I_{\Delta n}$	

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

Non-discriminating RCMs shall be tested according to Figure 3.

NOTE For discriminating RCMs the test of the correct operation in the case of a continuous rise of the residual direct current is under consideration.

The circuit being successively calibrated at the values of $I_{\Delta n}$, 2 $I_{\Delta n}$ and 5 $I_{\Delta n}$, and the auxiliary switch S_1 being in the closed position, the residual current is suddenly established by closing the switch S_2.

Two tests are made at each value of I_{Δ} multiplied by 1,4 for RCMs with $I_{\Delta n}$ > 0,01 A and multiplied by 2 for RCMs with $I_{\Delta n}$ < 0,01 A, at a current delay angle α = 0° with the auxiliary switch S_3 in position I for the first test and in position II for the second test.

The RCM shall operate at each test within 10 s.

9.19.3 ***Verification at the reference temperature of the correct operation with load***

*The tests of **9.19.1** are repeated, the pole under test and one other pole of the RCM being loaded with the rated current, this current being established shortly before the test.*

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

9.19.4 ***Verification of the correct operation in case of residual pulsating direct currents superimposed by smooth direct current of 0,006 A***

The RCM shall be tested according to Figure 4 with a half-wave rectified residual current (current delay angle α= 0°) superimposed by a smooth direct current of 0,006 A.

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

The half-wave current I_1, starting from zero, is steadily increased at an approximate rate of 1,4 $I_{\Delta n}/30$ amperes per second for RCMs with $I_{\Delta n} > 0,01$ A and 2 $I_{\Delta n}/30$ amperes per second for RCMs with $I_{\Delta n} < 0,01$ A. The device shall trip before this current reaches a value not exceeding 1,4 $I_{\Delta n}$ + 6 mA or 2 $I_{\Delta n}$ + 6 mA respectively.

9.20 Verification of reliability

Compliance is checked by the tests of ***9.20.1*** *and* ***9.20.2****.*

NOTE For RCMs having multiple settings the tests shall be made at the lowest settings.

9.20.1 *Climatic test*

The test is based on IEC 60068-2-30 taking into account IEC 60068-2-28.

9.20.1.1 *Test chamber*

The chamber shall be constructed as stated in clause **2** *of IEC 60068-2-30. Condensed water shall be continuously drained from the chamber and not used again until it has been re-purified. Only distilled water shall be used for the maintenance of chamber humidity.*

Before entering the chamber, the distilled water shall have a resistivity of not less than 500 Ωm and a pH value of 7,0 ± 0,2. During and after the test the resistivity should be not less than 100 Ωm and the pH value should remain within 7,0 ± 1,0.

9.20.1.2 *Severity*

The cycles are effected under the following conditions:
- *upper temperature: 55 °C ± 2 °C;*
- *number of cycles: 28.*

9.20.1.3 *Testing procedure*

The test procedure shall be in accordance with clause **4** *of IEC 60068-2-30 and with IEC 60068-2-28.*

a) *Initial verification*

An initial verification is made by submitting the RCM to the test according to ***9.9.2*** *c).*

b) *Conditioning*

The RCM, mounted and wired as for normal use, is introduced into the chamber.

The temperature of the RCM shall be stabilized at 25 °C ± 3 °C (see Figure 19):

— *either by placing the RCM in a separate chamber before introducing it into the test chamber,*

— *or by adjusting the temperature of the test chamber to 25 °C ± 3 °C after the introduction of the RCM and maintaining it at this level until temperature stability is attained.*

During the stabilization of temperature by either method, the relative humidity shall be within the limits prescribed for standard atmospheric conditions for testing (see Table 1).

During the final hour, with the RCM in the test chamber, the relative humidity shall be increased to not less than 95 % at an ambient temperature of 25 °C ± 3 °C.

c) *24-hour cycle (see Figure 20)*

The temperature of the chamber shall be progressively raised to the appropriate upper temperature prescribed in ***9.20.1.2****.*

The upper temperature shall be achieved in a period of 3 h ± 30 min and at a rate within the limits defined by the shaded area in Figure 20.

During this period, the relative humidity shall not be less than 95 %. Condensation shall occur on the RCM during this period.

NOTE The condition that condensation shall occur implies that the surface temperature of the RCM is below the dew point of the atmosphere. This means that the relative humidity has to be higher than 95 % if the thermal time-constant is low. Care should be taken so that no drops of condensed water can fall on the sample.

The temperature shall then be maintained for 12 h ± 30 min from the beginning of the cycle at a substantially constant value within the prescribed limits of ± 2 °C, for the upper temperature.

During this period, the relative humidity shall be 93 % ± 3 % except for the first and the last 15 min when it shall be between 90 % and 100 %.

Condensation shall not occur on the RCM during the last 15 min.

The temperature shall then fall to 25 °C ± 3 °C within 3 h to 6 h. The rate of fall for the first 1 h 30 min shall be such that, if maintained as indicated in Figure 20, it would result in a temperature of 25 °C ± 3 °C being attained in 3 h ± 15 min.

During the temperature fall period, the relative humidity shall be not less than 95 %, except for the first 15 min when it shall be not less than 90 %.

The temperature shall then be maintained at 25 °C ± 3 °C with a relative humidity of not less than 95 % until the 24-h cycle is completed.

9.20.1.4 *Recovery*

At the end of the cycles the RCM shall not be removed from the test chamber.

The door of the test chamber shall be opened and the temperature and humidity regulation is stopped.

A period of 4 h to 6 h shall then elapse to permit the ambient conditions (temperature and humidity) to be re-established before making the final measurement.

During the 28 cycles the RCM shall not actuate.

9.20.1.5 *Final verification*

Under the conditions of tests specified in ***9.9.2*** *c), the RCM shall actuate with a test current of 1,25* $I_{\Delta n}$*. One test only is made on one phase taken at random, without measurement of actuating time.*

9.20.2 ***Test with temperature of 40 °C***

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

For each phase, a single-core cable, 1 m long and having a nominal cross-sectional area as specified in Table 3, is connected on each side of the RCM, the terminal screws or nuts being tightened with a torque equal to two-thirds of that specified in Table 7. The assembly is placed in a heating cabinet.

The RCM is loaded with a current equal to rated current at any convenient voltage and is subjected, at a temperature of 40 °C ± 2 °C, to 28 cycles, each cycle comprising 21 h with current passing and 3 h without current. The current is interrupted by an auxiliary switch.

For four-path RCMs only three paths are loaded.

At the end of the last period of 21 h with current passing, the temperature rise of the terminals is determined by means of fine wire thermocouples; this temperature rise shall not exceed 65 K.

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

Under the conditions of tests specified in ***9.9.2*** *c), the RCM shall actuate with a test current of 1,25* $I_{\Delta n}$*. One test only is made on one phase taken at random without measurement of actuating time.*

9.21 Verification of ageing of electronic components

NOTE 1 A revision of this test is under consideration.

The RCM is placed for a period of 168 h in an ambient temperature of 40 °C ± 2 °C and loaded with the rated current. The supply voltage on the electronic parts shall be 1,1 times the rated voltage.

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

Under the conditions of tests specified in ***9.9.2*** *c), the RCM shall actuate with a test current of 1,25* $I_{\Delta n}$*. One test only is made on one phase taken at random without measurement of actuating time.*

NOTE 2 An example for the test circuit of this verification is given in Figure 21.

9.22 Verification of EMC requirements

[A1) *Acceptance criteria as applicable to the tests of Table 15.*

For the purposes of this standard the acceptance criteria of the IEC 61000 series are replaced for each test as follows:

Test Acceptance criteria

T 2.1 During the test the RCM shall not switch to the alarm state for a continuously applied residual current of 0,3 $I_{\Delta n}$ *and shall switch to the alarm state for a continuously applied residual current of 1,25* $I_{\Delta n}$.

NOTE Where an RCM has more than one value of $I_{\Delta n}$, the values 0,3 $I_{\Delta n}$ and 1,25 $I_{\Delta n}$ are applied to the lowest and the highest setting.

T 2.2 During this test the RCM shall not switch to the sustained alarm state in response to the disturbance. However, a momentary activation of the alarm is permitted. After the test the RCM shall be capable of performing satisfactorily the tests specified in items a), b) and c) of ***9.9.2***.

T 2.3 During this test the RCM shall not switch to the sustained alarm state in response to the disturbance. However, a momentary activation of the alarm is permitted. After the test, the RCM shall be capable of performing satisfactorily the tests specified in items a), b) and c) of ***9.9.2***.

T 2.5 During this test the RCM shall not switch to the alarm state for a continuously applied residual current of 0,3 $I_{\Delta n}$ *and shall switch to the alarm state for a continuously applied residual current of 1,25* $I_{\Delta n}$.

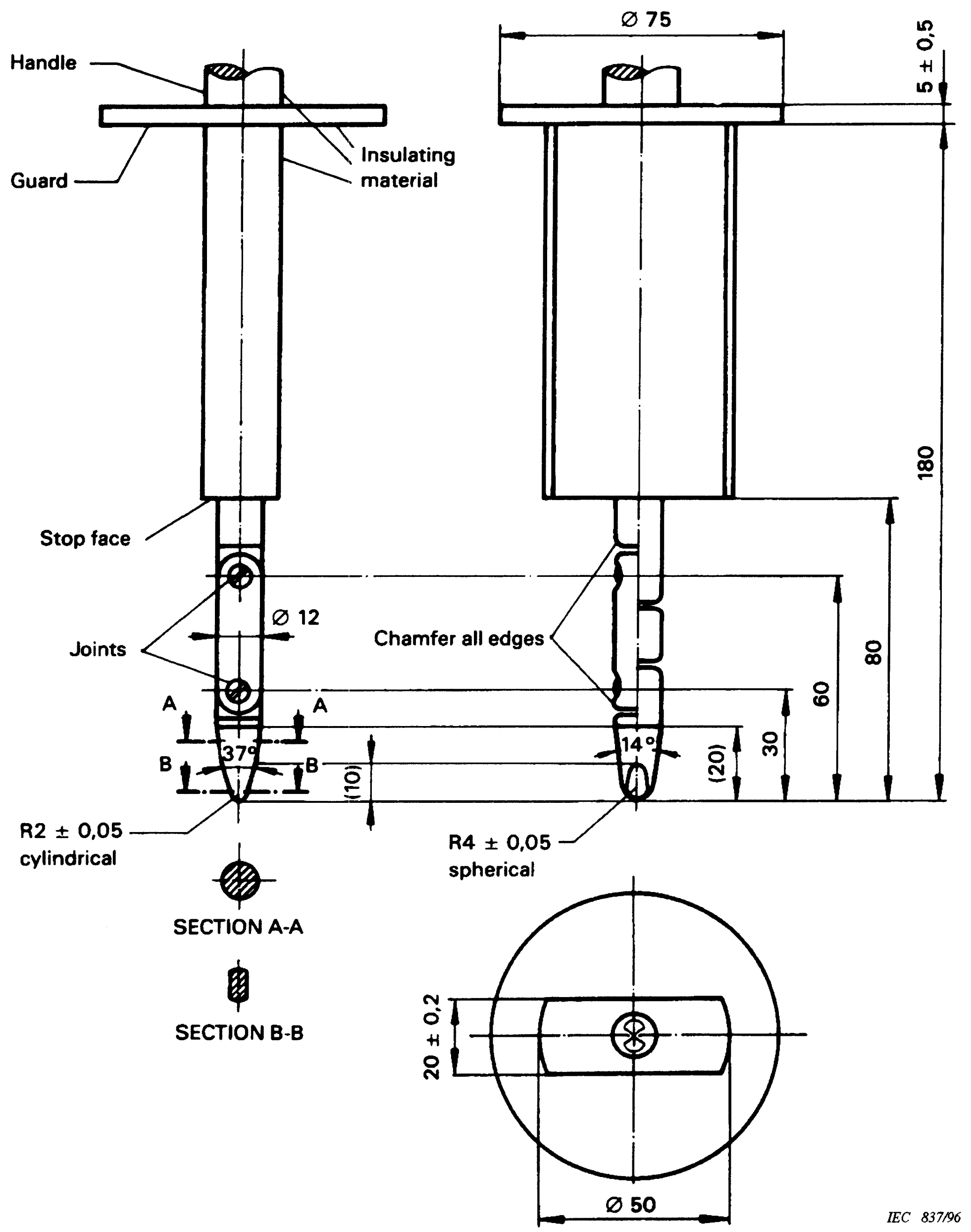
NOTE Where an RCM has more than one value of $I_{\Delta n}$, the value 0,3 $I_{\Delta n}$ is applied to the lowest setting and 1,25 In is applied to the highest setting.

