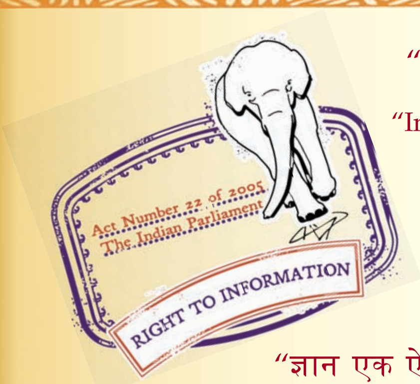
IS 12640-1 (2008): Residual Current Operated Circuit - Breakers for Household and Similar Uses, Part 1: Circuit-Breakers Without Integral Overcurrent Protection (RCCBs) [ETD 7: Low Voltage Switchgear and Controlgear]



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भारतीय मानक

घरेलू एवं समान प्रयोजनों के लिए अवशिष्ट करंट चालित सर्किट वियोजक

भाग 1 समेकित अतिधारा संरक्षण रहित सर्किट वियोजक

(पहला पुनरीक्षण)

Indian Standard

RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS FOR HOUSEHOLD AND SIMILAR USES

PART 1 CIRCUIT-BREAKERS WITHOUT INTEGRAL OVERCURRENT PROTECTION (RCCBs)

(First Revision)

ICS 29.120.50

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Low-Voltage Switchgear and Controlgear Sectional Committee, ETD 07

NATIONAL FOREWORD

This Indian Standard (Part 1) (First Revision) which is identical with IEC 61008-1 : 1996 'Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) — Part 1: General rules' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Low-Voltage Switchgear and Controlgear Sectional Committee and approval of the Electrotechnical Division Council.

This standard was first published in 2000. This revision has been undertaken to align it with IEC 61008-1 : 1996 along with Amendment Nos.1 and 2 published in the year 2002 and 2006 respectively.

The text of ISO Standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker, while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

In this adopted standard, reference appears to certain International Standards for which Indian Standards also exist. The corresponding Indian Standards which are to be substituted in their respective places are listed below along with their degree of equivalence for the editions indicated:

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60038 : 1983 IEC standard voltages	IS 12360 : 1988 Voltage bands for electrical installations including preferred voltages and frequency	Technically Equivalent
IEC 60050 (151) : 1978 International Electrotechnical Vocabulary (IEV) — Chapter 151: Electrical and magnetic devices	IS 1885 (Part 74) : 1993 Electrotechnical vocabulary: Part 74 Electrical and magnetic devices	Identical
IEC 60050 (441) : 1984 International Electrotechnical Vocabulary (IEV) — Chapter 441: Switchgear, controlgear and fuses	IS 1885 (Part 17) : 1979 Electrotechnical vocabulary: Part 17 Switchgear and controlgear (*first revision*)	Technically Equivalent
IEC 60051 : 1997 Direct acting indicating analogue electrical measuring instruments and their accessories	IS 1248 (Part 1) : 2003 Direct acting indicating analogue electrical measuring instruments and their accessories: Part 1 General requirements (*fourth revision*)	do
IEC 60060-1 : 1989 High-voltage test techniques — Part 1: General definitions and test requirements	IS 2071 (Part 1) : 1993 High-voltage test techniques: Part 1 General definitions and test requirements (*second revision*)	Identical
IEC 60060-2 : 1994 High-voltage test techniques — Part 2: Measuring systems	IS 2071 (Part 3) : 1976 High-voltage test techniques: Part 3 Measuring devices (*first revision*)	Technically Equivalent

International Standard	*Corresponding Indian Standard*	*Degree of Equivalence*
IEC 60068-2-30 : 1990 Environmental testing — Part 2: Tests — Test Db and guidance: Damp heat, cyclic (12+12 hour cycle)	IS 9000 (Part 5/Sec 1 and 2)) : 1981 Basic environmental testing procedures for electronic and electrical items: Part 5 Damp heat (cyclic) test, Section 1 16+8h cycle; Section 2 12+12h cycle	Technically Equivalent
IEC 60112 : 2003 Method for the determination of the proof and the comparative tracking indices of solid insulating materials	IS 2824 : 1975 Method for determining the comparative tracking index of solid insulating materials under moist conditions (*first revision*)	do
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	SP 30 : 1985 National Electrical Code	do
IEC 60364-5-53 : 1994 Electrical installations of buildings — Part 5: Selection and erection of electrical equipment — Chapter 53: Switchgear and controlgear		
IEC 60529 : 1989 Degrees of protection provided by enclosures (IP Code)	IS 12063 : 1987 Classification of degrees of protection provided by enclosures of electrical equipment	do
IEC 60664-1 : 1992[1] Insulation co-ordination for equipment within low-voltage systems — Part 1: Principles, requirements and tests	IS 15382 (Part 1) : 2003 Insulation coordination for equipment within low-voltage systems: Part 1 Principles, requirements and tests	Identical
IEC 61009-1 : 1996 Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) — Part 1: General rules	IS 12640 (Part 2) : 2008 Residual current operated circuit-breakers for household and similar uses: Part 2 Circuit-breakers with integral overcurrent protection (RCBOs) (*first revision*)	do

The technical committee responsible for the preparation of this standard has reviewed the provisions of the following International Standards referred in this adopted standard and has decided that they are acceptable for use in conjunction with this standard:

International Standard	*Title*
IEC 60068-2-28 : 1980	Environmental testing — Part 2: Tests — Guidance for damp heat tests
IEC 60417 : 1973	Graphical symbols for use on equipment. Index, survey and compilation of the single sheets
IEC 60695-2-1/0:1994	Fire hazard testing — Part 2: Test methods — Section 1/Sheet 0: Glow-wire test methods — General
IEC 60884-1 : 1994	Plugs and socket-outlets for household and similar purposes — Part 1: General requirements

[1] Since revised in 2002.

International Standard	*Title*
IEC 60755 : 1983	General requirements for residual current operated protective devices

Only the English text of the International Standard has been retained while adopting it as an Indian Standard, and as such the page numbers given here are not the same as in the IEC Publication.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be same as that of the specified value in this standard.

Indian Standard

RESIDUAL CURRENT OPERATED CIRCUIT-BREAKERS FOR HOUSEHOLD AND SIMILAR USES

PART 1 CIRCUIT-BREAKERS WITHOUT INTEGRAL OVERCURRENT PROTECTION (RCCBs)

(First Revision)

1 Scope

This International Standard applies to residual current operated circuit-breakers functionally independent of, or functionally dependent on, line voltage, for household and similar uses, not incorporating overcurrent protection (hereafter referred to as RCCBs), for rated voltages not exceeding 440 V a.c. and rated currents not exceeding 125 A, intended principally for protection against shock-hazard.

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

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

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

NOTE 1 The requirements for RCCBs are in line with the general requirements of IEC 60755. RCCBs are essentially intended to be operated by uninstructed persons and designed not to require maintenance. They may be submitted for certification purposes.

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

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

They are suitable for isolation.

Special precautions (e.g. lightning arresters) may be necessary when excessive overvoltages are likely to occur on the supply side (for example in the case of supply through overhead lines) (see IEC 60364-4-443).

RCCBs of the general type are resistant to unwanted tripping including the case where surge voltages (as a result of switching transients or induced by lightning) cause loading currents in the installation without occurrence of flashover.

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

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

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

Particular requirements are necessary for

- Residual current operated circuit-breakers with integral overcurrent protection (see IEC 61009);
- RCCBs incorporated in or intended only for association with plugs and socket-outlets or with appliance couplers for household or similar general purposes.

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

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

RCCBs including batteries are not covered by this standard.

2 Normative references

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

IEC 60038:1983, *IEC standard voltages*

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, *Direct acting indicating analogue electrical measuring instruments and their accessories*

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

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

IEC 60068-2-28:1980, *Environmental testing – Part 2: Tests – Guidance for damp heat tests*

IEC 60068-2-30:1990, *Environmental testing – Part 2: Tests – Test Db and guidance: Damp heat, cyclic (12 + 12 hour cycle)*

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

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 60417:1973, *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets*

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

IEC 60664-1:1992, *Insulation co-ordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

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

IEC 60755:1983, *General measurements for residual current-operated protective devices*

IEC 60884-1:1994, *Plugs and socket-outlets for household and similar purposes – Part 1: General requirements*

IEC 61009, *Residual current-operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)*

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.

NOTE For glossary of symbols see annex IB.

3.1 *Definitions relating to currents flowing from live parts to earth*

3.1.1
earth fault current
current flowing to earth due to an insulation fault

3.1.2
earth leakage current
current flowing from the live parts of the installation to earth in the absence of an insulation fault

3.1.3
pulsating direct current
current of pulsating wave form (IEV 101-04-34) 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
the time, expressed in angular measure, by which the starting instant of current conduction is delayed by phase control

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

3.2.1
energizing quantity
an electrical excitation quantity which alone, or in combination with other such quantities, shall be applied to a RCCB to enable it to accomplish its function under specified conditions

3.2.2
energizing input-quantity
energizing quantity by which the RCCB is activated when it is applied under specified conditions

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 RCCB (expressed as r.m.s. value)

3.2.4
residual operating current
value of residual current which causes the RCCB to operate under specified conditions

3.2.5
residual non-operating current
value of residual current at which and below which the RCCB does not operate under specified conditions

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

3.3.1
residual current operated circuit-breaker:
a mechanical switching device designed to make, carry and break currents under normal service conditions and to cause the opening of the contacts when the residual current attains a given value under specified conditions

3.3.2
residual current operated circuit-breaker without integral overcurrent protection (RCCB)
a residual current operated circuit-breaker not designed to perform the functions of protection against overloads and/or short circuits

3.3.3
residual current operated circuit-breaker with integral overcurrent protection (RCBO)
a residual current operated circuit-breaker designed to perform the functions of protection against overloads and/or short circuits

3.3.4
RCCBs functionally independent of line voltage
RCCBs for which the functions of detection, evaluation and interruption do not depend on the line voltage

NOTE These devices are defined in 2.3.2 of IEC 60755 as residual current devices without auxiliary source.

3.3.5
RCCBs functionally dependent on line voltage
RCCBs for which the functions of detection, evaluation or interruption depend on the line voltage

NOTE 1 This definition covers partially the definition of residual current devices with auxiliary source of 2.3.3 of IEC 60755.

NOTE 2 It is understood that the line voltage is applied to the RCCB, for detection, evaluation or interruption.

3.3.6
switching device
a device designed to make or to break the current in one or more electric circuits

3.3.7
mechanical switching device
A switching device designed to close and to open one or more electric circuits by means of separable contacts

3.3.8
trip-free RCCB
a RCCB the moving contacts of which return to and remain in the open position when the automatic opening operation is initiated after the initiation of the closing operation, even if the closing command is maintained

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

3.3.9
break time of a RCCB
the time which elapses between the instant when the residual operating current is suddenly attained and the instant of arc extinction in all poles

3.3.10
limiting non-actuating time
maximum delay during which a value of residual current higher than the residual non-operating current can be applied to the RCCB without causing it to operate

3.3.11
time-delay RCCB
RCCB specially designed to attain a predetermined value of limiting non-actuating time, corresponding to a given value of residual current

3.3.12
closed position
the position in which the predetermined continuity of the main circuit of the RCCB is secured

3.3.13
open position
the position in which the predetermined clearance between open contacts in the main circuit of the RCCB is secured

3.3.14
pole
that part of a RCCB associated exclusively with one electrically separated conducting path of its main circuit provided with contacts intended to connect and disconnect the main circuit itself and excluding those portions which provide a means for mounting and operating the poles together

3.3.15
switched neutral pole
a pole only intended to switch the neutral and not intended to have a short-circuit capacity

3.3.16
main circuit (of a RCCB)
all the conductive parts of a RCCB included in the current paths (see 4.3)

3.3.17
control circuit (of a RCCB)
a circuit (other than a path of the main circuit) intended for the closing operation or the opening operation, or both, of the RCCB

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

3.3.18
auxiliary circuit (of a RCCB)
all the conductive parts of a RCCB intended to be included in a circuit other than the main circuit and the control circuit of the RCCB

3.3.19
RCCB Type AC
RCCB for which tripping is ensured for residual sinusoidal alternating currents, whether suddenly applied or slowly rising

3.3.20
RCCB Type A
RCCB for which tripping is ensured for residual sinusoidal alternating currents and residual pulsating direct currents, whether suddenly applied or slowly rising

3.3.21
test device
device incorporated in the RCCB simulating the residual current conditions for the operation of the RCCB under specified conditions

3.4 Definitions relating to values and ranges of energizing quantities

3.4.1
rated value
a quantity value assigned by the manufacturer for a specific operating condition of a RCCB

3.4.2 Non-operating overcurrents in the main circuit

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

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

3.4.2.1
limiting value of overcurrent in case of a load through a RCCB with two current paths
maximum value of overcurrent of a load which, in the absence of any fault to frame or to earth, and in the absence of an earth leakage current, can flow through a RCCB with two current paths without causing it to operate

3.4.2.2
limiting value of overcurrent in case of a single phase load through a three-pole or four-pole RCCB
maximum value of a single phase overcurrent which, in the absence of any fault to frame or to earth, and in the absence of an earth leakage current, can flow through three-pole or four-pole RCCB without causing it to operate

3.4.3
residual short-circuit withstand current
maximum value of the residual current for which the operation of the RCCB is ensured under specified conditions and above which the device may undergo irreversible alterations

3.4.4
prospective current
the current that would flow in the circuit, if each main current path of the RCCB and of the overcurrent protective device (if any) were replaced by a conductor of negligible impedance

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

3.4.5
making capacity
a value of the a.c. component of a prospective current that a RCCB is capable of making at a stated voltage under prescribed conditions of use and behaviour

3.4.6
breaking capacity
a value of the a.c. component of a prospective current that a RCCB is capable of breaking at a stated voltage under prescribed conditions of use and behaviour

3.4.7
residual making and breaking capacity
a value of the a.c. component of a residual prospective current which a RCCB can make, carry for its opening time and break under specified conditions of use and behaviour

3.4.8
conditional short-circuit current
a value of the a.c. component of a prospective current, which a RCCB protected by a suitable short-circuit protective device (hereafter referred to as SCPD) in series can withstand under specified conditions of use and behaviour

3.4.9
conditional residual short-circuit current
a value of the a.c. component of a residual prospective current which an RCCB protected by a suitable SCPD in series, can withstand under specified conditions of use and behaviour

3.4.10
limiting values (U_x and U_y) of the line voltage for RCCBs functionally dependent on line voltage

3.4.10.1
U_x
minimum value of the line voltage at which a RCCB functionally dependent on line voltage still operates under specified conditions in case of decreasing line voltage (see 9.17.1)

3.4.10.2
U_y
minimum value of the line voltage below which a RCCB functionally dependent on line voltage opens automatically in the absence of any residual current (see 9.17.2)

3.4.11
I^2t (Joule integral)
the integral of the square of the current, over a given time interval (t_0, t_1):

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

3.4.12
recovery voltage
the voltage which appears across the terminals of a pole of a RCCB after the breaking of the current

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

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

3.4.12.1
transient recovery voltage
the recovery voltage during the time in which it has a significant transient character

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

3.4.12.2
power-frequency recovery voltage
the recovery voltage after the transient voltage phenomena have subsided

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 RCCB

3.5.2
reference value of an influencing quantity
the 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
the range of values of an influencing quantity which permits the RCCB to operate under specified conditions, the other influencing quantities having their reference values

3.5.5
extreme range of an influencing quantity
the range of values of an influencing quantity within which the RCCB suffers only spontaneously reversible changes, although not necessarily complying with all the requirements of this standard

3.5.6
ambient air temperature
the temperature, determined under prescribed conditions of the air surrounding the RCCB (for an enclosed RCCB it is the air outside the enclosure)

3.6 Definitions relating to terminals

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

3.6.1
terminal
a terminal is a conductive part of a device, provided for reusable electrical connection to external circuits

3.6.2
screw-type terminal
a 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
a 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

NOTE Examples of pillar terminals are shown in figure IC.1 of annex IC.