T 3.1 During this test the RCM may switch to the alarm state. After the test the RCM shall be capable of performing satisfactorily the tests specified in items a), b) and c) of ***9.9.2***.

9.23 Response of the RCM to temporary overvoltages on the LV-side, due to fault conditions on the HV-side

For devices with functional earth connection (FE), the following test shall be applied:

A test voltage of 1 200 V + U_0 *at power frequency is applied for 5 s between all live terminals (Phases and Neutral) connected together and the FE-terminal. Electronic circuity connected to the FE terminal shall not be disconnected. The test generator shall be capable of supplying a short circuit current of 0,2 A ± 10 %. During and after the test, damages, if any, shall be confined to the RCM itself.* (A1]



Material: metal, except where otherwise specified

Linear dimensions in millimetres

Tolerances on dimensions without specific tolerance:

on angles: $^{0}_{-10}$ '

on linear dimensions:

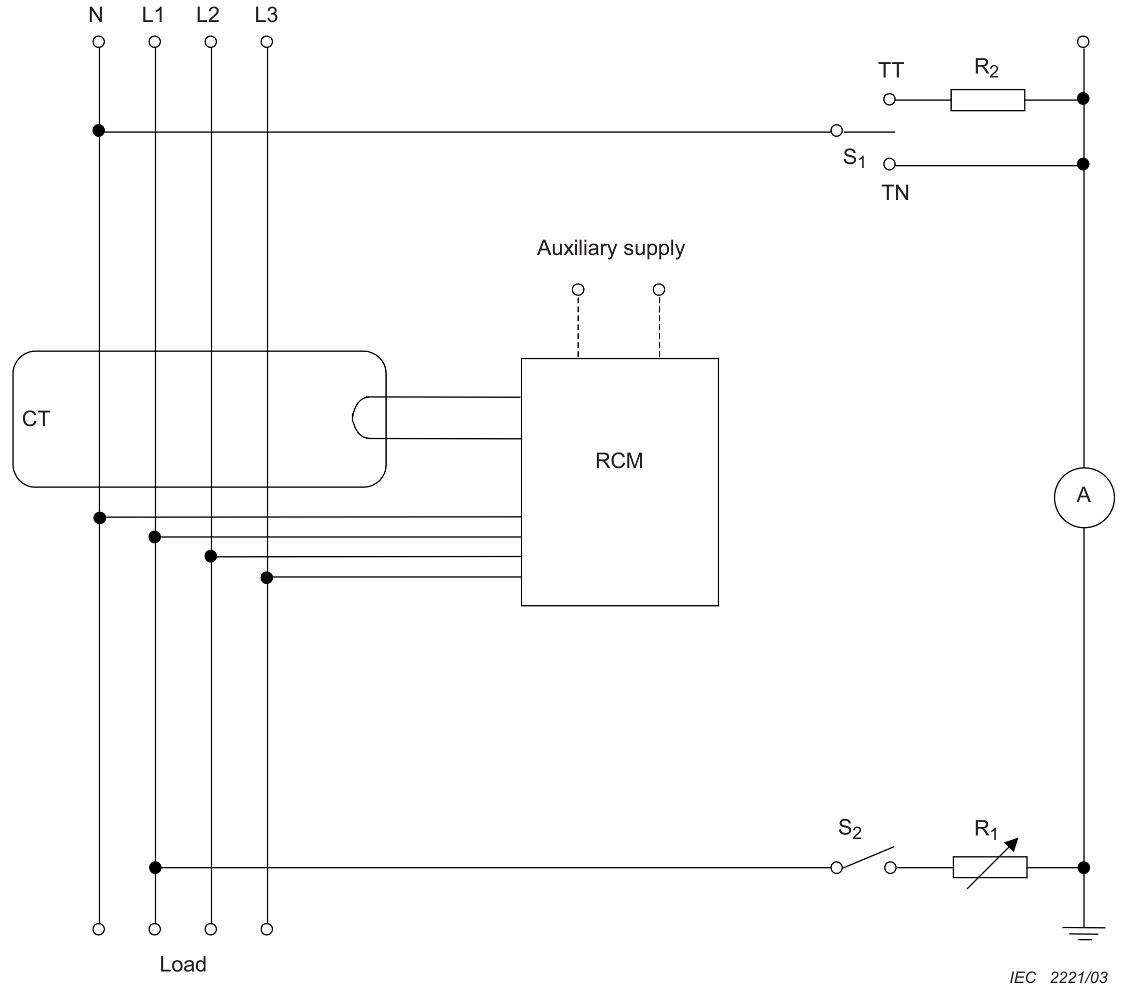
up to 25 mm: $^{0}_{0,05}$ mm

over 25 mm: ±0,2 mm

Both joints shall permit movement in the same plane and the same direction through an angle of 90 $^{+10}_{0}$ ° tolerance.

Figure 1 — Standard test finger (9.6)

[A1)

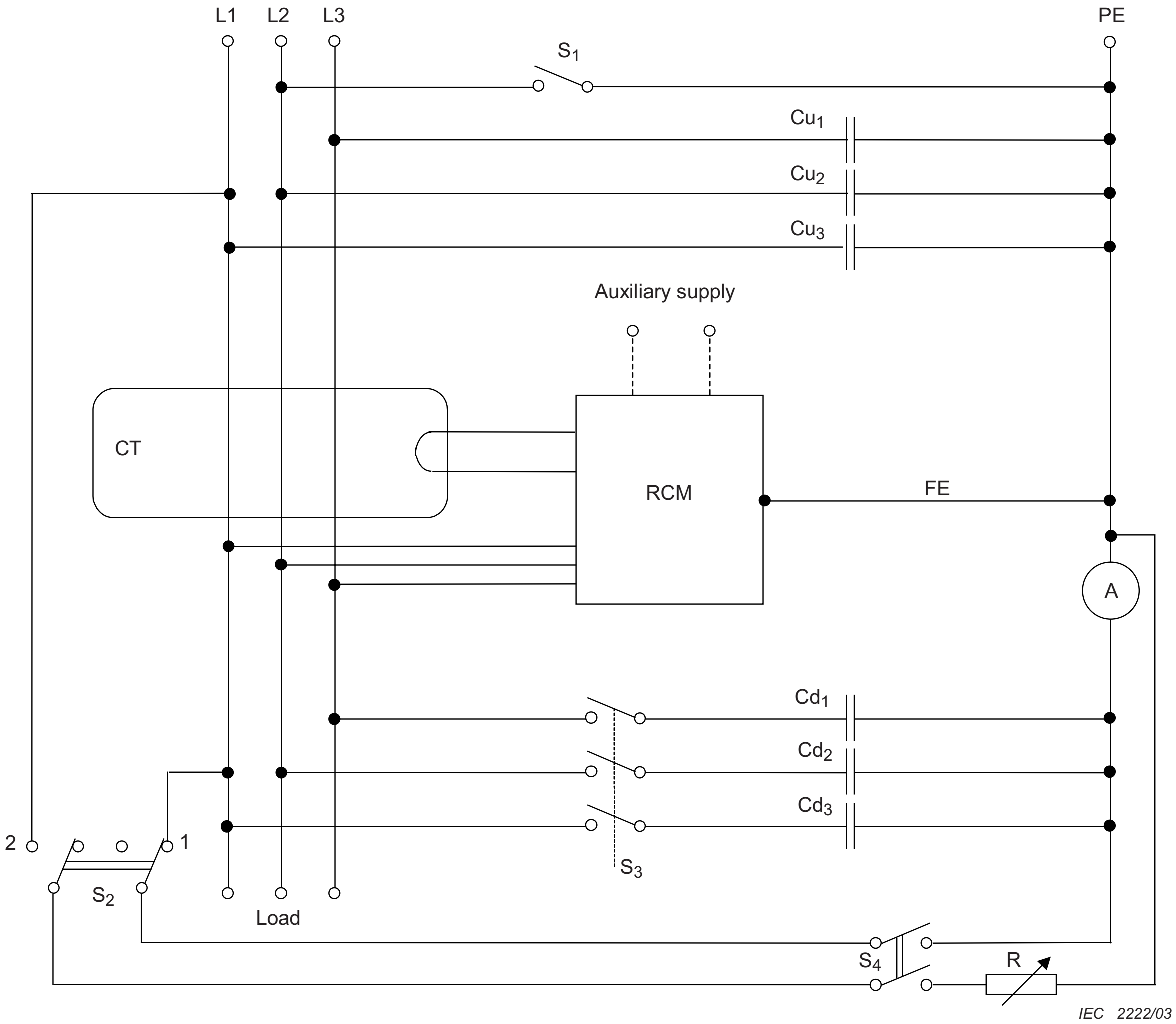


N, L1, L2, L3	Supply (For single phase RCMs, delete L2 and L3)
R_1	Adjustable resistor
R_2	Resistor 100 Ω
S_2	Switch for connection of simulated earth fault
S_1	Two-way switch for simulating TT or TN – system
RCM	RCM under test
CT	Residual current transformer for RCM
A	True r.m.s. ammeter

Figure 2a — Test circuit for the verification of the operating characteristics for RCMs for use in TN and TT-systems

(A1]

A1



L1, L2, L3 Supply (for single phase, delete L3)

S_1 Switch for testing discrimination in case of earth fault on supply side

S_2 Two-way switch for testing discrimination

S_3 Three-pole switch for connecting load-side capacitance

S_4 Switch for the connection of simulated earth fault

RCM RCM under test

CT Residual current transformer for RCM

A True r.m.s. ammeter

Cu_1 – Cu_3 Test capacitors simulating the leakage capacitance – supply side (Cu_3 deleted for single-phase supply)

$Cu = (12\ I_{\Delta n} \times 10^6) / (U \times 2\pi f)$, where the value of Cu, expressed in µF, is given with a tolerance of ±30 %

Cd_1 – Cd_3 Test capacitors simulating the leakage capacitance – load side (Cd_3 deleted for single

$Cd = (2\ I_{\Delta n} \times 10^6) / (U \times 2\pi f)$ where the value of Cd, expressed in µF, is given with a tolerance of ±30 %

U is the phase/phase voltage

f is the supply frequency

$I_{\Delta n}$ is the residual operating current

R is an adjustable resistor

FE connection required for directionally discriminating RCMs (see 3.3.13)

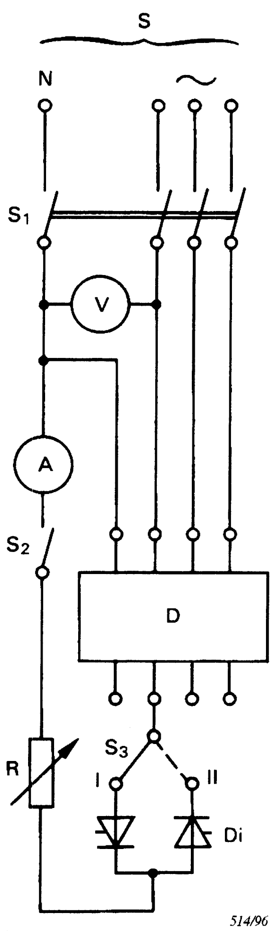
Explanation to the test circuit:

The equations for Cu and Cd provide values which are high enough to give the respective $I_{\Delta n}$ and to test the discrimination under practical mains conditions.

The values calculated for Cu or Cd are those for each separate capacitor.

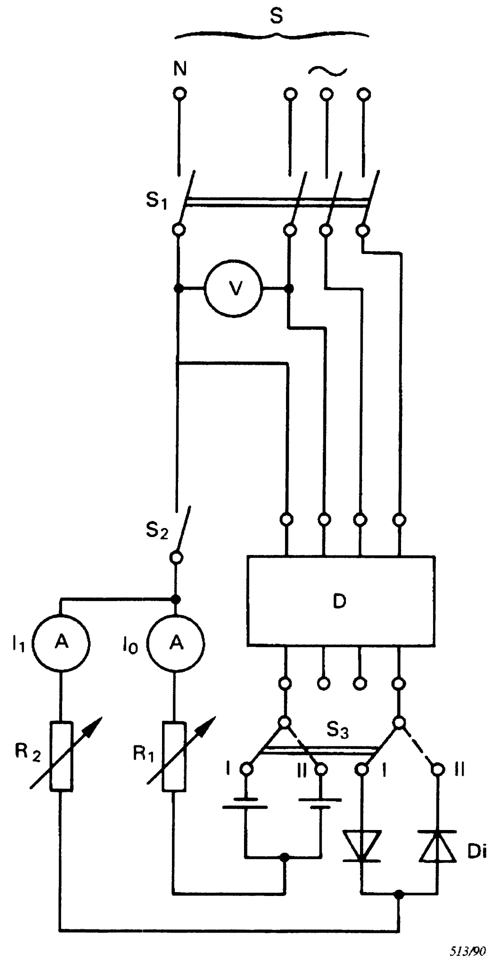
Figure 2b — Test circuit for the verification of directional discrimination in IT systems for RCMs classified according to 4.11

A1



S = Supply
V = Voltmeter
A = Ammeter (measuring r.m.s. values)
D = RCM under test
D_i = Thyristors
R = Variable resistor
S_1 = Multipole switch
S_2 = Single-pole switch
S_3 = Two-way switch

Figure 3 — Test circuit for the verification of the correct operation of RCMs in the case of residual pulsating direct currents



S = Supply
V = Voltmeter
A = Ammeter (measuring r.m.s. values)
D = RCM under test
D_i = Thyristors
R_1, R_2 = Variable resistor
S_1 = Multipole switch
S_2 = Single-pole switch
S_3 = Two-way switch

Figure 4 — Test circuit for the verification of the correct operation of RCMs in the case of residual pulsating direct currents superimposed by smooth direct current of 0,006 A

A_1

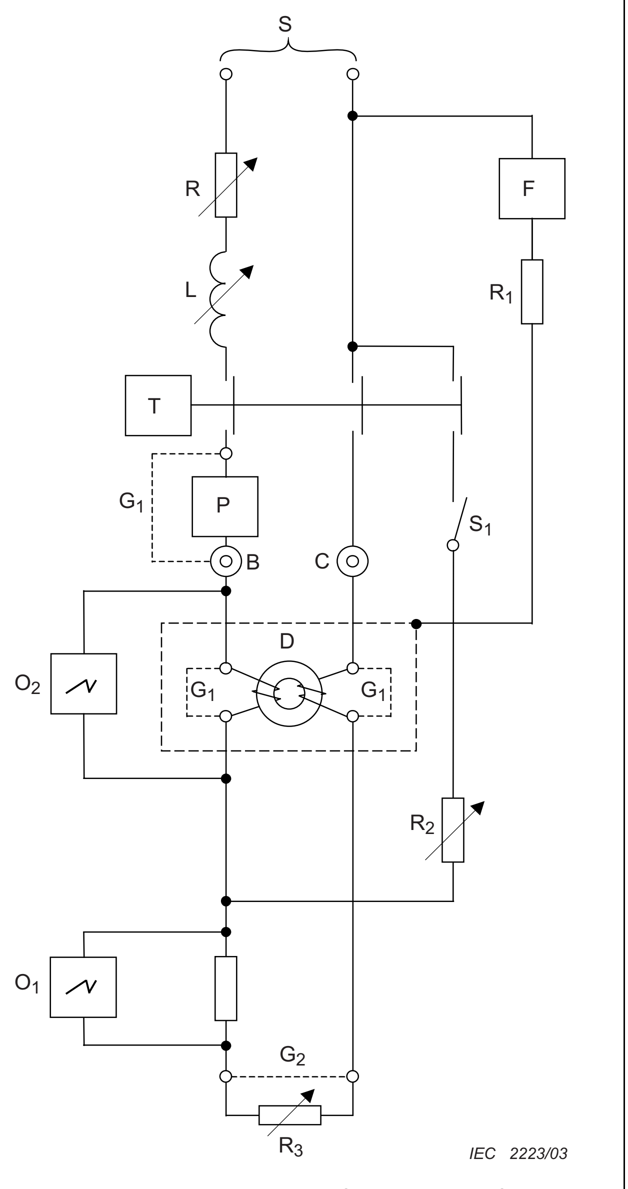


Figure 5 — Test circuit for the verification of the co-ordination with a SCPD of a RCM with two current paths (9.11)

A_1

A1

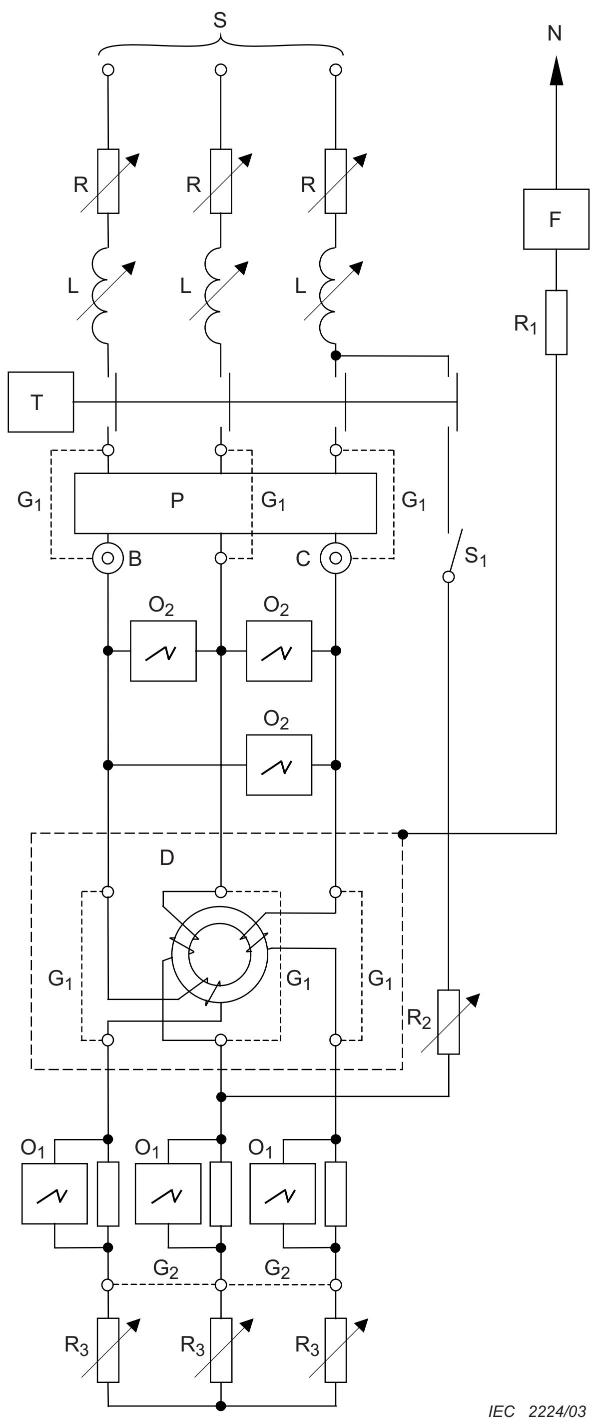


Figure 6 — Test circuit for the verification of the co-ordination with a SCPD of a RCM with three current paths in a three phase circuit (9.11)