3.6.4
screw terminal
a screw-type terminal in which the conductor is clamped under the head of the screw

The clamping pressure may be applied directly by the head of the screw or through an intermediate part, such as a washer, a clamping plate or an anti-spread device

NOTE Examples of screw terminals are shown in figure IC.2 of annex IC.

3.6.5
stud terminal
a 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

NOTE Examples of stud terminals are shown in figure IC.2 of annex IC.

3.6.6
saddle terminal
a screw-type terminal in which the conductor is clamped under a saddle by means of two or more screws or nuts

NOTE Examples of saddle terminals are shown in figure IC.3 of annex IC.

3.6.7
lug terminal
a screw terminal or a stud terminal, designed for clamping a cable lug or a bar by means of a screw or nut

NOTE Examples of lug terminals are shown in figure IC.4 of annex IC.

3.6.8
screwless terminal
a 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
a 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 tapping screw
a tapping screw having an uninterrupted thread; it is not a function of this thread to remove material from the hole

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

3.6.11
thread cutting tapping screw
a tapping screw having an interrupted thread; it is a function of this thread to remove material from the hole

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

3.7 Conditions of operation

3.7.1
operation
the transfer of the moving contact(s) from the open position to the closed position or vice versa

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

3.7.2
closing operation:
an operation by which the RCCB is brought from the open position to the closed position

3.7.3
opening operation
an operation by which the RCCB is brought from the closed position to the open position

3.7.4
operating cycle
a succession of operations from one position to another and back to the first position

3.7.5
sequence of operation
a succession of specified operations with specified time intervals

3.8 Test

3.8.1
type test
a test of one or more devices made to a certain design to show that the design meets certain requirements

3.8.2
routine tests
a test to which each individual device is subjected during and/or after manufacture to ascertain whether it complies with certain criteria

3.9 Definitions related to insulation coordination

3.9.1
insulation coordination
the mutual correlation of insulation characteristics of electrical equipment taking into account the expected micro-environment and the influencing stresses

[IEC 60664-1, definition 1.3.1]

3.9.2
working voltage
the highest r.m.s. value of the a.c. or d.c. voltage across any particular insulation which can occur when the equipment is supplied at rated voltage

[IEC 60664-1, definition 1.3.5]

NOTE 1 Transients are disregarded.

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

3.9.3
overvoltage
any voltage having a peak value exceeding the corresponding peak value of maximum steady-state voltage at normal operating conditions

[IEC 60664-1, definition 1.3.7]

3.9.4
impulse withstand voltage
the highest peak value of impulse voltage of prescribed form and polarity, which does not cause breakdown of the insulation under specific conditions

[IEC 60664-1, definition 1.3.8.1]

3.9.5
overvoltage category
a numeral defining a transient overvoltage condition

[IEC 60664-1, definition 1.3.10]

3.9.6
macro-environment
the environment of the room or other location, in which the equipment is installed or used

[IEC 60664-1, definition 1.3.12.1]

3.9.7
micro-environment
the immediate environment of the insulation which particularly influences the dimensioning of the creepage distances

[IEC 60664-1, definition 1.3.12.2]

3.9.8
pollution
any addition of foreign matter, solid, liquid or gaseous that can result in a reduction of electric strength or surface resistivity of the insulation

[IEC 60664-1, definition 1.3.11]

3.9.9
pollution degree
numeral characterising the expected pollution of the micro-environment

[IEC 60664-1, definition 1.3.13]

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

3.9.10
isolation (isolating function)
function intended to cut off the supply from the whole installation or a discrete section of it by separating it from every source of electrical energy for reasons of safety

[IEC 60947-1, definition 2.1.19 modified]

3.9.11
isolating distance
the clearance between open contacts, meeting the safety requirements specified for isolation purposes

[IEV 441-17-35 modified]

3.9.12
clearance (see Annex B)
shortest distance in air between two conductive parts along a string stretched the shortest way between these conductive parts

[IEV 441-17-31, modified]

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

3.9.13
creepage distance (see Annex B)
shortest distance along the surface of an insulating material between two conductive parts

[IEV 151-03-37]

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

4 Classification

RCCBs are classified:

4.1 According to the method of operation

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

4.1.1 RCCB functionally independent of line voltage (see 3.3.4)

4.1.2 RCCB functionally dependent on line voltage (see 3.3.5)

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

a) Reclosing automatically when the line voltage is restored;

b) Not reclosing automatically when the line voltage is restored.

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

a) Able to trip in case of a hazardous situation (e.g. due to an earth fault) arising on failure of the line voltage (requirements under consideration);

b) Not able to trip in case of a hazardous situation (e.g. due to an earth fault) arising on failure of line voltage.

NOTE The selection of the RCCBs of b) is subject to the conditions of 532.2.2.2 of IEC 60364-5-53.

4.2 According to the type of installation

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

4.3 According to the number of poles and current paths

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

4.4 According to the possibility of adjusting the residual operating current

- RCCB with a single value of rated residual operating current;
- RCCB with multiple settings of residual operating current by fixed steps (see note of 5.2.3).

4.5 According to resistance to unwanted tripping due to voltage surges

- RCCBs with normal resistance to unwanted tripping (general type as in table 1);
- RCCBs with increased resistance to unwanted tripping (S type as in table 1).

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

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

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

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

4.8 According to the protection against external influences

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

4.9 According to the method of mounting

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

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

4.10 According to the method of connection

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

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

5 Characteristics of RCCBs

5.1 Summary of characteristics

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

- type of installation (see 4.2);
- number of poles and current paths (see 4.3);
- rated current I_n (see 5.2.2);
- rated residual operating current $I_{\Delta n}$ (see 5.2.3);
- rated residual non-operating current (see 5.2.4);
- rated voltage U_n (see 5.2.1);
- rated frequency (see 5.2.5);
- rated making and breaking capacity I_m (see 5.2.6);
- rated residual making and breaking capacity $I_{\Delta m}$ (see 5.2.7);
- time-delay, if applicable, (see 5.2.8);
- operating characteristics in case of residual currents with d.c. components (see 5.2.9);
- insulation coordination including clearances and creepage distances (see 5.2.10);
- degree of protection (see IEC 60529);
- rated conditional short-circuit current I_{nc} (see 5.4.2);
- rated conditional residual short-circuit current $I_{\Delta c}$ (see 5.4.3).

For RCCBs functionally dependent on line voltage

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

5.2 Rated quantities and other characteristics

5.2.1 Rated voltage

5.2.1.1 Rated operational voltage (U_e)

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

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

5.2.1.2 Rated insulation voltage (U_i)

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

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

5.2.1.3 Rated impulse withstand voltage (U_{imp})

The rated impulse withstand voltage of a RCCB shall be equal to or higher than the standard values of rated impulse withstand voltage given in Table 18.

5.2.2 Rated current (I_n)

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

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

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

NOTE For a RCCB 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 RCCB by the manufacturer, at which the RCCB does not operate under specified conditions.

5.2.5 Rated frequency

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

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

5.2.6 Rated making and breaking capacity (I_m)

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

The conditions are those specified in 9.11.2.2.

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

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

The conditions are those specified in 9.11.2.3.

5.2.8 RCCB type S

A time-delay RCCB (see 3.3.11) which complies with the relevant part of table 1.

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

5.2.9.1 RCCB type AC

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

5.2.9.2 RCCB Type A

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

5.3 Standard and preferred values

5.3.1 Preferred values of rated voltage (U_n)

Preferred values of rated voltage are as follows:

RCCBs	Circuit supplying the RCCB	Rated voltage of RCCBs for use in systems 230 V or 230/400 V or 400 V V	Rated voltage of RCCBs for use in systems 120/240 V or 240 V V
Single pole (with two current paths)	Single-phase (phase to earthed middle conductor or phase to neutral)	230	120
Two-pole	Single phase (phase to neutral or phase to phase or phase to earthed middle conductor)	230	120
	Single phase (phase to phase)	400	240
	Single phase (phase to phase, 3-wire)		120/240
	Three phase (4-wire) (230/400 V-system phase to neutral or 230 V-system phase to phase)	230	
Three-pole (with three or four current path)	Three phase (3-wire or 4-wire) (400 V or 230/400 V or 240 V-system	400	240
Four-pole	Three phase (4-wire) (230/400 V-system)	400	

NOTE 1 In IEC 60038 the network voltage value of 230/400 V has been standardized. This value should progressively supersede the values of 220/380V and 240/415 V.

NOTE 2 Wherever in this standard there is a reference to 230 V or 400 V, they may be read as 220 V or 240 V, 380 V or 415 V, respectively.

NOTE 3 Wherever in this standard there is a reference to 120 V or 120/240 V or 240 V, they may be read as 100 V or 100/200 V or 200 V, respectively.

NOTE 4 Wherever in this standard there is a reference to 240 V three phases, it may be read as 100 V or 120/208V.

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

5.3.2 Preferred values of rated current (I_n)

Preferred values of rated current are

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

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

Standard values of rated residual operating current are

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

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

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

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

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

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

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

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

5.3.7 Preferred values of rated frequency

Preferred values of rated frequency are 50 Hz 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 Minimum value of the rated making and breaking capacity (I_m)

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

The associated power factors are specified in table 16.

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

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

The associated power factors are specified in table 16.

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

5.3.10.1 Values up to and including 10 000 A

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

3 000 – 4 500 – 6 000 – 10 000 A.

The associated power factors are specified in table 16.

5.3.10.2 Values above 10 000 A

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

The associated power factors are specified in table 16.

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

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

5.3.11.1 Values up to and including 10 000 A

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

3 000 – 4 500 – 6 000 – 10 000 A.

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

The associated power factors are specified in table 16.

5.3.11.2 Values above 10 000 A

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

The associated power factors are specified in table 16.

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

5.3.12 Standard values of break time and non-actuating time

The standard values of break time (see 3.3.9) and non-actuating time (see 3.3.10) for type AC RCCBs are given in table 1.

Table 1 – Standard values of break time and non-actuating time

Type	I_n A	$I_{\Delta n}$ A	Standard values of break time (s) and non-actuating time (s) at a residual current (I_Δ) equal to:				
			$I_{\Delta n}$	2 $I_{\Delta n}$	5 $I_{\Delta n}$	5 A, 10 A, 20 A, 50 A, 100 A, 200 A[b] 500 A	
General	Any value	Any value	0,3	0,15	0,04	0,04	Maximum break times
S	≥25	>0,030	0,5	0,2	0,15	0,15	Maximum break times
			0,13	0,06	0,05	0,04	Minimum non-actuating times

[a] For RCCBs of the general type with $I_{\Delta n} \leq$ 0,030 A, 0,25 A may be used as an alternative to 5 $I_{\Delta n}$.

[b] The tests at 5 A, 10 A, 20 A, 50 A, 100 A and 200 A are only made during the verification of the correct operation as mentioned in 9.9.2.4

For type A RCCBs the maximum break times stated in table 1 shall also be valid, the current values (i.e. $I_{\Delta n}$, 2 $I_{\Delta n}$, 5 $I_{\Delta n}$, 0,25 A and 500 A), however, being increased, for the test of 9.22.1.1, by the factor 1,4 for RCCBs with $I_{\Delta n}$ > 0,01 A and by the factor 2 for RCCBs with $I_{\Delta n} \leq$ 0,01 A.$

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

Table 18 gives the standard value of rated impulse withstand voltages as a function of the nominal voltage of the installation.

Table 18 – Rated impulse withstand voltage as a function of the nominal voltage of the installation

Rated impulse withstand voltage U_{imp} kV	Nominal voltage of the installation	
	Three-phase systems V	Single-phase system with mid-point earthed V
2,5[a]		120/240[b]
4[a]	230/400	120/240, 240[c]

NOTE 1 For test voltages to check the insulation, see Table 20.

NOTE 2 For test voltages to check the isolation distance across open contacts, see Table 19.

a The values 3 kV and 5 kV respectively are used for verifying the isolating distances across open contacts at the altitude of 2000 m (see Tables 3 and 19).

b For installation practice in Japan.

c For installation practice in North American countries.

5.4 Coordination with short-circuit protective devices (SCPDs)

5.4.1 General

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

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

NOTE The manufacturer of the RCCB may give references of suitable SCPDs in his catalogues.

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

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

5.4.3 The conditions are those specified in 9.11.2.4 a).

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

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

The conditions are those specified in 9.11.2.4 c).

6 Marking and other product information

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

a) the manufacturer's name or trade mark;

b) type designation, catalogue number or serial number;

c) rated voltage(s);

d) rated frequency, if the RCCB 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 RCCBs with multiple residual operating current settings;

h) rated making and breaking capacity;

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

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

l) rated residual making and breaking capacity, if different from rated making and breaking capacity;

m) the symbol $\boxed{S}$ (S in a square) for type S devices;

n) indication that the RCCB is functionally dependent on line voltage, if applicable (under consideration);

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

p) wiring diagram;

r) operating characteristic in presence of residual currents with d.c. components

- RCCBs of type AC with the symbol 

- RCCBs of type A with the symbol 

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

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

NOTE In Australia this marking on the circuit-breaker is mandatory but is not required to be visible after installation.