A1

A1

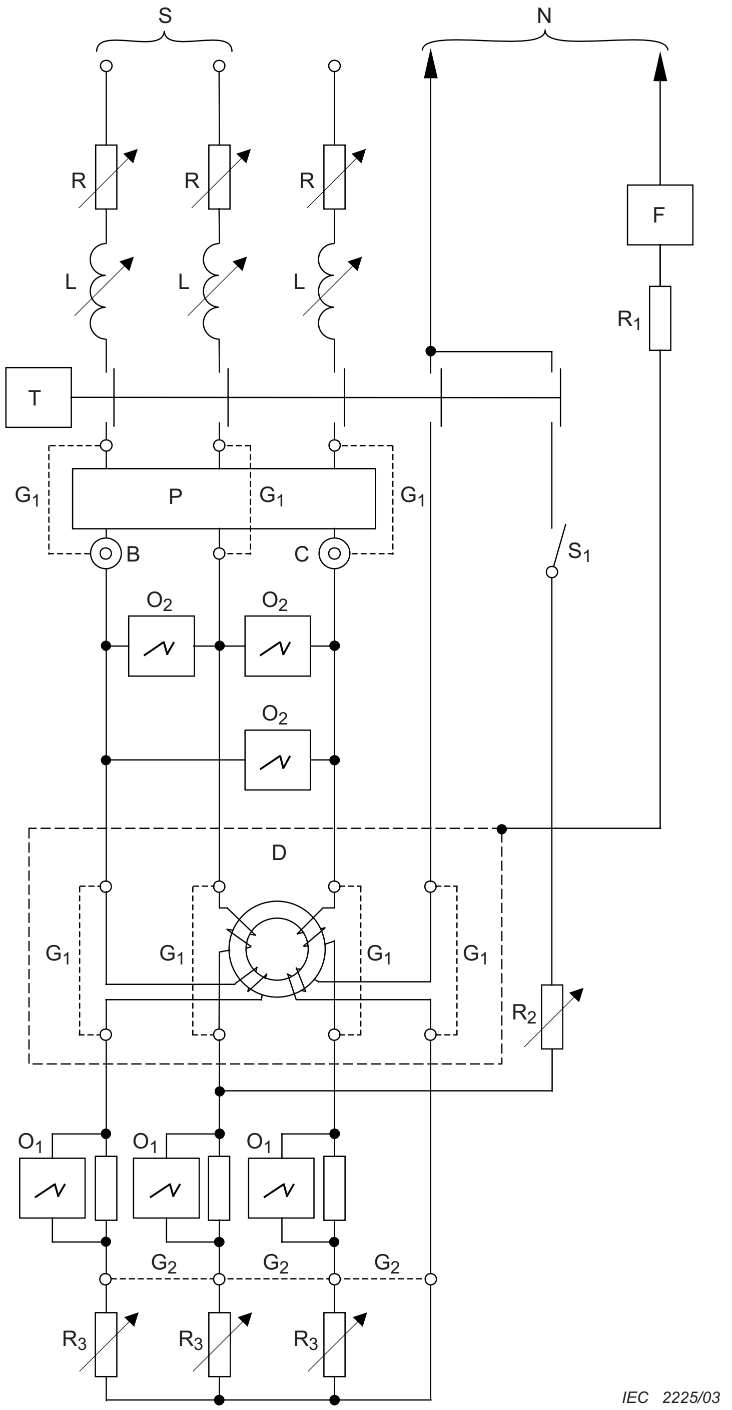
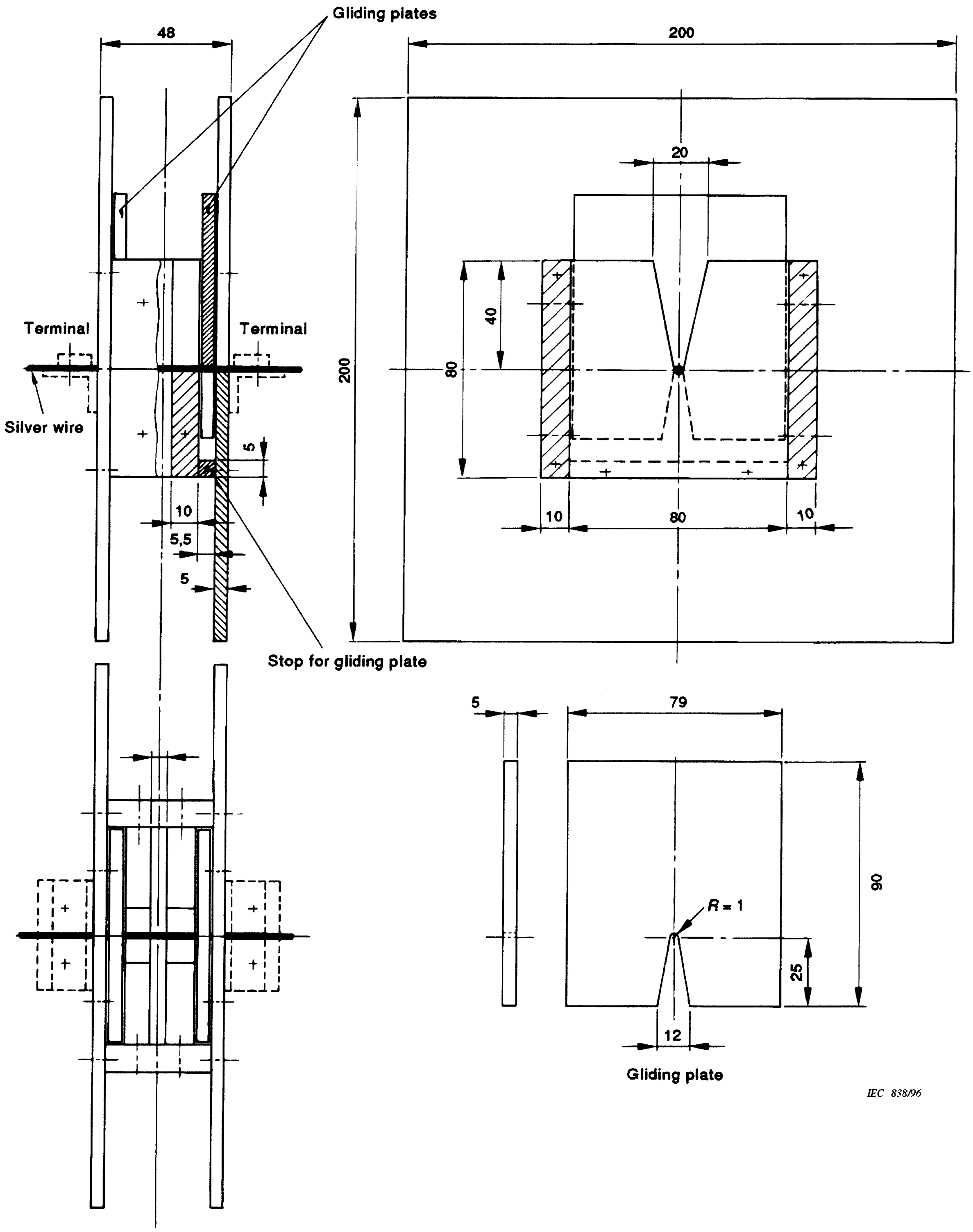


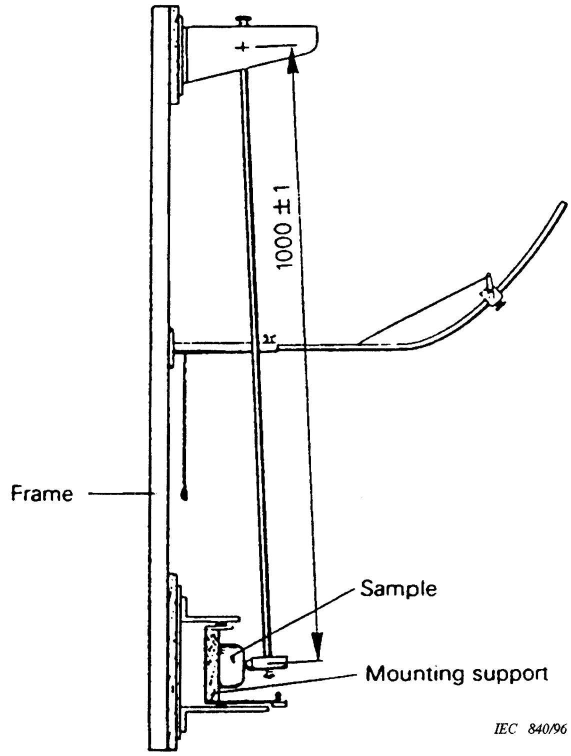
Figure 7 — Test circuit for the verification of the co-ordination with a SCPD of a RCM with four current paths on a three-phase circuit with neutral (9.11)

A1



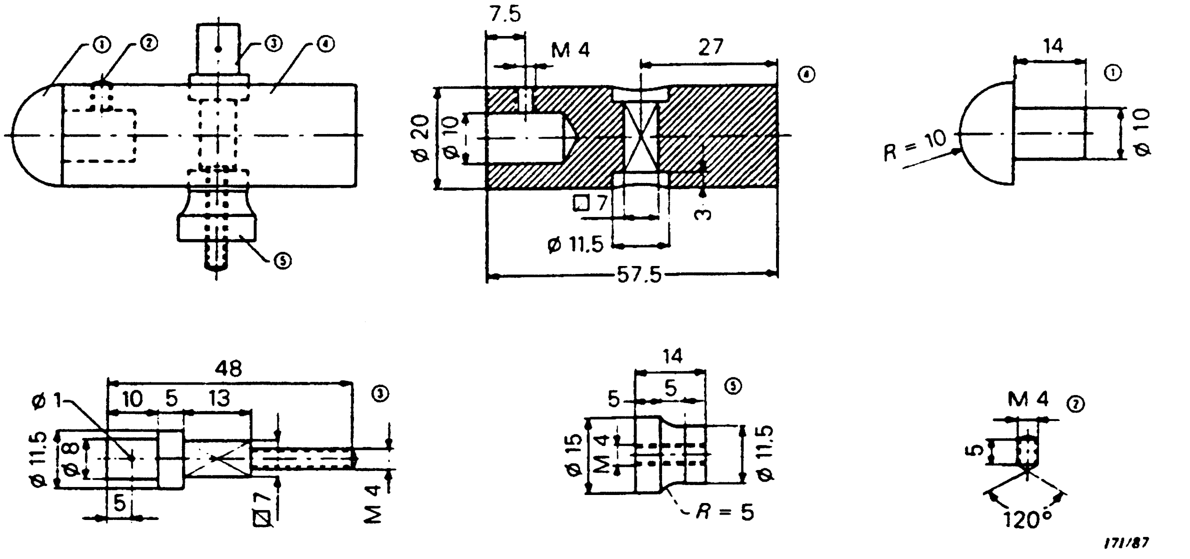
Dimensions in millimetres

Figure 8 — Test apparatus for the verification of the minimum I^2t and I_p values to be withstood by the RCM [9.11.2.1 a)]



Dimensions in millimetres

Figure 9 — Mechanical impact test apparatus (9.12.1)



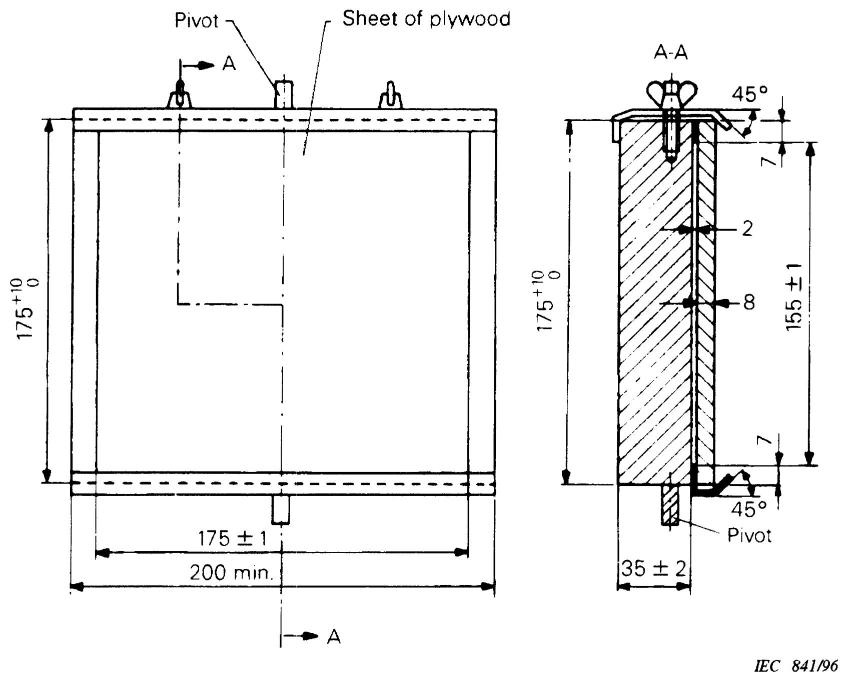
Dimensions in millimetres

Material of the parts:

1: polyamide

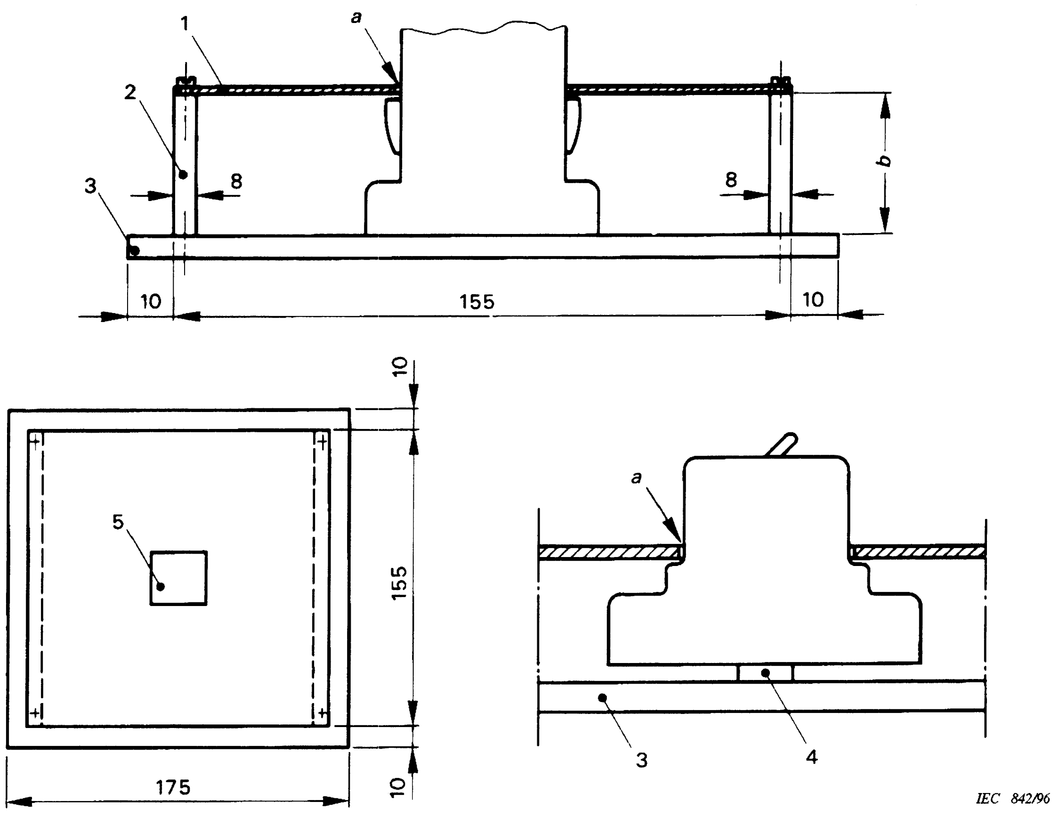
2, 3, 4, 5: steel Fe 360

Figure 10 — Striking element for pendulum impact test apparatus (9.12.1)