When the symbol is used on its own (i.e. not in a wiring diagram), combination with symbols of other functions is not allowed.

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

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

The manufacturer shall state the Joule integral I^2t and the peak current I_p withstand capabilities of the RCCB. Where these are not stated, minimum values as given in table 15 apply.

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

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

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

For RCCBs operated by means of two push-buttons, the push-button designed for the opening operation only shall be RED and/or be marked with the symbol "O".

Red shall not be used for any other push-button of the RCCB. If a push-button is used for closing the contact and is evidently identified as such, its depressed position is sufficient to indicate the closed position.

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

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

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

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

NOTE The symbol ⏚ (IEC 60417-5017a)), previously recommended, shall be progressively superseded by the preferred symbol IEC 60417-5019 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

RCCBs complying with this standard shall be capable of operating under the standard conditions shown in table 2.

Table 2 – Standard conditions for operation in service

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

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

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

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

4) When a RCCB is installed in proximity of a strong magnetic field, supplementary requirements may be necessary.

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

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

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

7.2 Conditions of installation

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

7.3 Pollution degree

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

8 Requirements for construction and operation

8.1 Mechanical design

8.1.1 General

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

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

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

8.1.2 Mechanism

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

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

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

RCCBs shall have a trip-free mechanism.

It shall be possible to switch the RCCB on and off by hand. For plug-in RCCBs without operating handle, this requirement is not considered met by the fact that the RCCB can be removed from its base.

RCCBs shall be so constructed that the moving contacts can come to rest only in the closed position (see 3.3.12) or in the open position (see 3.3.13), even when the operating means is released in an intermediate position.

RCCBs shall provide in the open position (see 3.3.13) an isolation distance in accordance with the requirements necessary to satisfy the isolating function (see 8.3).

Indication of the position of the main contacts shall be provided by one or both of the following means

- the position of the actuator (this being preferred), or
- a separate mechanical indicator.

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

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

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

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

RCCBs shall be designed so that the actuator, front plate or cover can only be correctly fitted in a manner which ensures correct indication of the contact position.

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

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

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

Compliance is checked by inspection, taking into account the instructions of the manufacturer.

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

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

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

When an indicator light is used, this shall be lit when the RCCB is in closed position and be of bright colour. The indicator light shall not be the only means to indicate the closed position.

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

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

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

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

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

NOTE 4 Provisionally in certain countries down closing movement is allowed.

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

8.1.3 Clearances and creepage distances (see Annex B)

The minimum required clearances and creepage distances are given in Table 3 which is based on the RCCB being designed for operating in an environment with pollution degree 2.

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

The clearances of items 2, 4 and 5 may be reduced provided that the tests according to Table 20 are withstood.

Compliance is checked, if relevant, with test voltages given in Table 20 with test arrangements of 9.7.2 item b), c), d), e) and 9.20 (without further treatment of humidity as described in 9.7.1).

The insulating materials are classified into Material Groups on the basis of their comparative tracking index (CTI) according to 2.7.1.1 and 2.7.1.3 of IEC 60664-1.

Table 3 – Minimum clearances and creepage distances

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

Table 3 *(continued)*

NOTE 1 The values given for 400 V are also valid for 440 V.
NOTE 2 The parts of the neutral path, if any, are considered to be live parts.
NOTE 3 Dimensioning rules for solid insulation are under consideration.
NOTE 4 Care should be taken to provide adequate clearances and creepage distances between live parts of different polarity of RCCBs, e.g. of the plug-in type mounted close to one another. If the clearance and creepage distances requirements are not fulfilled to all the surfaces adjacent to the RCD, appropriate information will be provided for installation purposes.
[a] For auxiliary and control contacts the values are given in the relevant standard.
[b] The values are doubled if clearances and creepage distances between live parts of the device and the metallic screen or the surface on which the RCCB is mounted are not dependent on the design of the RCCB only, so that they can be reduced when the RCCB is mounted in the most unfavourable condition.
[c] Including a metal foil in contact with the surfaces of insulating material which are accessible after installation for normal use. The foil is pushed into corners, grooves, etc., by means of a straight unjointed test finger according to 9.6 (see Figure 3).
[d] See IEC 60112.
[e] Interpolation is allowed in determining creepage distances corresponding to voltage values intermediate to those listed as working voltage. For determination of creepage distances, see Annex B.
[f] Creepage distances cannot be less than the associated clearances.
[g] To cover all different voltages including ELV in an auxiliary contact.
[h] For material group IIIb (100 V $\le$ CTI < 175 V), the values for material group IIIa multiplied by 1,6 apply.
[i] For working voltages up to and including 25 V, reference may be made to IEC 60664-1.

8.1.4 Screws, current-carrying parts and connections

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

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

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

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

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

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

Compliance is checked by inspection and by manual test.

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

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

Compliance is checked by inspection.

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

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

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

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

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 RCCBs shall be provided with terminals which shall allow the connection of copper conductors having nominal cross-sectional areas as shown in table 4.

NOTE Examples of possible designs of terminals are given in annex IC.

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

Table 4 – Connectable cross-sections of copper conductors for screw-type terminals

Rated current A		Range of nominal cross-section to be clamped* 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	25 to 35

* 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.

NOTE For AWG cross-sections see annex ID.

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

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

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

Compliance is checked by inspection.

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

8.1.5.5 Terminals shall have adequate mechanical strength.

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

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

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

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

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

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

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

This requirement does not apply to lug terminals.

Compliance is checked by the test of 9.5.3.

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

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

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

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

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

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

Compliance is checked by manual test.

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

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

8.2 Protection against electric shock

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

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

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

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

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

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

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

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

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

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

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

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

8.3 Dielectric properties and isolating capability

RCCBs shall have adequate dielectric properties and shall ensure isolation.

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

Compliance is checked by the tests of 9.7 and 9.20.

8.4 Temperature-rise

8.4.1 Temperature-rise limits

The temperature-rises of the parts of a RCCB specified in table 5, measured under the conditions specified in 9.8.2, shall not exceed the limiting values stated in that table.

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

Table 5 – Temperature-rise values

Parts [a), b)]	Temperature-rise K
Terminals for external connections [c)]	65
External parts liable to be touched during manual operation of the RCCB, including operating means of insulating material and metallic means for coupling insulated operating means of several poles	40
External metallic parts of operating means	25
Other external parts, including that face of the RCCB in direct contact with the mounting surface	60

a) No value is specified for the contacts, since the design of most RCCBs is such that a direct measurement of the temperature of those parts cannot be made without the risk of causing alterations or displacement of parts likely to affect the reproducibility of the tests.

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

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

c) For plug-in type RCCBs the terminals of the base on which they are installed.

8.4.2 Ambient air temperature

The temperature-rise limits given in table 5 are applicable only if the ambient air temperature remains between the limits given in table 2.

8.5 Operating characteristic

The operating characteristic of RCCBs shall comply with the requirements of 9.9.

8.6 Mechanical and electrical endurance

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

Compliance is checked by the test of 9.10.

8.7 Performance at short-circuit currents

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

Compliance is checked by the tests of 9.11.

8.8 Resistance to mechanical shock and impact

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

Compliance is checked by the test of 9.12.

8.9 Resistance to heat

RCCBs shall be sufficiently resistant to heat.

Compliance is checked by the test of 9.13.

8.10 Resistance to abnormal heat and to fire

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

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

8.11 Test device

RCCBs shall be provided with a test device to simulate the passing through the detecting device of a residual current in order to allow a periodic testing of the ability of the residual current device to operate.

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

The ampere-turns produced when operating the test device of a RCCB supplied at rated voltage or at the highest value of the voltage range, if applicable, shall not exceed 2,5 times the ampere-turns produced, when a residual current equal to $I_{\Delta n}$ is passed through one of the poles of the RCCB.

In the case of RCCBs having several settings of residual operating current (see 4.4) the lowest setting for which the RCCBs have been designed shall be used. The test device shall comply with the test of 9.16.

The protective conductor of the installation shall not become live when the test device is operated. It shall not be possible to energize the circuit on the load side by operating the test device when the RCCB is in the open position and connected as in normal use.

The test device shall not be the sole means of performing the opening operation and is not intended to be used for this function.

8.12 Requirements for RCCBs functionally dependent on line voltage

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

Compliance is checked by the test of 9.17 under the supplementary test conditions specified in 9.9.2. According to their classification, RCCBs shall comply with the requirements given in table 6.

Table 6 – Requirements for RCCBs functionally dependent on line voltage

Classification of the device according to 4.1		Behaviour in case of failure of the line voltage
RCCBs opening automatically in case of failure of the line voltage (4.1.2.1)	Without delay	Opening without delay according to the test conditions stated in 9.17.2 a)
	With delay	Opening with delay, according to 9.17.2 b). Correct operation during the delay shall be verified according to 9.17.3
RCCBs which do not open automatically in case of failure of the line voltage (4.1.2.2)		No opening

8.13 Behaviour of RCCBs in case of overcurrents in the main circuit

RCCBs shall not operate under specified conditions of overcurrents.

Compliance is checked by the test of 9.18.

8.14 Behaviour of RCCBs in the case of current surges caused by impulse voltages

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

Compliance is checked by the tests of 9.19.

8.15 Behaviour of RCCBs in case of earth fault currents comprising a d.c. component

RCCBs shall adequately perform in presence of earth fault currents comprising a d.c. component in accordance with their classification.

Compliance is checked by the tests of 9.21.

8.16 Reliability

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

Compliance is checked by the tests of 9.22 and 9.23.

9 Tests

9.1 General

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

Type tests required by this standard are listed in table 7.

Table 7 – List of type tests

Test	Subclause
– Indelibility of marking	9.3
– Reliability of screws, current-carrying parts and connections	9.4
– Reliability of terminals for external conductors	9.5
– Protection against electric shock	9.6
– Dielectric properties	9.7
– Temperature-rise	9.8
– Operating characteristic	9.9
– Mechanical and electrical endurance	9.10
– Behaviour of RCCBs under short-circuit conditions	9.11
– Resistance to mechanical shock and impact	9.12
– Resistance to heat	9.13
– Resistance to abnormal heat and to fire	9.14
– Trip-free mechanism	9.15
– Operation of the test device at the limits of rated voltage	9.16
– Behaviour of RCCBs in case of failure of the line voltage for RCCBs classified according to *4.1.2.1*.	9.17
– Limiting values of the non-operating current under overcurrent conditions	9.18
– Resistance against unwanted tripping due to current surges	9.19
– Resistance of the insulation against an impulse voltage	9.20
– Behaviour of RCCBs in case of an earth fault current comprising a d.c. component	9.21
– Reliability	9.22
– Ageing of electronic components	9.23

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

NOTE The term "certification" denotes:

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

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

Unless otherwise specified, each type test (or sequence of type tests) is made on RCCBs in a clean and new condition, the influencing quantities having their normal reference values (see table 2).

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

9.2 Test conditions

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

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

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

Unless otherwise specified, the RCCB is wired with the appropriate cable having the cross-section specified in table 8 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.

Table 8 – Test copper conductors corresponding to the rated currents

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

NOTE For AWG copper conductors, see annex ID.

Where tolerances are not specified, type tests are carried out at values not less severe than those specified in this standard. Unless otherwise specified, tests are carried out at the rated frequency ±5 %.

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

For the tests of 9.8, 9.9, 9.10 and 9.23, the RCCB 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 9.

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/cm³).

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 RCCB, 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 9.

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 4, solid or stranded, whichever is the most unfavourable. The conductor is moved each time the screw or nut is loosened.

Table 9 – 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 RCCB.

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 4 is placed in the terminal (for nominal cross-sections exceeding 6 mm², a rigid stranded conductor is used; for other nominal cross-sections, a solid conductor is used), and by the tests of 9.5.1, 9.5.2 and 9.5.3.

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

9.5.1 *The terminals are fitted with copper conductors of the smallest and largest cross-sectional areas specified in table 4, 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 9.

Each conductor is then subjected to the pull shown in table 10.

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

Table 10 – Pulling forces

Cross-section of conductor accepted by the terminal mm²	*Up to* 4	*Up to* 6	*Up to* 10	*Up to* 16	*Up to* 50
Pull N	50	60	80	90	100

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 4, 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 9.*

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 11.*

Table 11 – Conductor dimensions

Range of nominal cross-sections to be clamped mm²	*Stranded conductor*	
	Number of strands	*Diameter of strands* mm
1,0 to 2,5*	7	0,67
1,0 to 4,0*	7	0,85
1,5 to 6,0*	7	1,04
2,5 to 10,0	7	1,35
4,0 to 16,0	7	1,70
10,0 to 25,0	7	2,14
16,0 to 35,0	19	1,53
25,0 to 50,0	19	1,83

* *If the terminal is intended to clamp solid conductors only (see note of table 4), 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 9.

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

9.6 Verification of protection against electric shock

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

The test is made with the standard test finger shown in figure 3, on the RCCB 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 RCCB.

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.

RCCBs 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 RCCB being at this temperature.

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

9.7 Test of dielectric properties

9.7.1 Resistance to humidity

9.7.1.1 Preparation of the RCCB for test

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

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

9.7.1.2 Test conditions

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

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

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

9.7.1.3 Test procedure

The sample is kept in the cabinet for 48 h.

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

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

9.7.1.4 Condition of the RCCB 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 main circuit

The RCCB 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 this treatment the insulation resistance is measured 5 s after application of a d.c. voltage of approximately 500 V, successively as follows:

a) *with the RCCB in the open position, between each pair of the terminals which are electrically connected together when the RCCB is in the closed position, in turn on each pole;*

b) *with the RCCB in the closed position, in turn between each pole and the others connected together, electronic components connected between current paths being disconnected for the test;*

c) *with the RCCB in the closed position, between all poles connected together and the frame, including a metal foil in contact with the outer surface of the internal enclosure of insulating material, if any;*

d) *between metal parts of the mechanism and the frame;*

NOTE Access to the metal part of the mechanism may be specifically provided for this measurement.

e) *for RCCBs with a metal enclosure having an internal lining of insulating material, between the frame and a metal foil in contact with the innner surface of the lining of insulating material, including bushings and similar devices.*

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

The term "frame" includes

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

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

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

The insulation resistance shall not be less than

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

9.7.3 Dielectric strength of the main circuit

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

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

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

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

The values of the test voltage shall be as follows:

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

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

No flashover or breakdown shall occur during the test.

Glow discharges without drop in voltage are neglected.

9.7.4 Insulation resistance and dielectric strength of auxiliary circuits

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

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

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

   The insulation resistance shall be not less than 2 MΩ.