Dimensions in millimetres

Figure 11 — Mounting support for sample for mechanical impact test (9.12.1)



Dimensions in millimetres

1 Interchangeable steel plate with a thickness of 1 mm

2 Aluminium plates with a thickness of 8 mm

3 Mounting plate

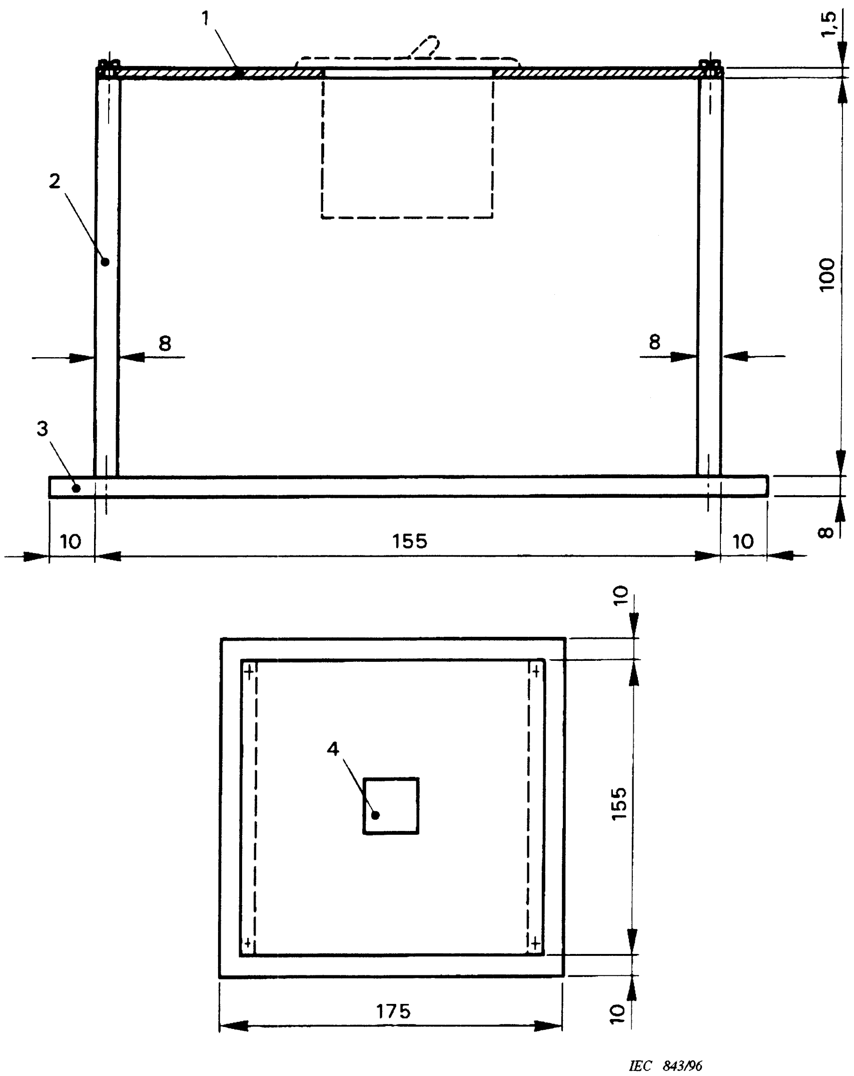
4 Rail for RCM designed to be mounted on a rail

5 Cut-out for the RCM in the steel plate

a) the distance between the edges of the cut-out and the faces of the RCM shall be between 1 mm and 2 mm

b) the height of the aluminium plates shall be such that the steel plate rests on the supports of the RCM. If the RCM has no such supports, the distance from live parts, which are to be protected by an additional cover plate, to the underside of the steel, is 8 mm.

Figure 12 — Example of mounting an unenclosed RCM for mechanical impact test (9.12.1)



Dimensions in millimetres

1 Interchangeable steel plate with a thickness of 1,5 mm
2 Aluminium plates with a thickness of 8 mm
3 Mounting plate
4 Cut-out for the RCM in the steel plate

NOTE In particular cases the dimensions may be increased.

Figure 13 — Example of mounting of panel mounting type RCM for the mechanical impact test (9.12.1)

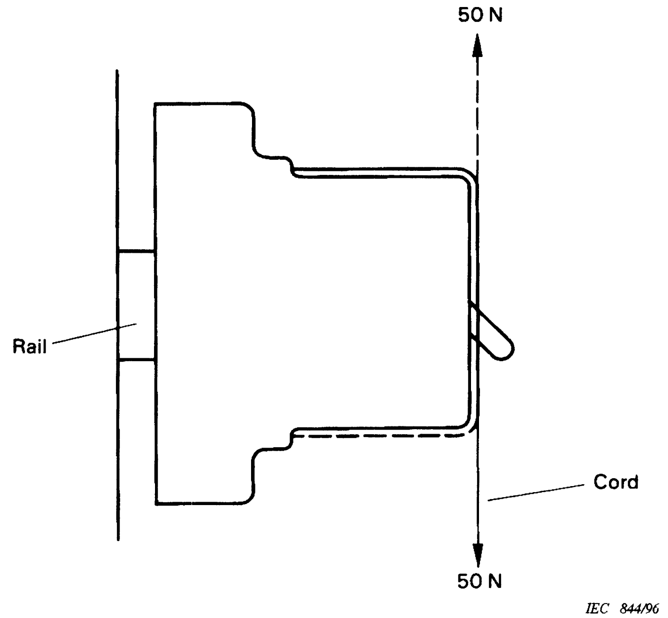


Figure 14 — Application of force for mechanical test of rail-mounted RCM (9.12.2)

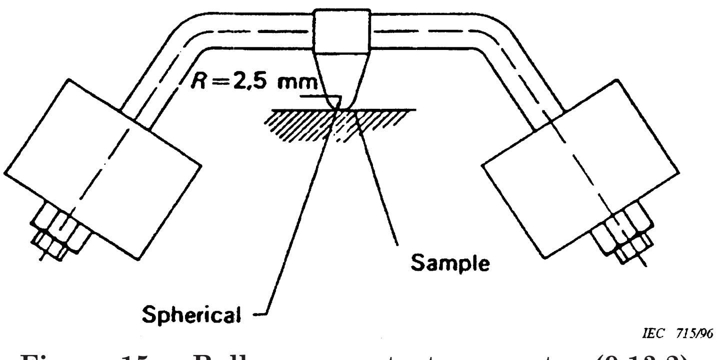
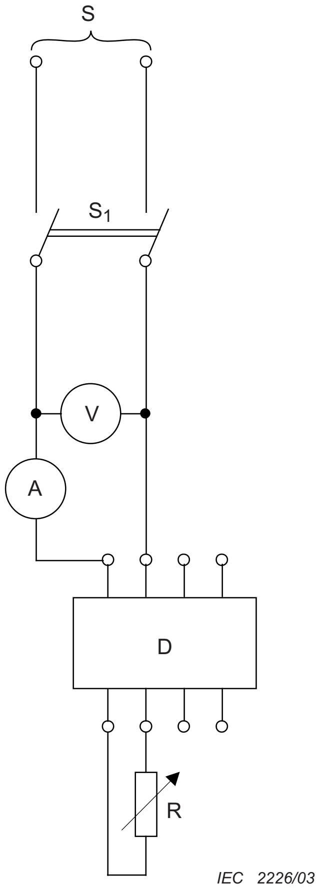


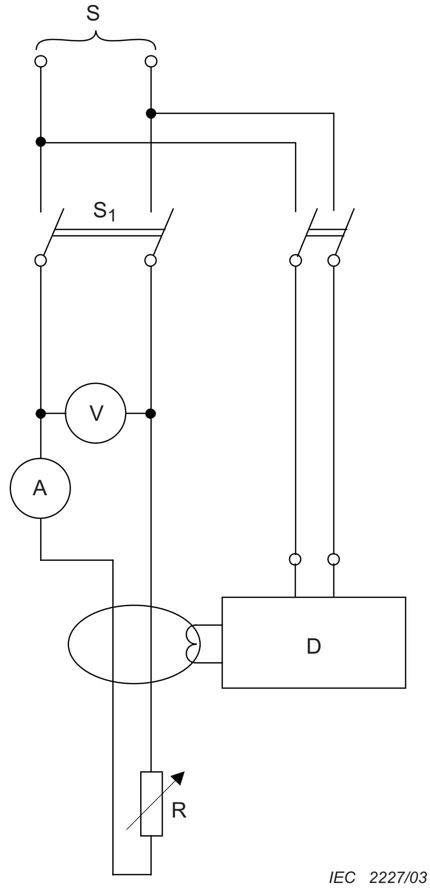
Figure 15 — Ball-pressure test apparatus (9.13.2)

A1



S = Supply
S1 = Two-pole switch
V = Voltmeter
A = True r.m.s. ammeter
D = RCM under test
R = Variable resistor

Figure 16a Test circuit for the verification of the limiting value of overcurrent in the case of single phase load through a three-phase RCM



S = Supply
S1 = Two-pole switch
V = Voltmeter
A = True r.m.s. ammeter
D = RCM under test
R = Variable resistor

Figure 16b Test circuit for the verification of the limiting value of overcurrent in the case of single phase load through an RCM with an external detecting device