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

The voltage values to be applied are specified in table 12.

Table 12 – Test voltage of auxiliary circuits

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

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

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

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

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

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

NOTE 4 Control circuits other than those of 9.7.5 and 9.7.6 are submitted to the same tests as the auxiliary circuits.

9.7.5 Secondary circuit of detection transformers

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

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

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

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

- *open voltage: 600 V* $^{+25}_{0}$ *V*

  NOTE This value is provisional.

- *maximum ripple : 5 %*

  where

$$ripple = \frac{max.\ value\ -mean\ value}{mean\ value} \times 100$$

- *short-circuit current: 12 mA* $^{+2}_{0}$ *mA.*

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

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

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

9.7.7.1 Verification of impulse withstand voltage across the open contacts (suitability for isolation)

The test is carried out on a RCCB fixed on a metal support as in normal use.

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 as follows:

±5 % for the peak value;

±30 % for the front time;

±20 % for the time to half-value.

The surge impedance of the test apparatus shall have a nominal value of 500 Ω.

The shape of the impulses is adjusted with the RCCB 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.

The 1,2/50 μs impulse voltage according to Figure 6 of IEC 60060-1 is applied between the line terminals connected together and the load terminals connected together with the contacts in the open position.

Three positive impulses and three negative impulses are applied, the interval between consecutive impulses being at least 1 s for impulses of the same polarity and being at least 10 s for impulses of the opposite polarity.

The test impulse voltage values shall be chosen from Table 19, in accordance with the rated impulse voltage of the RCCB as given in Table 18. These values are corrected for barometric pressure and/or altitude at which the tests are carried out, according to Table 19.

There shall be no disruptive discharges during the test.

Table 19 – Test voltage across the open contacts for verifying the suitability for isolation, referred to the rated impulse withstand voltage of the RCCB and the altitude where the test is carried out

Rated impulse voltage withstand U_{imp} kV	Test voltages at corresponding altitude $U_{1,2/50}$ a.c. peak kV				
	Sea level	200 m	500 m	1 000 m	2 000 m
2,5	3,5	3,5	3,4	3,2	3
4	6,2	6,0	5,8	5,6	5,0

9.7.7.2 Verification of impulse withstand voltage for the parts not tested in 9.7.7.1

The test is carried out on a RCCB fixed on a metal support 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.

The surge impedance of the test apparatus shall have a nominal value of 500 Ω.

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

NOTE 1 For RCCBs with incorporated surge arresters the shape of the impulses is adjusted without connection of the RCCB to the impulse generator.

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

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

A first series of tests is made applying the impulse voltage between the phase pole(s), connected together, and the neutral pole (or path) of the RCCB, as applicable.

A second series of tests is made applying the impulse voltage between the metal support connected to the terminal(s) intended for the protective conductor(s), if any, and the phase pole(s) and the neutral pole (or path) connected together.

In both cases three positive impulses and three negative impulses are applied, the interval between consecutive impulses being at least 1 s for impulses of the same polarity and at least 10 s for impulses of the opposite polarity.

The test impulse voltage values shall be chosen in Table 20 in accordance with the rated impulse voltage of the RCCB as given in Table 18. These values are corrected for barometric pressure and/or altitude at which the tests are carried out, according to Table 20.

There shall be no flashover nor unintentional disruptive discharges during the test. If, however, only one such disruptive discharge occurs, six 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.

NOTE 2 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.

Table 20 – Test voltage for verification of impulse withstand voltage for the parts not tested in 9.7.7.1

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

9.7.7.3 Verification of leakage currents across open contacts (suitability for isolation)

Each pole of a RCCB having been submitted to one of the applicable tests of 9.11.2.2, or 9.11.2.3, or 9.11.2.4a), or 9.11.2.4b) or 9.11.2.4c) is supplied at a voltage 1,1 times its rated operational voltage, the circuit-breaker being in the open position.

The leakage current flowing across the open contacts is measured and shall not exceed 2 mA.

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 RCCB at about half its height and at a distance of about 1 m from the RCCB.

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

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

9.8.2 Test procedure

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

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

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

During these tests the temperature-rise shall not exceed the values shown in table 5.

9.8.3 Measurement of the temperature-rise of parts

The temperature of the different parts referred to in table 5 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 characteristic

9.9.1 Test circuit

The RCCB is installed as for normal use.

The test circuit shall be of negligible inductance and correspond to figure 4a.

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 RCCB shall perform the tests of 9.9.2.1, 9.9.2.2 and 9.9.2.3 (each one comprising five measurements), made on one pole only, taken at random.

For RCCBs having multiple settings of residual operating current, the tests are made for each setting.

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

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

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

9.9.2.2 Verification of the correct operation at closing on residual current

The test circuit being calibrated at the rated value of the operating residual current $I_{\Delta n}$ and the test switches S_1 and S_2 being closed, the RCCB is closed on the circuit so as to simulate service conditions as closely as possible. The break time is measured five times. No measurement shall exceed the limiting value specified for $I_{\Delta n}$ in table 1, according to the type of RCCB.

In the case of RCCBs functionally dependent on line voltage, classified according to 4.1.2.2 a), the control circuit of which is supplied from the line side of the main circuit, this verification does not take into account the time necessary to energize the RCCB. In this case, therefore, the verification is considered as made by establishing the residual current by closing S_1, the RCCB under test and S_2 being previously closed.

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

a) *All types*

The test circuit being successively calibrated at each of the values of residual current specified in table 1, the test switch S_1 and the RCCB being in the closed position, the residual current is suddenly established by closing the test switch S_2.

The RCCB shall trip during each test.

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

No value shall exceed the relevant specified limiting value.

b) *Additional test for type S*

The test circuit being successively calibrated at each of the values of residual current specified in table 1, the test switch S_1 and the RCCB being in the closed position, the residual current is suddenly established by closing the test switch S_2 for periods corresponding to the relevant minimum non-actuating times, with a tolerance of $^{0}_{-5}$ %.

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

The RCCB shall not trip during any of the tests.

The test is then repeated, except for the test current of 500 A, at the ambient temperatures of −5 °C and +40 °C.

The RCCB shall not trip during any of the tests.

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

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

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

The test switch S_1 and the RCCB being in the closed position, the residual current is suddenly established by closing the test switch S_2.

The test is made once for each value of the residual current with measurement of the break time.

The RCCB shall trip during each test. The break time shall not exceed the times given in table 1.

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

The tests of 9.9.2.2 and 9.9.2.3 are repeated, the RCCBs being loaded with rated current 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.

In the case of RCCBs having multiple settings of residual operating current, the tests are made for each setting.

9.9.4 Tests at the temperature limits

The RCCB shall perform the tests specified in 9.9.2.3 under the following conditions, successively:

a) ambient temperature: –5 °C, off-load;

b) ambient temperature: +40 °C, the RCCB having been previously loaded with the rated current, at any convenient voltage, until it attains thermal steady-state conditions.

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

In the case of RCCBs having multiple settings of residual operating current, the tests are made for each setting.

NOTE Preheating may be made at reduced voltage but auxiliary circuits shall be connected to their normal operating voltage (particularly for components depending on the line voltage).

9.9.5 Particular test conditions for RCCBs functionally dependent on line voltage

For RCCBs functionally dependent on line voltage, each test is made at the following values of the line voltage, applied to the relevant terminals: 1,1 and 0,85 times the rated line voltage.

9.10 Verification of mechanical and electrical endurance

9.10.1 General test conditions

The RCCB is fixed to a metal support.

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

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

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

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

The RCCB is connected to the circuit with conductors of the sizes indicated in table 8.

9.10.2 Test procedure

RCCBs having $I_{\Delta n}$ > 0,010 A are subjected to 2 000 operating cycles, each operating cycle consisting of a closing operation followed by an opening operation.

The RCCB shall be operated as for normal use.

The opening operations shall be effected as follows:

- *for the first 1 000 operating cycles by using the manual operating means;*
- *for the following 500 operating cycles by using the test device;*
- *for the last 500 operating cycles by passing through one pole a residual operating current of value $I_{\Delta n}$.*

For RCCBs having $I_{\Delta n} \leq$ 0,010 A the number of opening operations shall be: 500 – 750 – 750 respectively.

In addition the RCCB is further subjected without load, using the manual operating means, to

- *2 000 operating cycles for RCCBs having $I_n \leq$ 25 A;*
- *1 000 operating cycles for RCCBs having I_n > 25 A.*

The operating frequency shall be

- *four operating cycles per minute for RCCBs of $I_n \leq$ 25 A, the ON period having a duration of 1,5 s to 2 s;*
- *two operating cycles per minute for RCCBs of I_n > 25 A, the ON period having a duration of 1,5 s to 2 s.*

NOTE For RCCBs having multiple settings the tests are made at the lowest setting.

9.10.3 Condition of the RCCB after test

Following the test of 9.10.2 the RCCB shall not show

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

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

The RCCB shall then perform satisfactorily the dielectric strength test specified in 9.7.3 but at a voltage equal to its rated voltage, for 1 min, however not less than 900 V and without previous humidity treatment.

9.11 Verification of the behaviour of the RCCB under short-circuit conditions

9.11.1 List of the short-circuit tests

The various tests to verify the behaviour of the RCCB under short-circuit conditions are shown in table 13.

Table 13 – Tests to be made to verify the behaviour of RCCBs under short-circuit conditions

Verification of	*Subclause*
Rated making and breaking capacity I_m	*9.11.2.2*
Rated residual making and breaking capacity $I_{\Delta m}$	*9.11.2.3*
Coordination at rated conditional short-circuit current Inc	*9.11.2.4 a)*
Coordination at rated making and braking capacity Im	*9.11.2.4 b)*
Coordination at rated conditional residual short-circuit current $I\Delta c$	*9.11.2.4 c)*

9.11.2 Short-circuit tests

9.11.2.1 General conditions for test

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

NOTE For RCCBs having multiple settings the tests are made at the lowest setting.

a) Test circuit

Figures 5, 6, 7, 8 and 9 respectively give diagrams of the circuits to be used for the tests concerning

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

The supply S feeds a circuit including resistors R, reactors L, the SCPD (if any) (see 3.4.8), the RCCB 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 RCCB.

The SCPD, or the equivalent impedance (see 9.11.2.2 a) and 9.11.2.3 a)), is inserted between the resistors R and the RCCB.

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

For the tests of 9.11.2.4 a) and c) the RCCB shall be connected with cables having a length of 0,75 m per pole and the maximum cross-section corresponding to the rated current according to table 4.

NOTE It is recommended that 0,5 m be connected on the supply side and 0,25 m on the load side of the RCCB.

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 one of the following currents:

- *a residual current of 10 $I_{\Delta n}$ such as to cause the operation of the RCCB within the appropriate minimum operating time specified in table 1;*
- *the rated residual making and breaking current $I_{\Delta m}$;*
- *the rated conditional residual short-circuit current $I_{\Delta c}$.*

S_1 is an auxiliary switch.

For the purpose of verifying the minimum I^2t and I_p values to be withstood by the RCCB as given in table 15, tests have to be performed. The SCPD, if any, shall be adjusted and shall be embodied either by a silver wire or by a fuse (as proposed in Annex IF) or by any other means. The manufacturer may specify the type of SCPD to be used in the tests.

For the purpose of this test, verification of the correctly selected and adjusted SCPD (I^2t and I_p) is made prior to testing, the RCCB being replaced by a temporary connection having a negligible impedance.

The minimum values of let-through energy I^2t and peak current I_p, based on an electrical angle of 45°, are given in table 15.

Without an agreement of the manufacturer, these values shall not be higher than 1,1 times the values given in table 15.

Table 15 – Minimum values of I^2t and I_p

		I_n A								
I_{nc} and $I_{\Delta c}$ A		≤ 16	≤ 20	≤ 25	≤ 32	≤ 40	≤ 63	≤ 80	≤ 100	≤ 125
500	I_p (kA)	0,45	0,47	0,5	0,57					
	I^2t (kA²s)	0,4	0,45	0,53	0,68					
1000	I_p (kA)	0,65	0,75	0,9	1,18					
	I^2t (kA²s)	0,50	0,9	1,5	2,7					
1500	I_p (kA)	1,02	1,1	1,25	1,5	1,9	2,1			
	I^2t (kA²s)	1	1,5	2,4	4,1	9,75	22			
3000	I_p (kA)	1,1	1,2	1,4	1,85	2,35	3,3	3,5	3,8	3,95
	I^2t (kA²s)	1,2	1,8	2,7	4,5	8,7	22,5	26	42	72,5
4500	I_p (kA)	1,15	1,3	1,5	2,05	2,7	3,9	4,3	4,8	5,6
	I^2t (kA²s)	1,45	2,1	3,1	5,0	9,7	28	31	45	82,0
6000	I_p (kA)	1,3	1,4	1,7	2,3	3	4,05	4,7	5,3	5,8
	I^2t (kA²s)	1,6	2,4	3,7	6,0	11,5	25	31	48	65,0
10000	I_p (kA)	1,45	1,8	2,2	2,6	3,4	4,3	5,1	6	6,4
	I^2t (kA²s)	1,9	2,7	4	6,5	12	24	31	48	60,0

NOTE At the request of the manufacturer higher values of I^2t and I_p may be used.

For intermediate values of short-circuit test currents the next higher short-circuit current shall apply.

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

For coordination with circuit-breakers, tests with this combination are necessary.

All the conductive parts of the RCCB normally earthed in service, including the metal support on which the RCCB is mounted or any metal enclosure (see 9.11.2.1 f)), 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 RCCB.

The voltage sensors O_2 are connected:

- *across the terminals of the pole, for single-pole RCCBs;*
- *across the supply terminals, for multipole RCCBs.*

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.

RCCBs 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).

In the case of RCCBs according to 4.1.2.1, in order to permit the breaking operations to be made, it is necessary either to position the device T making the short-circuit on the load side of the RCCB or to insert an additional short-circuit making device in that position.

b) Tolerances on test quantities

All the tests concerning the verification of rated making and breaking capacity and of the correct coordination between RCCBs and SCPDs shall be performed at values of influencing quantities and factors as stated by the manufacturer in accordance with table 1 of this standard, unless otherwise specified.

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:* see 9.2;
- *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.

Two examples are given in annex IA.

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 16.

Table 16 – Power factors for short-circuit tests

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

d) Power frequency recovery voltage

The value of the power frequency recovery voltage shall be equal to a value corresponding to 105 % of the rated voltage of the RCCB under test.

NOTE The value of 105 % of the rated voltage is deemed to cover the effects of the variations of the system voltage under normal service conditions. The upper limit value may be increased with the approval of the manufacturer.