A1

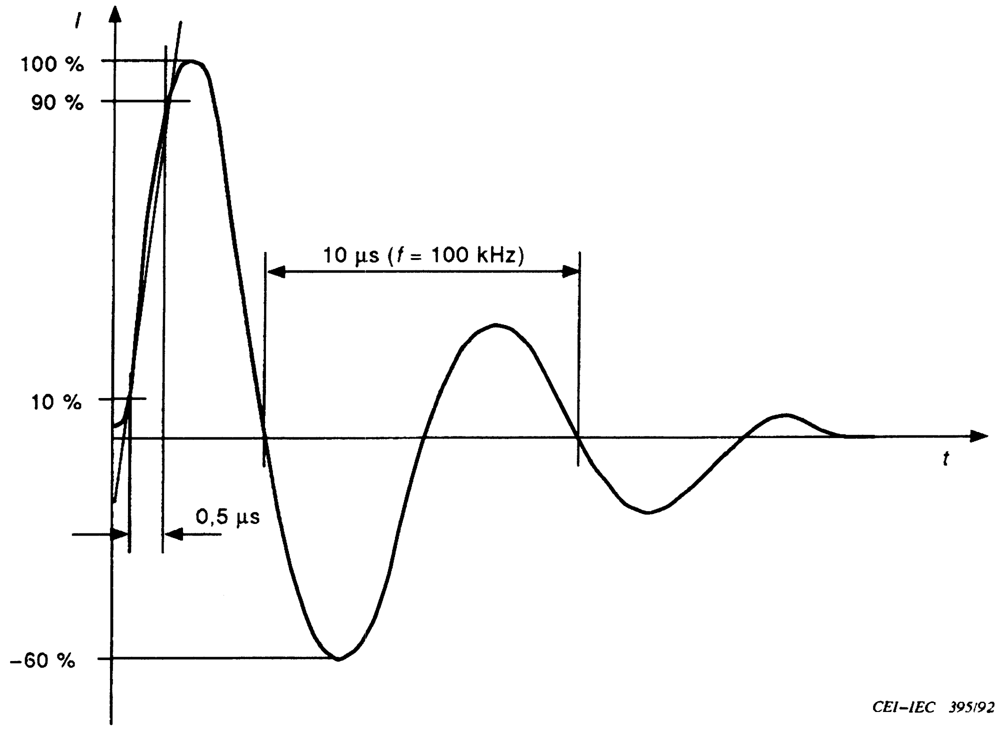
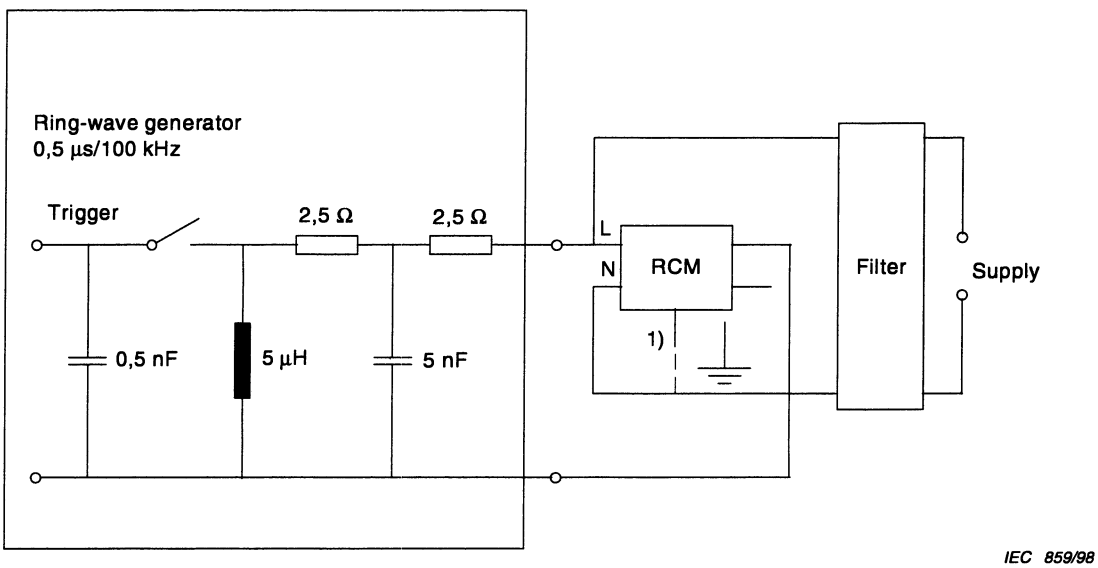


Figure 17 — Current ring wave 0,5 µs/100 kHz



1) If the RCM has an earthing terminal, it shall be connected to the neutral terminal, if any, and if so marked on the RCM or, failing that, to any phase terminal.

Figure 18 — Test circuit for the ring-wave test at RCMs

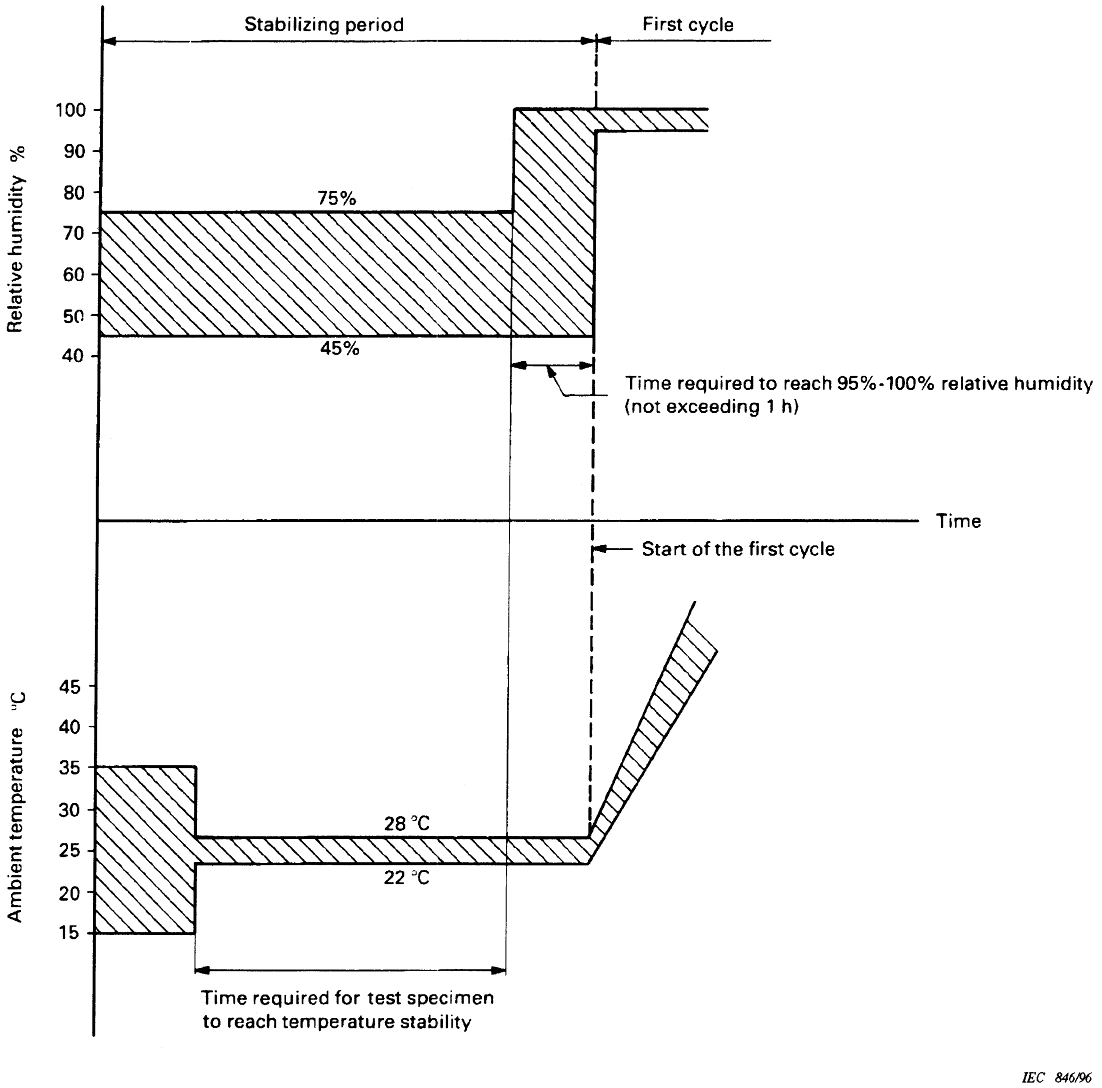


Figure 19 — Stabilizing period for reliability test (9.20.1.3)

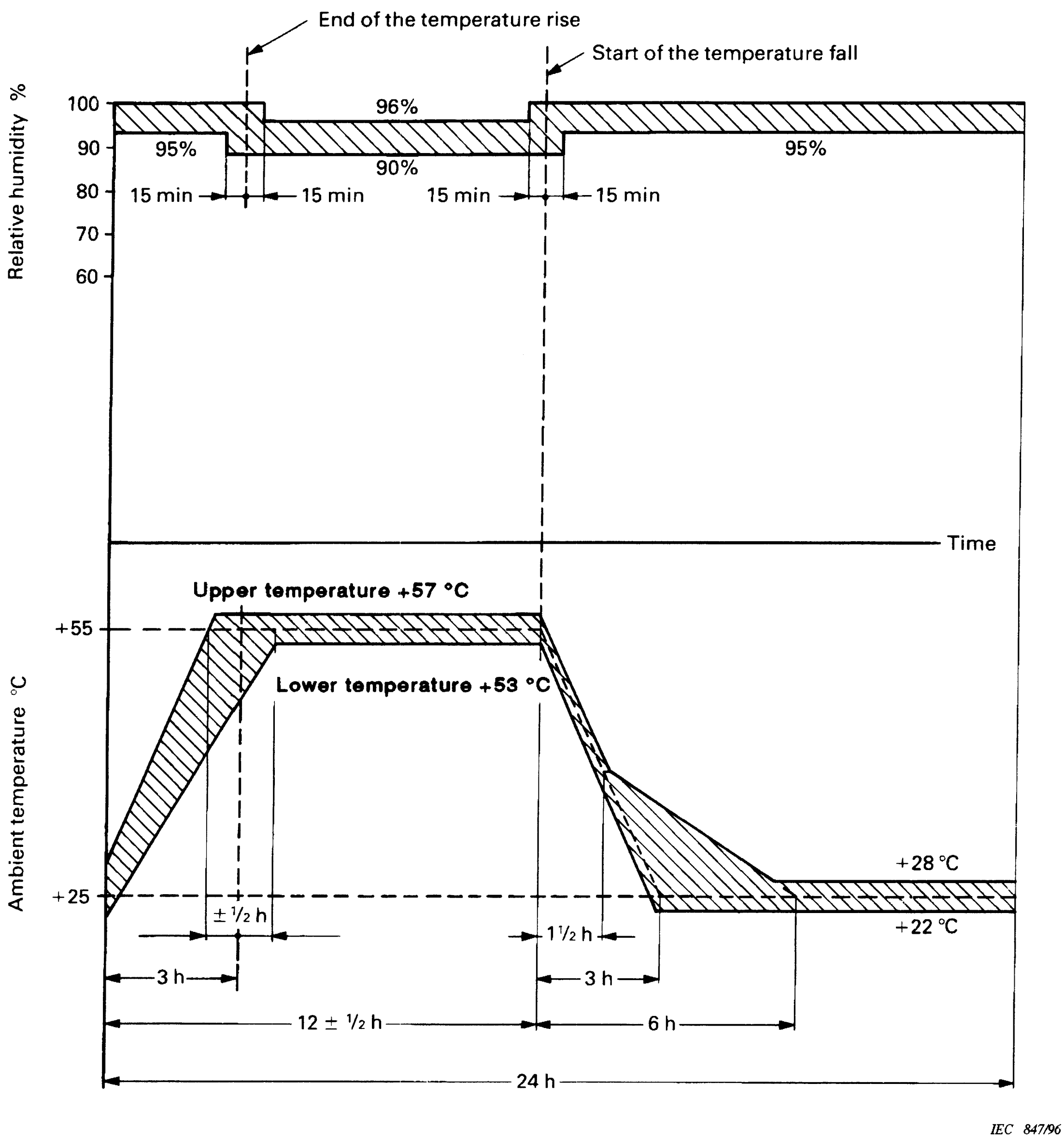
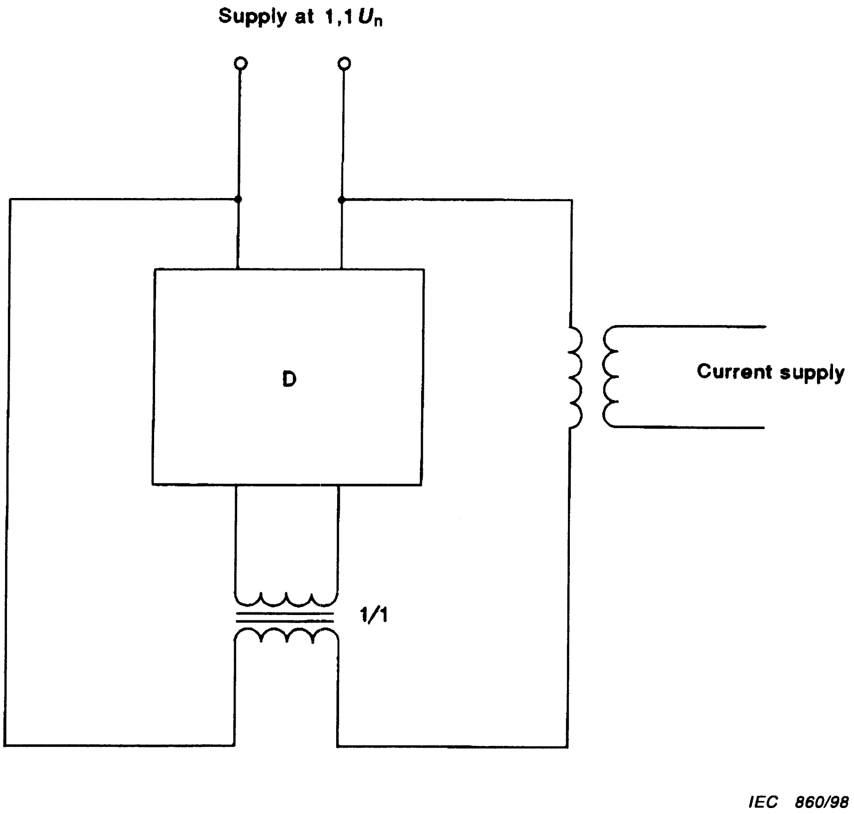


Figure 20 — Reliability test cycle (9.20.1.3)



D = RCM under test

Figure 21 — Example for test circuit for verification of ageing of electronic components (9.21)

[A1) The following Figure 22a and Figure 22b are representative of RCMs covered by this standard.

RCMs can be divided into two distinct categories:

a) those to which the monitored lines are not connected (**4.9.1**);

b) those to which the monitored lines are connected (**4.9.2**).

The RCM may use an internal or an external CT or have facility for selecting an internal or external CT for monitoring purposes as shown below, depending on the design. (A1]

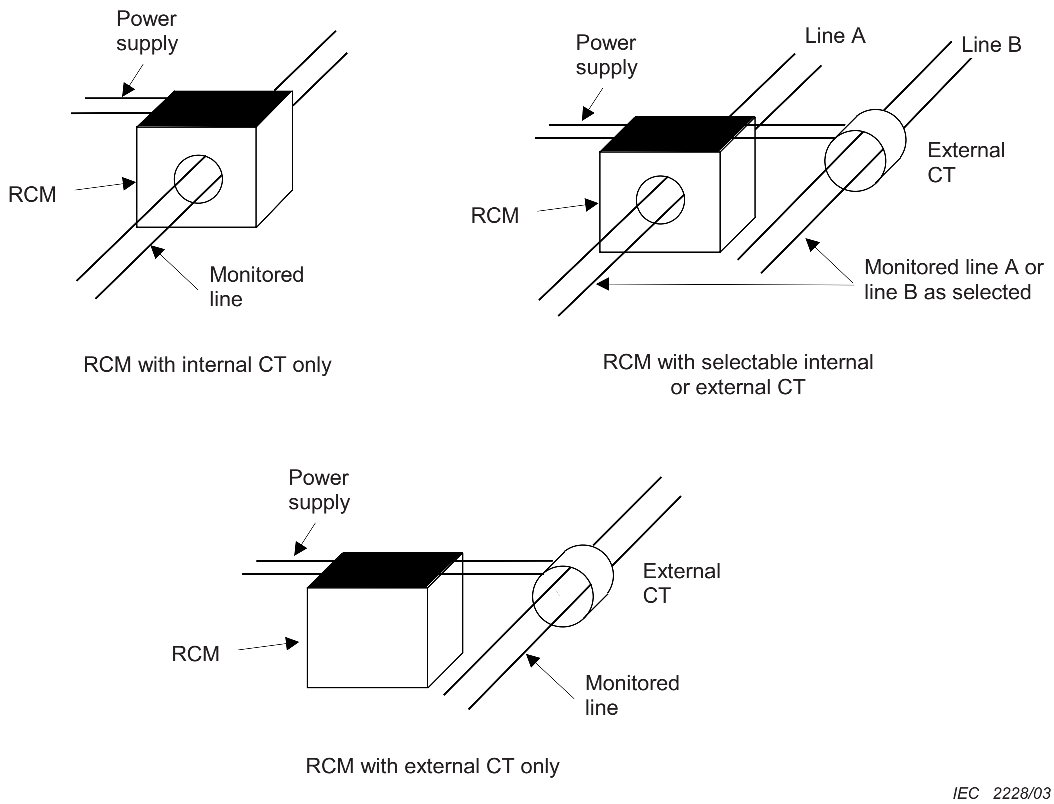


Figure 22a — RCMs without monitored lines connected

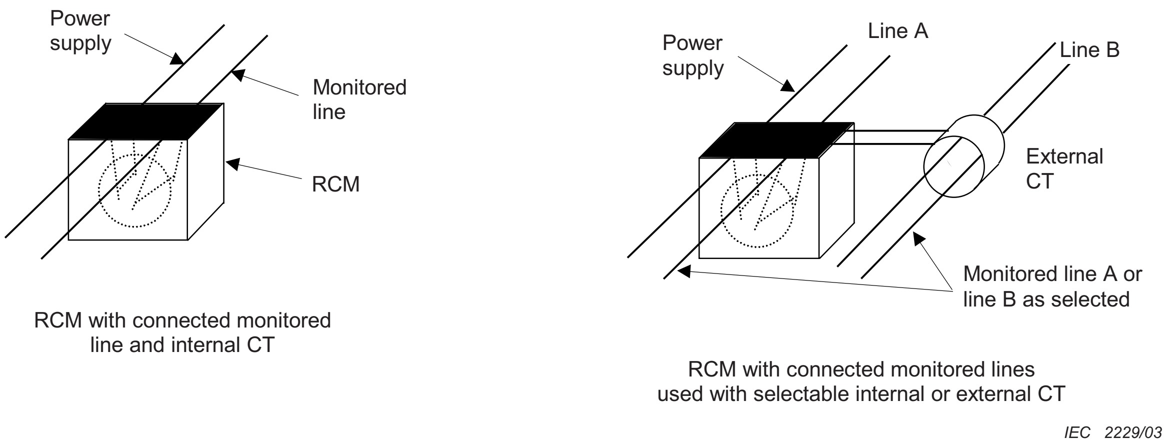


Figure 22b — RCMs with monitored lines connected

[A1] Annex A (normative) Test sequence and number of samples to be submitted for verification of conformity to the standard

The verification of conformity may be made

— by the manufacturer for the purpose of supplier's declaration (***13.5.1*** of ISO/IEC Guide 2);

— by an independent certification body for certification (***13.5.2*** of ISO/IEC Guide 2).

A.1 Test sequences

The tests are made according to Table A.1 of this annex, where the tests in each sequence are carried out in the order indicated.

Table A.1 — Test sequences

Test sequence		Clause or subclause	Test (or inspection)
A		**6**	Marking
			General[a]
		9.3	Indelibility of marking
		9.4	Reliability of screws, current-carrying parts and connections
		9.5	Reliability of terminals for external connections
		9.6	Protection against electric shock
		9.10	Operational endurance
		9.13	Resistance to heat
		8.1.3	Clearances and creepage distances
		9.14	Resistance to abnormal heat and fire
B		**9.7**	Test of dielectric properties
		9.8	Temperature rise
		9.18	Resistance of insulation against impulse voltages
		9.20.2	Reliability at 40 °C
		9.21	Ageing of components
C	C_0	**9.9**	Operating characteristics
	C_1	**9.17**	Unwanted tripping
		9.19	d.c. components
		9.15	Test device
		9.12	Resistance to mechanical impact
		9.16	Non-operating current under overcurrent condition
D		**9.11.2.2** a)	Coordination at I_{nc}
E		**9.11.2.2** b)	Coordination at $I_{\Delta c}$
F		**9.20.1**	Reliability (climatic test)
G		**9.22**	Electromagnetic compatibility
H		**9.23**	Response of the RCM to temporary overvoltages on the LV-side due to fault conditions on the HV-side

[a] General consists of inspections and measurements contained in **8.1.1** and **8.1.2**. Individual tests to these subclauses may be performed at any convenient place within the test sequence A.

[A1]

[A1) A.2 Number of samples to be submitted for full test procedure

If only one type of RCM, of one current rating and one residual operating current rating is submitted for the test, the number of samples to be submitted to the different test series are those indicated in Table A.2 where also the minimum test criteria are indicated.

If all samples according to the second column of Table A.2 pass the tests, compliance with the standard is met. If the minimum number given in the third column only pass the tests, additional samples as shown in the fourth column shall be tested, and all shall then satisfactorily complete the test sequence.

Table A.2 — Number of samples submitted to tests

Test sequence	Number of samples[a]	Minimum number of accepted samples[b]	Number of samples for repeated tests[c]
A[d]	1	1	—
B[d]	2	1	2
C	2	1[e]	2
D	2	1[e]	2
E	2	1[e]	2
F	2	1	2
G	2	1	2
H	2	1	2

[a] In total a maximum of three test sequences may be repeated.
[b] It is assumed that a sample which has not passed the test has not met the requirements due to workmanship or assembly defects which are not representative of the design.
[c] In the case of repeated tests, all the tests shall be passed successfully.
[d] If dismantling for test purposes is necessary, one more sample may be required. In this case the manufacturer shall supply samples, which may be specially prepared.
[e] All samples shall meet the requirements in **9.9.2** and **9.9.3** as appropriate. In addition permanent arcing shall not occur in any sample during the tests of **9.11.2.2**a) or **9.11.2.2** b).

A.3 Number of samples to be submitted for simplified test procedures in the case of simultaneous submission of a range of RCMs of the same fundamental design

A.3.1 If a range of RCMs of the same fundamental design, or additions to such a range of RCMs are submitted for certification, the number of samples to be tested may be reduced according to Table A.3.

NOTE For the purpose of this annex, the same fundamental design comprises a series of rated currents (I_n) and a series of rated residual operating currents ($I_{\Delta n}$).

RCMs can be considered to be of the same fundamental design if the conditions from a) to i) inclusive are satisfied:

a) they have the same basic design, e.g. types dependent on line voltage and types dependent on other energy source shall not occur together in the same range;

b) the residual current operating means have identical actuating functions and identical relays etc. except for the variations permitted in 3) and 4) below;

c) the materials, finish and dimensions of the internal current-carrying parts are identical other than the variations detailed in 1) below;

d) the terminals are of similar design [see 2) below] for RCMs classified according to **4.11.2**;

e) the manual operating mechanism, materials and physical characteristics are identical;

f) the moulding and insulating materials are identical;

g) the basic design of the residual current sensing device is identical for a given kind of characteristic other than the variations permitted in 3) below;

h) the basic design of the residual current actuating device is identical except for the variations permitted in 4) below;

i) the basic design of the test device is identical except for the variations permitted in 5) below. (A1]

[A1] The following variations are permitted provided that the RCMs comply in all other respects with the requirements detailed above:

1) cross-sectional area of the internal current-carrying connecting means and length of the toroid connections;

2) size of terminals;

3) number of turns and cross-sectional area of the windings and the size and material of the core of the differential transformer;

4) sensitivity of the relay and/or the associated electronic circuit, if any;

5) the ohmic value of the means to produce the maximum ampere turns necessary to comply with for the test of **9.15**. The circuit may be connected across phases or phase to neutral.

A.3.2 For RCMs of the same classification regarding **4.7** and **4.11** and of the same fundamental design, having different current rating and rated residual current, the number of samples to be tested may be reduced according to Table A.3.