After each arc extinction, the power frequency recovery voltage shall be maintained for not less than 0,1 s.

e) Calibration of the test circuit

The RCCB and the SCPD, if any, are replaced by temporary connections G_1 having a negligible impedance compared with that of the test circuit.

For the test of 9.11.2.4 a) the load terminals of the RCCB 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, at the test voltage, a current equal to the rated conditional short-circuit current at the prescribed power-factor; the test circuit is energized simultaneously in all poles and the current curve is recorded with the current sensor O_1.

Moreover, for the tests of 9.11.2.2, 9.11.2.3, 9.11.2.4 b) and c) the additional resistors R_2 and/or R_3 are used, as necessary, so as to obtain the required test current values (I_m, $I_{\Delta m}$ and $I_{\Delta c}$ respectively).

f) Condition of the RCCB for test

RCCBs shall be tested in free air according to f1) of this subclause, unless they are designed for use only in enclosures specified by the manufacturer or are intended for use in individual enclosures only, in which cases they shall be tested according to f2) of this subclause or, with the agreement of the manufacturer, according to f1) of this subclause.

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

The RCCB shall be operated simulating as closely as possible the normal operation.

f1) Test in free air

The RCCB under test is mounted as shown in figure C.1 of annex C.

The polyethylene sheet and the barrier of insulating material specified in annex C are placed as shown in figure C.1 for opening (O) operations only.

The grid(s) specified in annex C shall be so positioned that the bulk of the emitted ionized gases passes through the grid(s). The grid(s) shall be placed in the most unfavourable position(s).

NOTE 1 If the position of the vents is not obvious, or if there are no vents, appropriate information should be provided by the manufacturer.

The grid circuit(s) (see figure C.3) shall be connected to the points B and C according to the test circuit diagrams of figures 5 to 9.

The resistor R' shall have a resistance of 1,5 Ω. The copper wire F' (see figure C.3) shall have a length of 50 mm and a diameter of 0,12 mm for RCCBs having a rated voltage of 230 V and 0,16 mm for RCCBs having a rated voltage of 400 V.

NOTE 2 The data for other voltages are under consideration.

For test currents up to and including 1 500 A, the distance "a" shall be 35 mm.

For higher short-circuit currents up to I_{nc}, the distance "a" may be increased and/or additional barriers or insulating means may be fitted, as stated by the manufacturer; "a", if increased, shall be chosen from the series 40 – 45 – 50 – 55 – .. mm and stated by the manufacturer.

f2) Test in enclosures

The grid and the barrier of insulating material shown in figure C.1 are omitted.

The test shall be performed with the RCCB placed in an enclosure having the most unfavourable configuration, under the most unfavourable conditions.

NOTE This means that if other RCCBs (or other devices) are normally fitted in the direction(s) in which the grid(s) would be placed, they should be installed there. These RCCBs (or other devices) should be supplied as in normal use but via F' and R' as defined in f1) of this subclause and connected as shown in the appropriate figures 5 to 9.

In accordance with the manufacturer's instructions, barriers or other means, or adequate clearances may be necessary to prevent ionized gases from affecting the installation.

The polyethylene sheet as described in annex C is placed as shown in figure C.1 at a distance of 10 mm from the operating means, for O operations only.

g) Sequence of operations

The test procedure consists of a sequence of operations.

The following symbols are used for defining the sequence of operations:

O represents an opening operation, the short-circuit being established by the switch *T*, with the RCCB and the SCPD, if any, in the closed position;

CO represents a closing operation of the RCCB, both the switch *T* and the SCPD, if any, being in the closed position, followed by an automatic opening (in the case of a SCPD see 9.11.2.4);

t represents the time interval between two successive short-circuit operations which shall be 3 min or such longer time as may be required for resetting or renewing the SCPD, if any.

h) Behaviour of the RCCB during tests

During tests, the RCCB shall not endanger the operator.

Furthermore, there shall be no permanent arcing, no flashover between poles or between poles and exposed conductive parts, no melting of the fuse F and, if applicable, of the fuse F'.

i) Condition of the RCCB after tests

After each of the tests applicable carried out in accordance with 9.11.2.2, 9.11.2.3, 9.11.2.4 a), 9.11.2.4 b) and 9.11.2.4 c), the RCCBs shall show no damage impairing their further use and shall be capable, without maintenance, of withstanding the following tests:

- *leakage current across open contacts, according to 9.7.7.3;*
- *dielectric strength tests according to 9.7.3 carried out between 2 h and 24 h after the short-circuit test at a voltage of twice its rated voltage, for 1 min, without previous humidity treatment;*
- *making and breaking its rated current at its rated voltage.*

During these tests, after the test carried out under the conditions specified in item a) of 9.7.2. it shall be verified that the indicating means show the open position and during the test carried out under the condition specified in item b) of 9.7.2 the indicating means shall show the closed position.

Under the test conditions of 9.9.2.3 a) the RCCB shall trip with a test current of 1,25 $I_{\Delta n}$. One test only is made on one pole taken at random, without measurement of breaktime.

The polyethylene sheet shall show no holes visible with normal or corrected vision without additional magnification.

In addition, RCCBs functionally depending on line voltage shall be capable of satisfying the test of 9.17, if applicable.

9.11.2.2 Verification of the rated making and breaking capacity (I_m)

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

a) Test conditions

The RCCB is tested in a circuit according to the general test conditions prescribed in 9.11.2.1, no SCPD being inserted in the circuit.

The connections G_1 of negligible impedance are replaced by the RCCB and by connections having approximately the impedance of the SCPD.

The auxiliary switch S_1 remains closed.

b) Test procedure

With a residual operating current equal to 10 $I_{\Delta n}$ flowing through the switch S_1 and the resistance R_2, the following sequence of operation is performed:

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

9.11.2.3 Verification of the rated residual making and breaking capacity ($I_{\Delta m}$)

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

a) Test conditions

The RCCB shall be tested according to the general test conditions prescribed in 9.11.2.1, no SCPD being inserted in the circuit, but connected in such a manner that the short-circuit current is a residual current.

For this test the resistors R3 are not used, the circuit being left open.

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

The connections G_1 of negligible impedance are replaced by the RCCB and by connections having approximately the impedance of the SCPD.

The auxiliary switch S_1 remains closed.

The test is performed on each pole in turn excluding the switched neutral pole, if any.

b) Test procedure

The following sequence of operations is performed:

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

For the breaking operation the auxiliary switch T is synchronized with respect to the voltage wave so that the point of initiation is 45° ± 5°. The same pole shall be used as reference for the purpose of synchronization for the different samples.

9.11.2.4 Verification of the coordination between the RCCB and the SCPD

These tests are intended to verify that the RCCB, protected by the SCPD, is able to withstand, without damage, short-circuit currents up to its rated conditional short-circuit current (see 5.3.10).

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

During the test either both the RCCB and the SCPD or the SCPD only may operate. However, if only the RCCB opens, the test is also considered as satisfactory.

The SCPD is renewed or reset as applicable after each operation.

The following tests (see also table 13) are made under the general conditions of 9.11.2.1:

- *a test (see 9.11.2.4 a)) to check that at the rated conditional short-circuit current I_{nc} the SCPD protects the RCCB.*

  The test is made without establishing any residual current.
- *a test (see 9.11.2.4 b)) to check that at short-circuit currents of a value corresponding to the rated making and breaking capacity I_m, the SCPD operates and protects the RCCB.*

  The test is made without establishing any residual current.
- *a test (see 9.11.2.4 c)) to check that in the case of phase to earth short-circuits with currents up to the value of the rated conditional residual short-circuit current $I_{\Delta c}$, the RCCB is able to withstand the corresponding stresses.*

For the breaking operations, the auxiliary switch T is synchronized with respect to the voltage wave so that the point of initiation of one pole is 45° ± 5°. The same pole shall be used as reference for the purpose of synchronization for the different samples.

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 RCCB and by the SCPD.

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

2) Test procedure

The following sequence of operations is performed:

$$O - t - CO.$$

b) Verification of the coordination at the rated making and breaking capacity (I_m)

1) Test conditions

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

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

2) Test procedure

The following sequence of operations is performed:

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

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

1) Test conditions

The RCCB shall be tested according to the general test conditions prescribed in 9.11.2.1, but connected in such a manner that the short-circuit current is a residual current.

The test is performed on one pole only which shall not be the switched neutral of the RCCB.

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

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

The auxiliary switch S_1 remains closed.

2) Test procedure

The following sequence of operations is performed:

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

9.12 Verification of resistance to mechanical shock and impact

9.12.1 Mechanical shock

9.12.1.1 Test device

The RCCB is subjected to mechanical shocks using an apparatus as shown on figure 11. A wooden base A is fixed to a concrete block and a wooden platform B is hinged to A. This platform carries a wooden board C, which can be fixed at various distances from the hinge and in two vertical positions. The end of B bears a metal stop-plate D which rests on a coiled spring having a flexion constant of 25 N/mm.

The RCCB is secured to C in such a way that the distance of the horizontal axis of the sample is 180 mm from B, C being in turn so fixed that the distance of the mounting surface is 200 mm from the hinge, as shown in the figure.

On C, opposite to the mounting surface of the RCCB, an additional mass is fixed so that the static force on D is 25 N, in order to ensure that the moment of inertia of the complete system is substantially constant.

9.12.1.2 Test procedure

With the RCCB in the closed position, but not connected to any electrical source, the platform is lifted at its free end and then allowed to fall 50 times from a height of 40 mm, the interval between consecutive falls being such that the sample is allowed to come to rest.

The RCCB is then secured to the opposite side of C and B is again allowed to fall 50 times as before. After this test C is turned through 90° about its vertical axis and, if necessary, repositioned so that the vertical axis of symmetry of the RCCB is 200 mm from the hinge.

The platform is then allowed to fall 50 times, as before, with the RCCB on one side of C, and 50 times with the RCCB on the opposite side.

Before each change of position the RCCB is manually opened and closed.

During the tests the RCCB shall not open.

9.12.2 Mechanical impact

Compliance is checked on those exposed parts of the RCCB mounted as for normal conditions of use (see note in 8.2), which may be subjected to mechanical impact in normal use, by the test of 9.12.2.1, for all types of RCCB and, in addition, by the tests of

- *9.12.2.2 for RCCBs intended to be mounted on a rail;*
- *9.12.2.3 for plug-in type RCCBs.*

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

9.12.2.1 *The samples are subjected to blows by means of an impact-test apparatus as shown on figures 12 to 14.*

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 ± 0,0025 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 RCCBs are mounted on a sheet of plywood, 175 mm x 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 14.

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 RCCBs are mounted in a device, as shown on figure 15, which is fixed to the mounting support.

Panel-mounting type RCCBs are mounted in a device, as shown in figure 16, which is fixed to the mounting support.

Plug-in type RCCBs are mounted in their appropriate sockets, which are fixed on the sheet of plywood or in the devices according to figure 15 or 16, as applicable.

RCCBs 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 RCCB, 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 plate 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 9.

The striking element is allowed to fall from a height of 10 cm on the surfaces which are exposed when the RCCB 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 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 RCCB is subjected to ten blows, two of them being applied to the operating means and the remainder being 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 operating 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.

The two blows on the operating means shall be applied: one when the operating means is in the ON position and the other when the operating means is in the OFF position.

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 RCCB, operating means, 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 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 neglected.

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

9.12.2.2 *RCCBs 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 RCCB, immediately followed by an upward vertical force of 50 N for 1 min (figure 17).

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

9.12.2.3 Plug-in type RCCBs

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 9.9.2.3 a) the RCCB shall trip with a test current of 1,25 $I_{\Delta n}$. Only one test is made, on one pole taken at random, without measurement of break-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 RCCBs 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 18, 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 RCCBs 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 the higher.*

NOTE For the purpose of the tests of 9.13.2 and 9.13.3, bases of surface-type RCCBs 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 RCCBs 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 RCCBs 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 trip-free mechanism

9.15.1 General test conditions

The RCCB is mounted and wired as in normal use.

It is tested in a substantially non-inductive circuit, the diagram of which is shown in figure 4a.

9.15.2 Test procedure

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

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

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

NOTE 1 If the RCCB is fitted with more than one operating means, the trip-free operation is verified for all operating means.

NOTE 2 For RCCBs having multiple settings the test is made for each setting.

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

a) *The RCCB being supplied with a voltage equal to 0,85 times the rated voltage, the test device is momentarily actuated 25 times at intervals of 5 s, the RCCB being reclosed before each operation.*

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

c) *Test b) is then repeated, but only once, the operating means of the test device being held in the closed position for 30 s.*

At each test the RCCB shall operate. After the test, it shall show no change impairing its further use.

In order to check that the ampere-turns due to the operations of the test device are less than 2,5 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 RCCB is necessary, a separate sample shall be used.

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

9.17 Verification of the behaviour of RCCBs functionally dependent on line voltage, classified under 4.1.2.1, in case of failure of the line voltage

9.17.1 Determination of the limiting value of the line voltage (U_x)

A voltage equal to the rated voltage is applied to the line terminals of the RCCB and is then progressively lowered so as to attain zero within a period of about 30 s or within a period long enough with respect to the opening with delay, if any, (see 8.12), whichever is the longer, until automatic opening occurs.

The corresponding voltage is measured.

Five measurements are made.

All the values measured shall be less than 0,85 times the rated voltage (or, if relevant, 0,85 times the minimum value of the range of rated voltages).

At the end of these measurements, it shall be verified that the RCCB operates in accordance with table 1 when a residual current equal to $I_{\Delta n}$ is applied in case of drop of the line voltage, under the conditions specified in this subclause, until automatic opening occurs, the applied voltage being just above the highest value measured.

Then it shall be checked that for any value of the line voltage less than the lowest value which is measured it shall not be possible to close the apparatus by the manual operating means.

9.17.2 Verification of the automatic opening in case of failure of the line voltage

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

The line voltage is then switched off.

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

Five measurements are made:

a) *for RCCBs opening without delay: no value shall exceed 0,5 s;*

b) *for RCCBs opening with delay: the maximum and the minimum values shall be situated within the range indicated by the manufacturer.*

NOTE Verification of the value of U_y (see 3.4.10.2) is not considered in this standard.

9.17.3 Verification of the correct operation, in presence of a residual current, for RCCBs opening with delay in case of failure of the line voltage

The RCCB is connected according to figure 4a and is supplied on the line side with the rated voltage (or, if relevant, with any voltage having a value within its range of rated voltages).

All phases but one are then switched off by means of switch S_3.

During the delay (see table 6) indicated by the manufacturer the RCCB is submitted to the tests of 9.9.2, the closing and subsequent opening of switch S_3 being required before each measurement.

NOTE The test of 9.9.2.1 is only made if the delay is greater than 30 s.

9.17.4 Verification of the correct operation of RCCBs with three or four current paths, with a residual current, one line terminal only being energized

In the case of RCCBs with three or four current paths (see 4.3) a test is made in accordance with 9.9.2.3, but with the neutral and one line only being energized in turn, the connections being made in accordance with figure 4.

9.17.5 Verification of the reclosing function of automatically reclosing RCCBs

Under consideration.

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

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

9.18.1 Verification of the limiting value of overcurrent in case of a load through a RCCB with two current paths

The RCCB is connected as for normal use with a substantially non-inductive load equal to 6 I_n.

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 RCCB shall not open.

RCCBs 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).

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

The RCCB is connected according to figure 19.

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 RCCB D may be replaced by connections of negligible impedance.

The test switch S_1, being initially open, is closed and re-opened after 1 s.

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

The RCCB shall not open.

RCCBs 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).

9.19 Verification of behaviour of RCCBs in case of current surges *caused by impulse voltages*

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

The RCCB is tested using a surge generator capable of delivering a damped oscillator current wave as shown in figure 19a. An example of circuit diagram for the connection of the RCCB is shown in figure 19b.

One pole of the RCCB 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 RCCB 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 RCCBs with $I_{\Delta n} \leq 10$ 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 RCCB shall not trip. After the ring wave test, the correct operation of the RCCB is verified by a test according to 9.9.2.3 at $I_{\Delta n}$ only with the measurement of the tripping time.

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

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

9.19.2.1 Test conditions

The RCCB is tested using a current generator capable of delivering a damped surge current 8/20 μs (IEC 60060-2) as shown in figure 23. An example of circuit diagram for the connection of the RCCB is shown in figure 24.

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

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

peak value	*3 000 A $^{+10}_{0}$ %*
virtual front time:	*8 μs ± 20 %*
virtual time to half value:	*20 μs ± 20 %*
peak of reverse current:	*less than 30 % of peak value.*

The current should be adjusted to the asymptotic current shape. For the tests on other samples of the same type with the same I_n and the same $I_{\Delta n}$, the reverse current, if any, should not exceed 30 % of the peak value.

9.19.2.2 Test results for S-type RCCBs

During the tests the RCCB shall not trip.

After the surge current tests the correct operation of the RCCB is verified by a test according to 9.9.2.3, at $I_{\Delta n}$ only, with the measurement of the break time.

9.19.2.3 Test results for RCCBs of the general type

During the test the RCCB may trip. After any tripping the RCCB shall be re-closed.

After the surge current tests the correct operation of the RCCB is verified by a test according to 9.9.2.3, at $I_{\Delta n}$ only, with the measurement of the break time.

9.20 Verification of resistance of the insulation against an impulse voltage

The test is carried out on a RCCB 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 pole(s), connected together, and the neutral pole (or path) of the RCCB.

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 pole(s) and the neutral pole (or path) connected together.

NOTE 1 The surge impedance of the test apparatus should be 500 Ω; a substantial reduction of this value is under consideration.

NOTE 2 The values of 6 kV and 8 kV are provisional.

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.

NOTE 3 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.

NOTE 4 Intentional discharges cover discharges of any incorporated surge arresters.

The shape of the impulses is adjusted with the RCCB 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.

9.21 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 figures 4b and 4c, as applicable.

9.21.1 Type A residual current devices

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

The test shall be performed according to figure 4b.

The auxiliary switches S_1 and S_2 and the RCCB D 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 RCCB shall be tested twice at each of the current delay angles, in position I 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 RCCBs with $I_{\Delta n}$ > 0,01 A, and at an approximate rate of 2 $I_{\Delta n}$/30 amperes per second for RCCBs with $I_{\Delta n} \leq$ 0,01 A, starting from zero. The tripping current shall be in accordance with table 17.

Table 17 – Tripping current ranges for type A RCCBs

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 5.3.12)*
90°	*0,25 $I_{\Delta n}$*	
135°	*0,11 $I_{\Delta n}$*	

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

The RCCB shall be tested according to figure 4b.

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

NOTE In the case of RCCBs functionally dependant on line voltage, classified according to 4.1.2.2 a), the control circuit of which is supplied from the line side of the main circuit, this verification does not take into account the time necessary to energize the RCCB. In this case therefore the verification is considered as made by establishing the residual current by closing S_1, the RCCB under test and S_2 being previously closed.

The test is carried out at each value of residual current specified in table 1, according to the type of RCCB.

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

No value shall exceed the specified limiting values.

9.21.1.3 Verification at the reference temperature of the correct operation with load

The tests of 9.21.1.1 are repeated, the pole under test and one other pole of the RCCB 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 4b.

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

The RCCB shall be tested according to figure 4c 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 RCCB is tested in turn, twice at each of positions I and II.

The half-wave current I_1, starting from zero, being steadily increased at an approximate rate of 1,4 $I_{\Delta n}$/30 amperes per second for RCCBs with $I_{\Delta n}$ > 0,01 A and 2 $I_{\Delta n}$/30 amperes per second for RCCBs with $I_{\Delta n} \leq$ 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.

9.22 Verification of reliability

Compliance is checked by the tests of 9.22.1 and 9.22.2.

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

9.22.1 Climatic test

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

9.22.1.1 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.

9.22.1.2 Severity

The cycles are effected under the following conditions:

- *upper temperature:* 55 °C ± 2 °C
- *number of cycles :* 28.

9.22.1.3 Testing procedure

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

a) Initial verification

An initial verification is made by submitting the RCCB to the test according to 9.9.2.3, but only at $I_{\Delta n}$.

b) Conditioning

1) The RCCB mounted and wired as for normal use is introduced into the chamber.

It shall be in the closed position.

2) Stabilizing period (see figure 20)

The temperature of the RCCB shall be stabilized at 25 °C ± 3 °C:

a) either by placing the RCCB in a separate chamber before introducing it into the test chamber;

b) or by adjusting the temperature of the test chamber to 25 °C ± 3 °C after the introduction of the RCCB 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 2).

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

3) *Description of the 24-hour cycle (see figure 21)*

a) *The temperature of the chamber shall be progressively raised to the appropriate upper temperature prescribed in 9.22.1.2.*

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 21.

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

NOTE The condition that condensation shall occur implies that the surface temperature of the RCCB 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.

b) *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 RCCB during the last 15 minutes.

c) *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 21, 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 %.

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

9.22.1.4 Recovery

At the end of the cycles the RCCB 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 RCCB shall not trip.

9.22.1.5 Final verification

Under the conditions of tests specified in 9.9.2.3, the RCCB shall trip with a test current of 1,25 $I_{\Delta n}$. One test only is made on one pole taken at random, without measurement of break time.

9.22.2 Test with temperature of 40 °C

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

For each pole, a single-core cable, 1 m long and having a nominal cross-sectional area as specified in table 4, is connected on each side of the RCCB, the terminal screws or nuts being tightened with a torque equal to two-thirds of that specified in table 9. The assembly is placed in a heating cabinet.

The RCCB 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, the RCCB being not operated.

For four-pole RCCBs only three poles 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 RCCB, in the cabinet, is allowed to cool down to approximately room temperature without current passing.

Under the conditions of tests specified in 9.9.2.3, the RCCB shall trip with a test current of 1,25 $I_{\Delta n}$. One test only is made on one pole taken at random without measurement of break time.

9.23 Verification of ageing of electronic components

NOTE 1 A revision of this test in under consideration.

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

After this test, the RCCB 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 9.9.2.3, the RCCB shall trip with a test current of 1,25 $I_{\Delta n}$. One test only is made on one pole taken at random without measurement of break time.

NOTE 2 An example for the test circuit of this verification is given in figure 22.

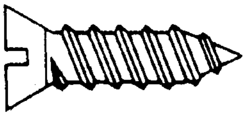


Figure 1 – Thread-forming tapping screw (3.6.10)

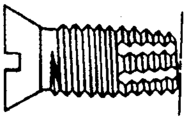
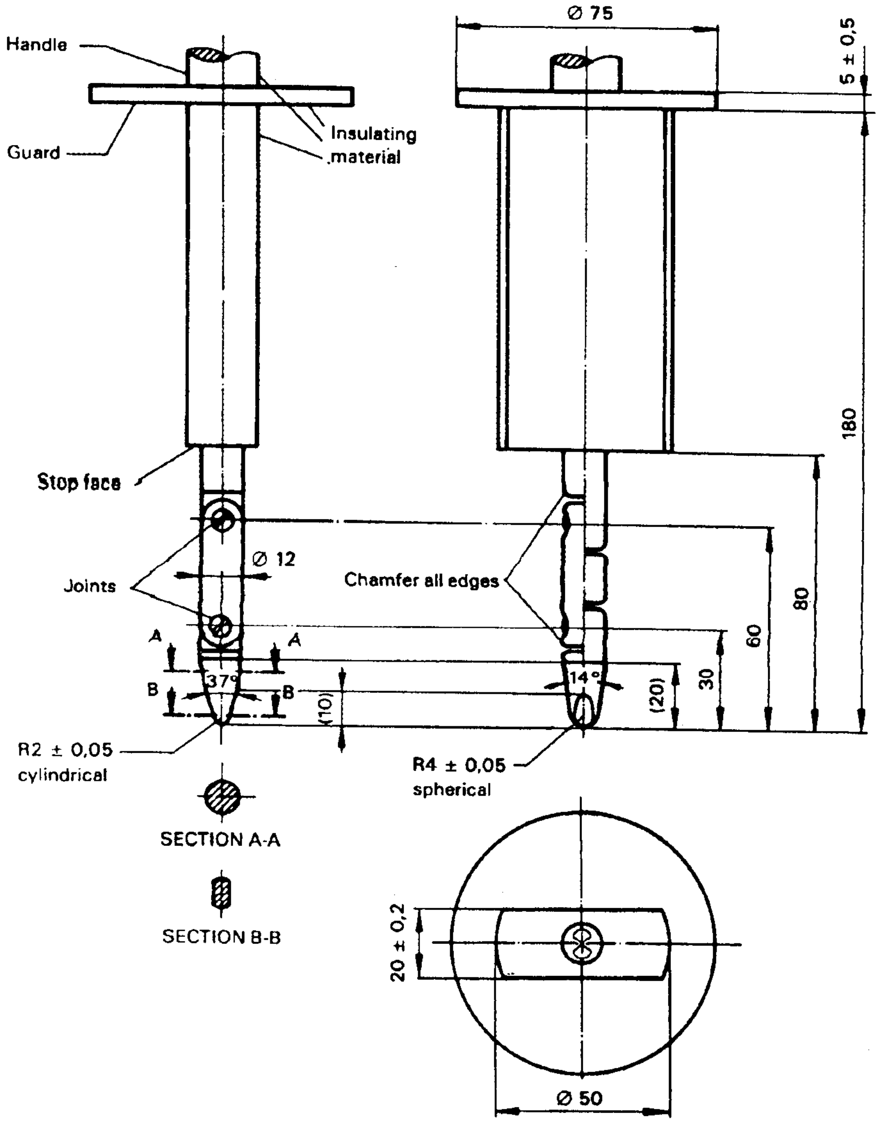


Figure 2 – Thread-cutting tapping screw (3.6.11)



Material: metal, except where otherwise specified

Linear dimensions in milimetres

Tolerances on dimensions without specific tolerance:

on angles: 0/–10'

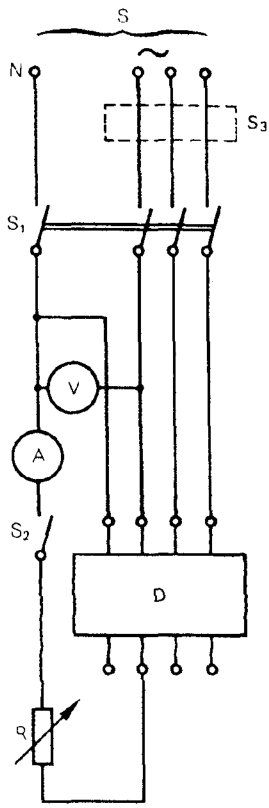
on linear dimensions:

up to 25 mm: 0/–0,05

over 25 mm: ±0,2

Both joints shall permit movement in the same plane and the same direction through an angle of 90° with a 0° to +10° tolerance.

Figure 3 – Standard test finger (9.6)

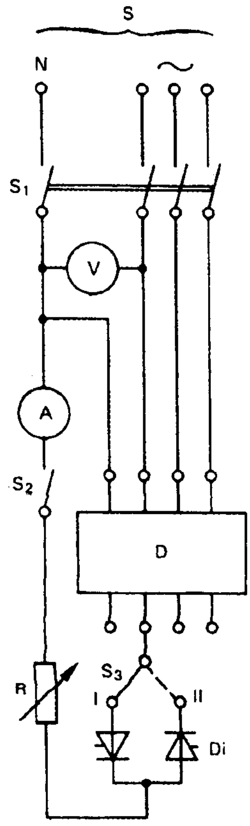


S = Supply
V = Voltmeter
A = Ammeter
S_1 = All-pole switch
S2 = Single-pole switch
S_3 = Switch operating all phases but one
D = RCCB under test
R = Variable resistor

NOTE S_3 remains closed except for the test of 9.17.3.