Table A.3 — Tests with reduced number of samples

Test sequence	Number of samples according to the number of current paths[a]		
	2-pole[b]	3-pole[c]	4-pole
A	1 max. rating I_n min. rating $I_{\Delta n}$	1 max. rating I_n min. rating $I_{\Delta n}$	1 max. rating I_n min. rating $I_{\Delta n}$
B	2 max. rating I_n min. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$
$C_0 + C_1$	2 max. rating I_n min. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$
C_0	1 for all other ratings of $I_{\Delta n}$		
D	2 max. rating I_n min. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$
E	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$
F	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$
G	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$
H	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$	2 max. rating I_n min. rating $I_{\Delta n}$ 2 min. rating I_n[d] max. rating $I_{\Delta n}$

[a] If a test is to be repeated according to the minimum performance criteria of Clause **A.2**, a new set of samples is used for the relevant test. In the repeated test all test results must be acceptable.
[b] If only 3-pole or 4-pole RCMs are submitted, this column shall also apply to a set of samples with the smallest number of paths.
[c] This column is omitted when 4-path RCMs have been tested.
[d] If only one value of $I_{\Delta n}$ is submitted, these sets of samples are not required.

[A1]

Annex B (normative)
Determination of clearances and creepage distances

In determining clearances and creepage distances, the following points shall be considered.

If a clearance or creepage distance is influenced by one or more metal parts, the sum of the sections shall have at least the prescribed minimum value.

Individual sections of less than 1 mm in length should not be taken into consideration in the calculation of the total length of clearances and creepage distances.

In determining creepage distance

— grooves at least 1 mm wide and 1 mm deep should be measured along their contour;

— grooves having any dimension less than these dimensions should be neglected;

— ridges at least 1 mm high are measured

- along their contour, if they are integral parts of a component of insulating material (for instance by moulding, welding or cementing);
- along the shorter of the following paths: the joint or the profile of the ridge, if the ridges are not integral parts of a component of insulating material.

The application of the foregoing recommendations is illustrated as follows:

— Figure B.1, Figure B.2 and Figure B.3 indicate the inclusion or exclusion of a groove in a creepage distance;

— Figure B.4 and Figure B.5 indicate the inclusion or exclusion of a ridge in a creepage distance;

— Figure B.6 indicates how to take into account a joint when the ridge is formed by an inserted insulating barrier, the outside profile of which is longer than the length of the joint;

— Figure B.7, Figure B.8, Figure B.9 and Figure B.10 illustrate how to determine the creepage distance in the case of fixing means situated in recesses in insulating parts of insulating material.

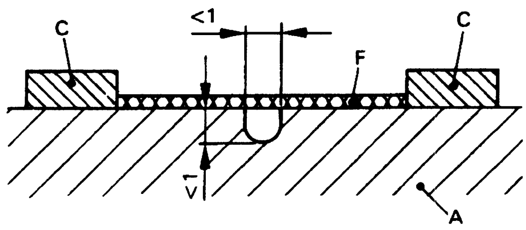


Figure B.1

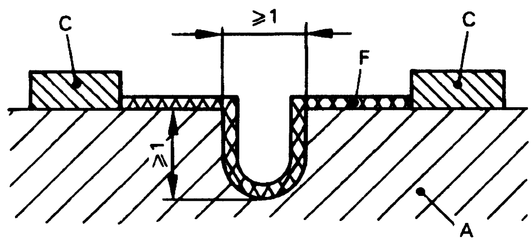


Figure B.2

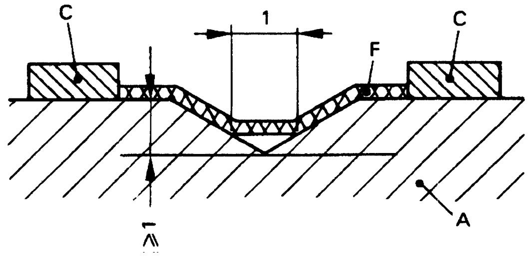


Figure B.3

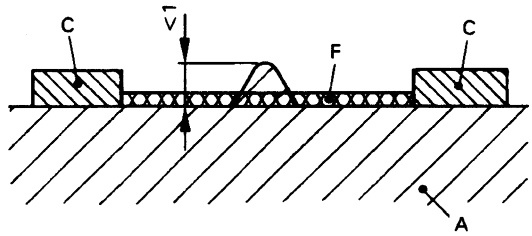


Figure B.4

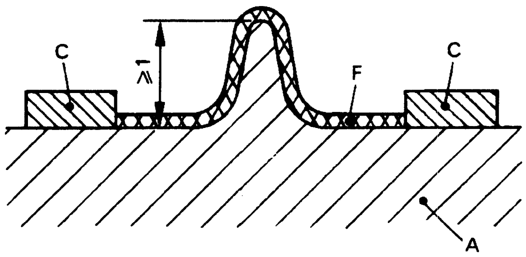


Figure B.5

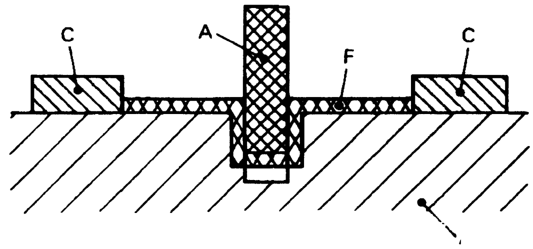


Figure B.6

IEC 861/98

Dimensions in millimetres

A = insulating material
C = conducting part
F = creepage distance

Figure B.1 to Figure B.10 — Illustrations of the application of creepage distances

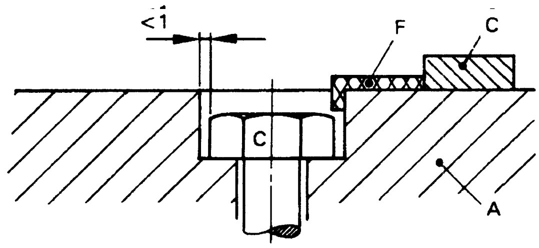


Figure B.7

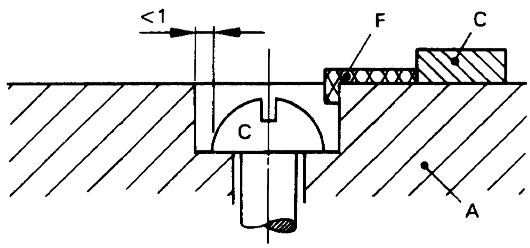


Figure B.8

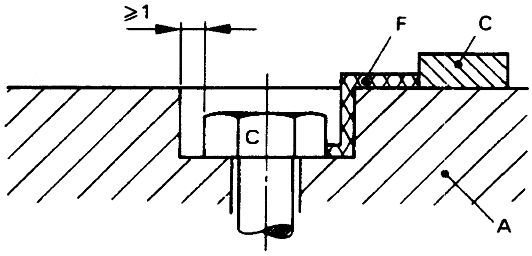


Figure B.9

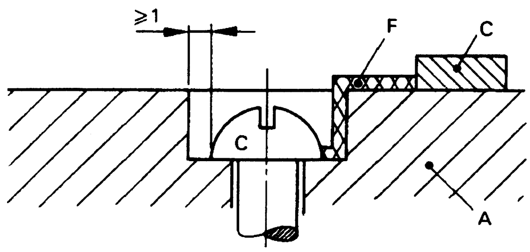


Figure B.10

IEC 862/98

Dimensions in millimetres

A = insulating material
C = conducting part
F = creepage distance

Figure B.1 to Figure B.10 — Illustrations of the application of creepage distances *(concluded)*

Annex ZA (normative) Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60038 (mod)	1983	IEC Standard voltages	HD 472 S1[a]	1989
IEC 60050(101)	1998	International Electrotechnical Vocabulary (IEV) Part 101: Mathematics	—	—
IEC 60050(151)	1978	Chapter 151: Electrical and magnetic devices	—	—
IEC 60050(441)	1984	Chapter 441: Switchgear, controlgear and fuses	—	—

[a] The title of HD 472 S1 is: *Nominal voltages for low voltage public electricity supply systems.*
[b] The European Standard EN 61008-1:1994 (IEC 61008-1:1990 + A1:1992, mod.) + corrigendum December 1997 + A2:1995
(IEC/A2:1995) + A11:1995 + A12:1998 + corrigendum April 1998 + A13:1998 + A14:1998 applies.
[c] EN 45020 is superseded by EN 45020:1998 which is based on ISO/IEC Guide 2:1996.

Publication	Year	Title	EN/HD	Year
IEC 60051	series	Direct acting indicating analogue electrical measuring instruments and their accessories	EN 60051	series
IEC 60664-3	2003	Insulation coordination for equipment within low-voltage systems Part 3: Use of coating, potting or moulding for protection against pollution	EN 60664-3	2003
IEC 60068-2-28	1980	Environmental testing Part 2: Tests — Guidance for damp heat tests	HD 323.2.28 S1	1988
IEC 60068-2-30 + A1	1980 1985	Part 2: Tests — Test Db and guidance: Damp heat, cyclic (12 + 12 hour cycle)	HD 323.2.30 S3	1988
IEC 60364-4-443	1995	Electrical installations of buildings Part 4: Protection for safety Chapter 44: Protection against overvoltages Section 443: Protection against overvoltages of atmospheric origin or due to switching	—	—
IEC 60364-5-53	1994	Part 5: Selection and erection of electrical equipment — Chapter 53: Switchgear and controlgear	—	—
IEC 60417-2	1998	Graphical symbols for use on equipment Part 2: Symbol originals	—	—
IEC 60529	1989	Degrees of protection provided by enclosures (IP Code)	EN 60529 + corr. May	1991 1993
IEC 60664-1 (mod)	1992	Insulation coordination for equipment within low-voltage systems Part 1: Principles, requirements and tests	HD 625.1 S1 + corr. November	1996 1996
IEC 60695-2-1/0	1994	Fire hazard testing Part 2: Test methods Section 1/sheet 0: Glow-wire test methods General	EN 60695-2-1/0	1996
IEC 60755	1983	General requirements for residual current operated protective devices	—	—
IEC 61008-1	1996[b]	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCB's) Part 1: General rules	—	—
IEC 61543	1995	Residual current-operated protective devices (RCDs) for household and similar use Electromagnetic compatibility	EN 61543	1995
IEC 61557-8	1997	Electrical safety in low voltage distribution systems up to 1 kV a.c. and 1,5 kV d.c. Equipment for testing, measuring or monitoring of protective measures Part 8: Insulation monitoring devices for IT systems	EN 61557-8	1997

[a] The title of HD 472 S1 is: *Nominal voltages for low voltage public electricity supply systems.*
[b] The European Standard EN 61008-1:1994 (IEC 61008-1:1990 + A1:1992, mod.) + corrigendum December 1997 + A2:1995 (IEC/A2:1995) + A11:1995 + A12:1998 + corrigendum April 1998 + A13:1998 + A14:1998 applies.
[c] EN 45020 is superseded by EN 45020:1998 which is based on ISO/IEC Guide 2:1996.

ISO/IEC Guide 2	1991	General terms and their definitions concerning standardization and related activities	EN 45020[c]	1993
CISPR 14-1 A1 A2	2000 2001 2002	Electromagnetic compatibility — Requirements for household appliances, electric tools and similar apparatus Part 1: Emission	EN 55014-1 A1 A2	2000 2001 2002

[a] The title of HD 472 S1 is: *Nominal voltages for low voltage public electricity supply systems.*
[b] The European Standard EN 61008-1:1994 (IEC 61008-1:1990 + A1:1992, mod.) + corrigendum December 1997 + A2:1995 (IEC/A2:1995) + A11:1995 + A12:1998 + corrigendum April 1998 + A13:1998 + A14:1998 applies.
[c] EN 45020 is superseded by EN 45020:1998 which is based on ISO/IEC Guide 2:1996.

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