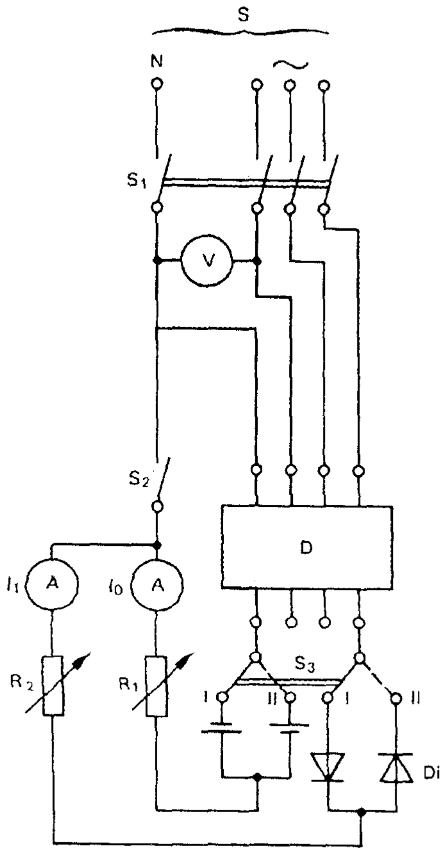
Figure 4a – **Test circuit for the verification of**

- **operating characteristics** (9.9)
- **trip-free mechanism** (9.15)
- **behaviour in case of failure of line voltage** (9.17.3 and 9.17.4) **for RCCBs functionally dependent on line voltage**



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

Figure 4b – Test circuit for the verification of the correct operation of RCCBs in the case of residual pulsating direct currents



S	=	Supply
V	=	Voltmeter
A	=	Ammeter (measuring r.m.s. values)
D	=	RCCBs 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 4c – Test circuit for the verification of the correct operation of RCCBs in the case of residual pulsating direct currents

N = neutral conductor
S = supply
R = adjustable resistors
L = adjustable reactors
P = short-circuit protective device (SCPD)
D = RCCB under test
G_1 = temporary connections for calibration
G_2 = connections for the test with rated conditional short-circuit current
T = device making the short circuit
O_1 = recording current sensor(s)
O_2 = recording voltage sensor(s)
F = device for the detection of a fault current
R_1 = resistor limiting the current in the device F
R_2 = adjustable resistor for the calibration of I_Δ
R_3 = additional adjustable resistor to obtain current below the rated conditional short-circuit current
S_1 = auxiliary switch
B and C = points of connection of the grid(s) shown in annex C.

Explanation of letter symbols used in figure 5 to 9

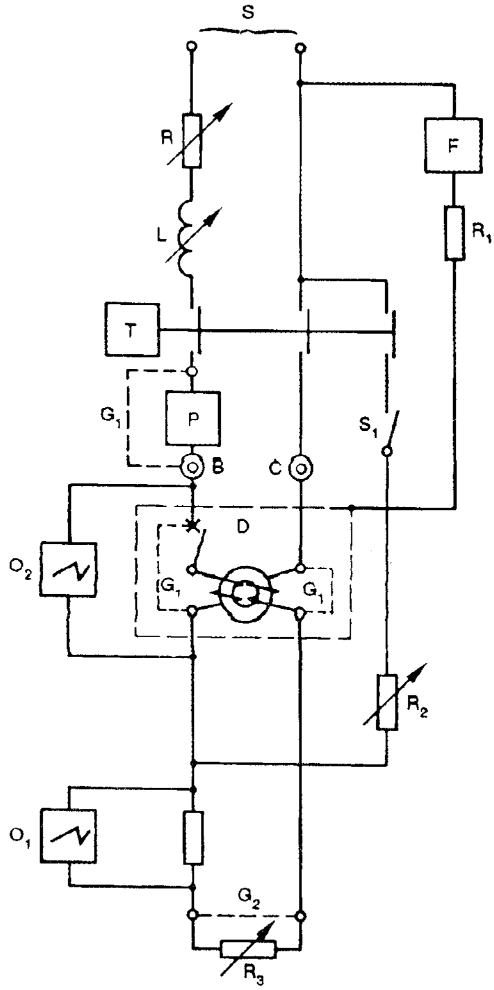


Figure 5 – Test circuit for the verification of the rated making and breaking capacity and of the co-ordination with a SCPD of a single-pole RCCB with two current paths (9.11)

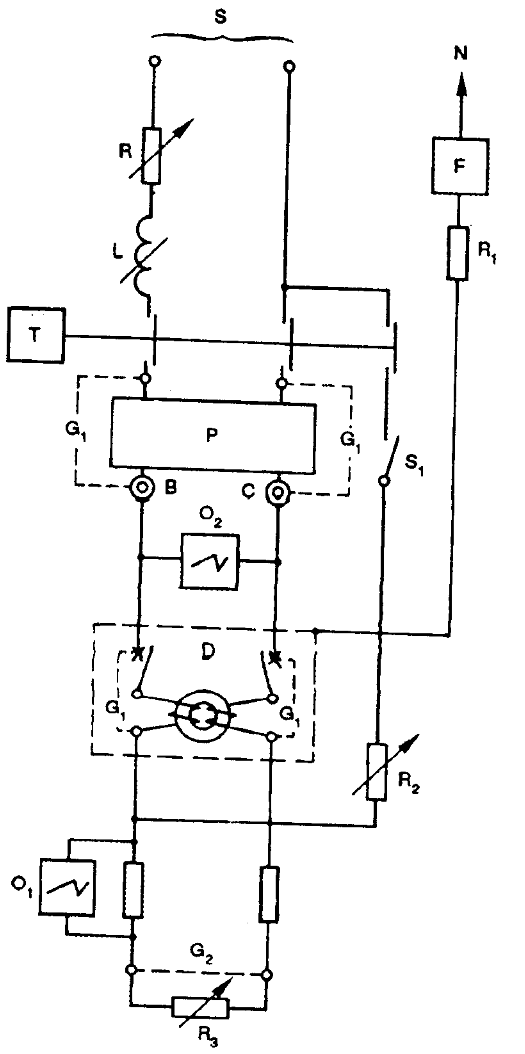


Figure 6 – Test circuit for the verification of the rated making and breaking capacity and of the co-ordination with a SCPD of a two-pole RCCB, in case of a single-phase circuit (9.11)

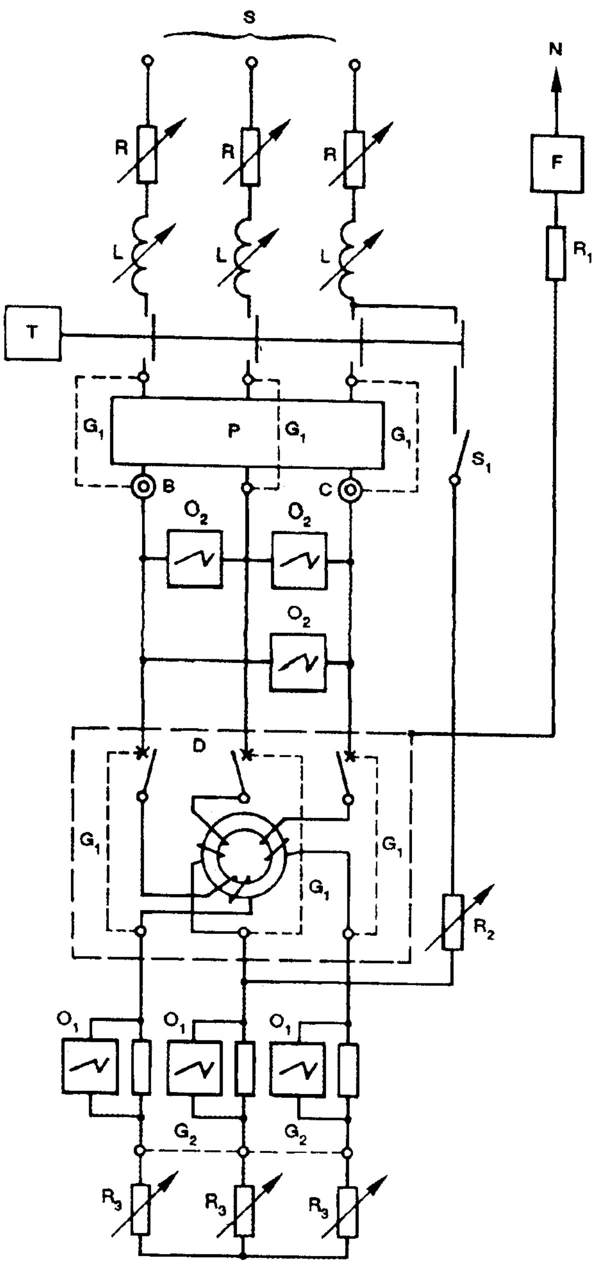


Figure 7 – Test circuit for the verification of the rated making and breaking capacity and of the co-ordination with a SCPD of a three-pole RCCB on three-phase circuit (9.11)

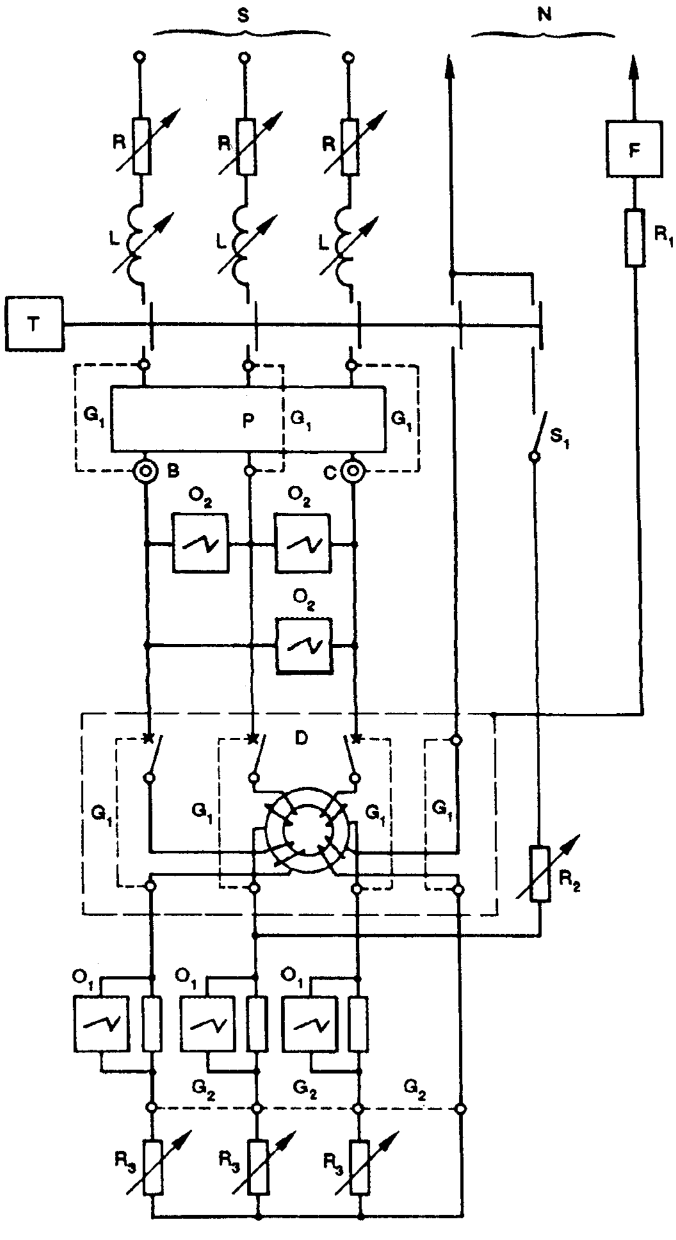


Figure 8 – Test circuit for the verification of the rated making and braking capacity and of the co-ordination with a SCPD of a three-pole RCCB with four current paths on a three-phase circuit with neutral (9.11)

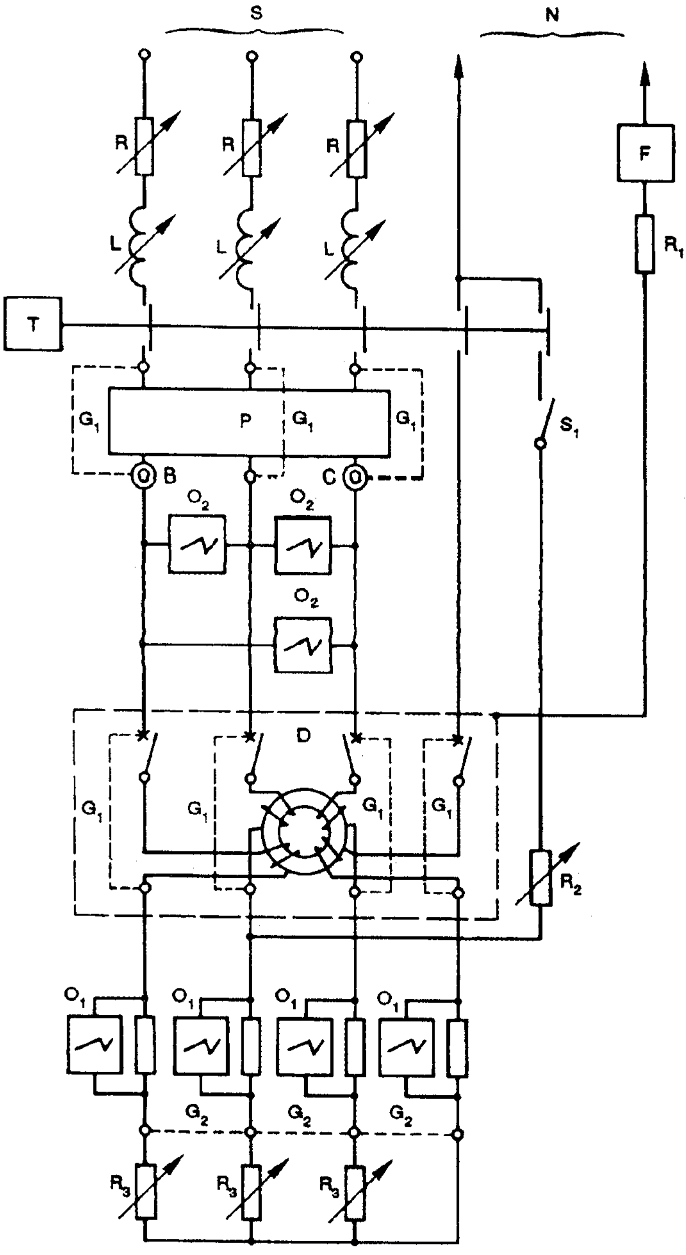
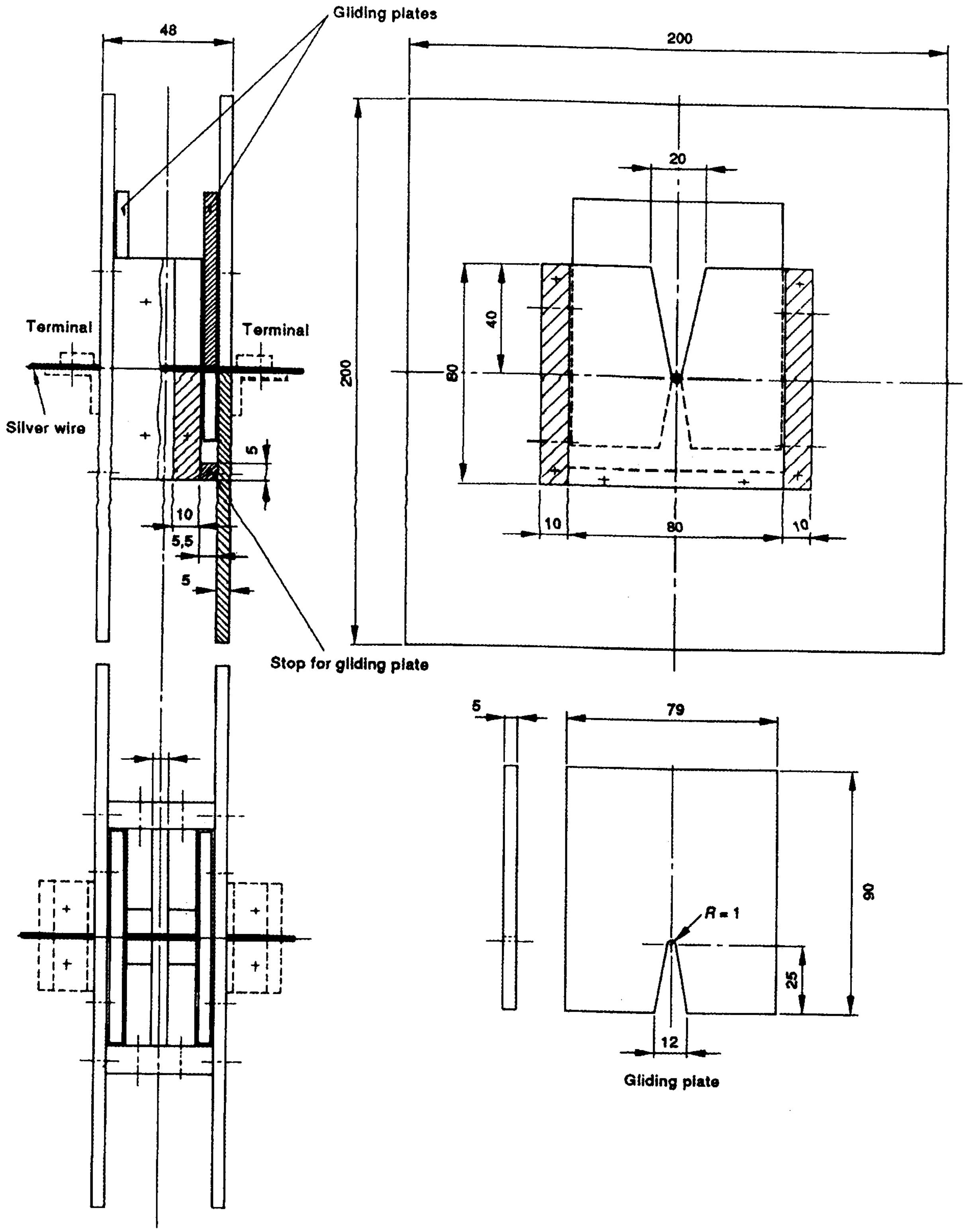
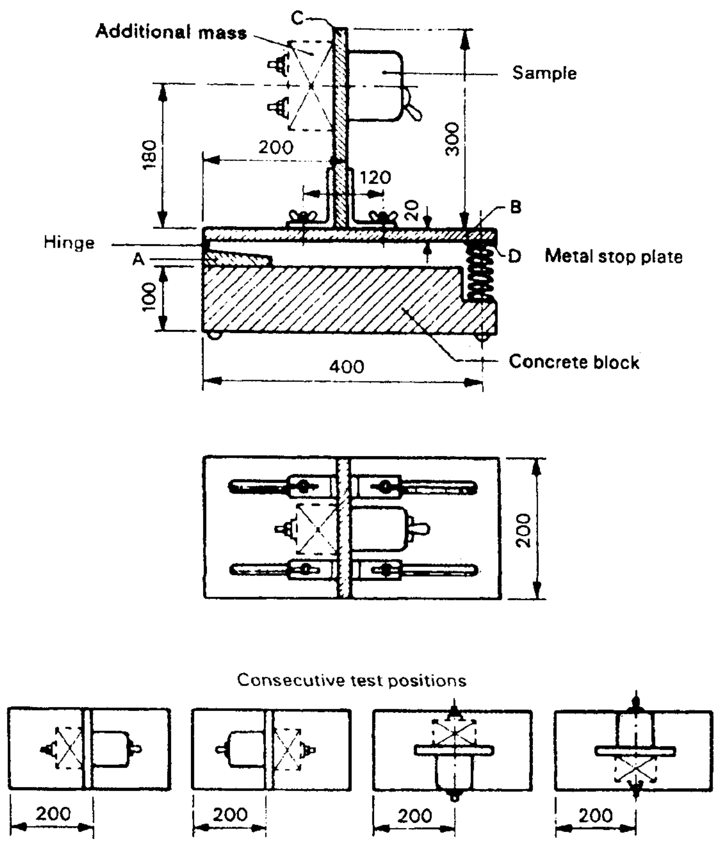


Figure 9 – Test circuit for the verification of the rated making and breaking capacity and of the co-ordination with a SCPD of a four-pole RCCB on a three-phase circuit with neutral (9.11)



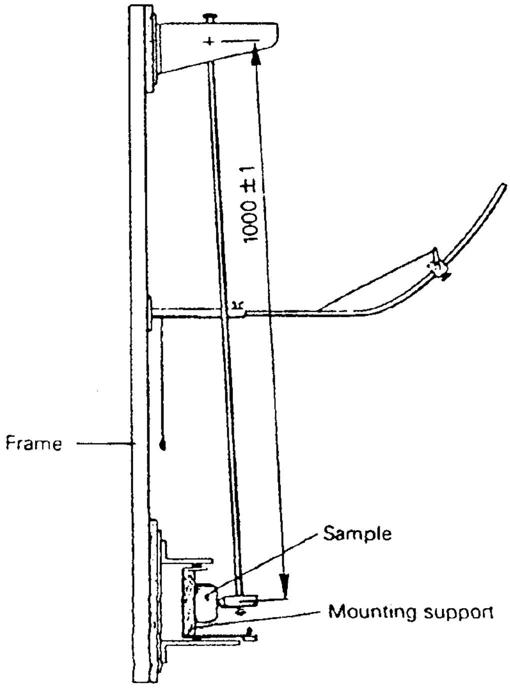
Dimensions in millimetres

Figure 10 – Test apparatus for the verification of the minimum I^2t and I_p values to be withstood by the RCCB (9.11.2.1 a))



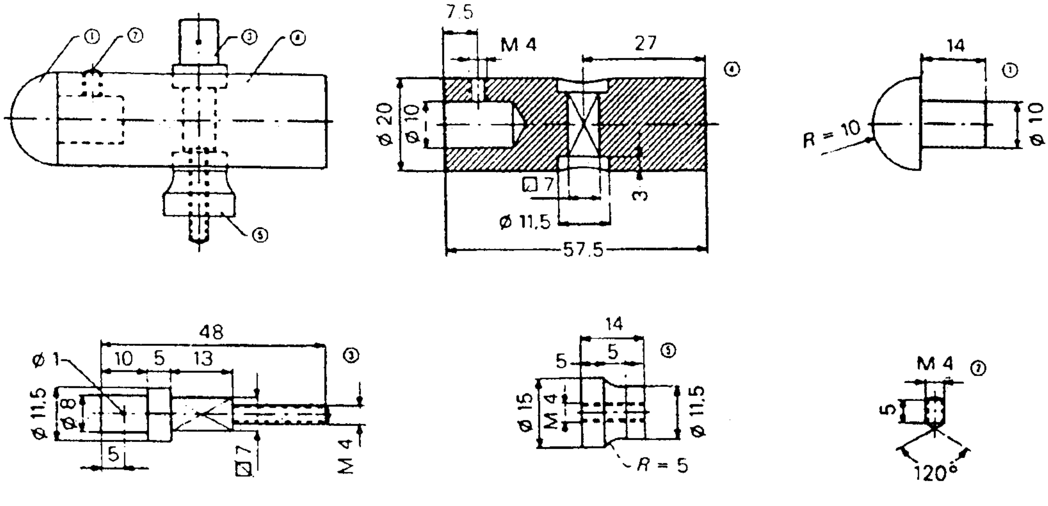
Dimensions in millimetres

Figure 11 – Mechanical shock test apparatus (9.12.1)



Dimensions in millimetres

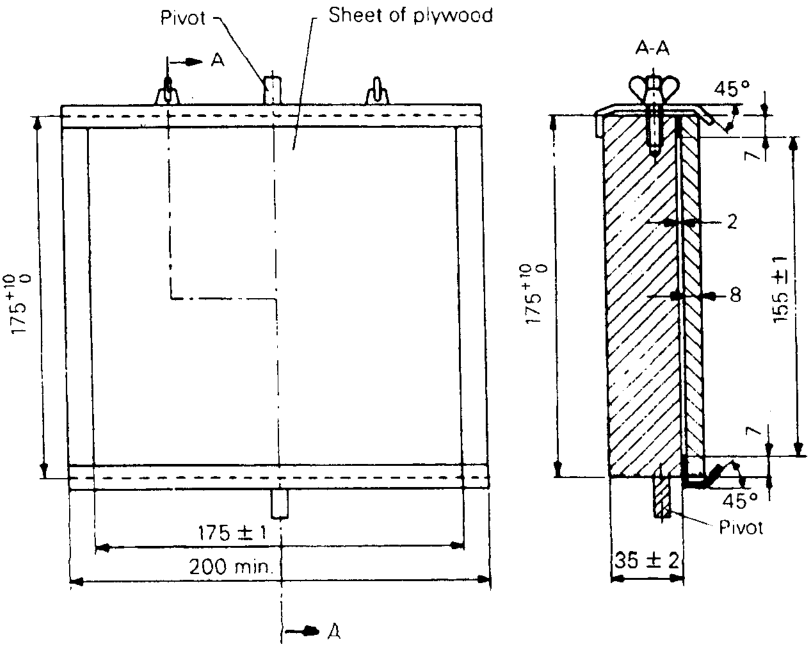
Figure 12 – Mechanical impact test apparatus (9.12.2.1)



Dimensions in millimetres

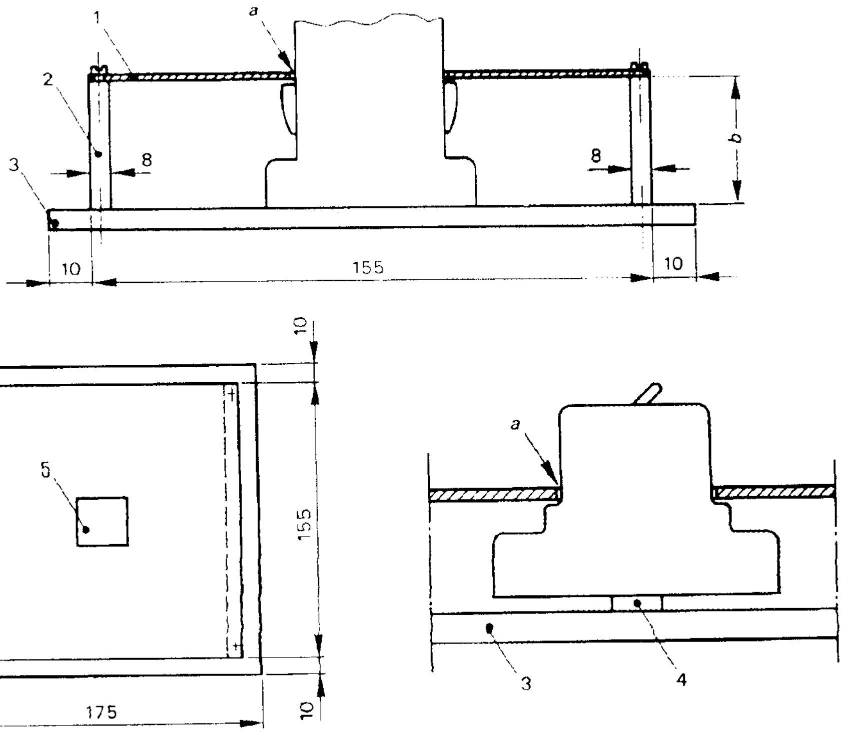
Material of the parts:
1: Polyamide
2, 3, 4, 5: steel Fe 360

Figure 13 – Striking element for pendulum impact test apparatus (9.12.2.1)



Dimensions in millimetres

Figure 14 – Mounting support for sample for mechanical impact test (9.12.2.1)



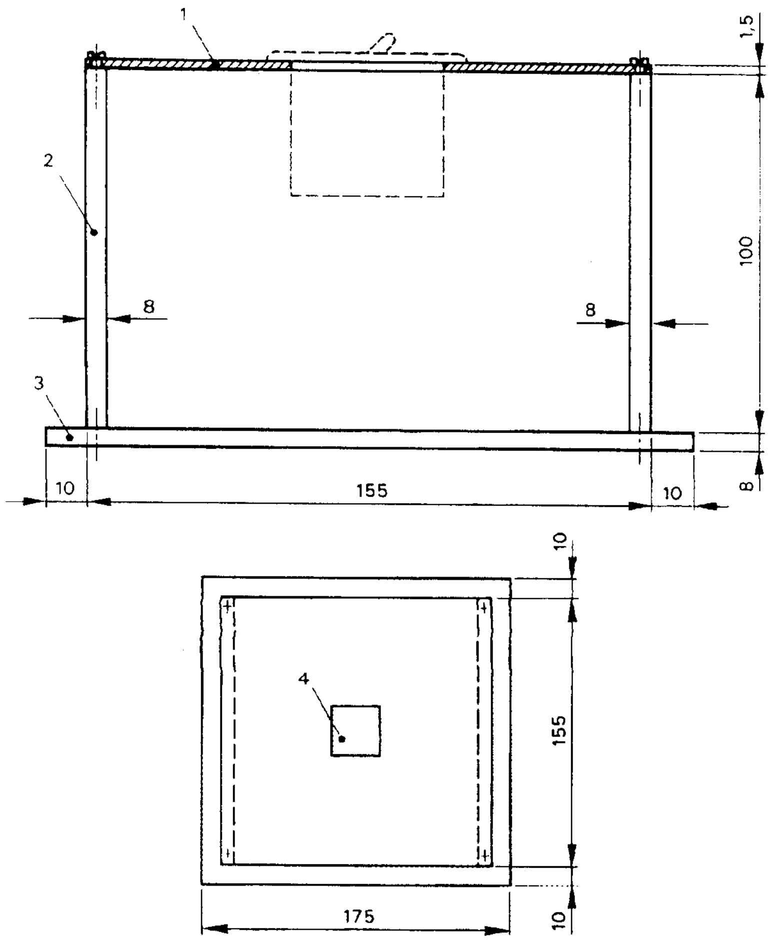
Dimensions in millimetres

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 RCCB designed to be mounted on a rail
5. Cut-out for the RCCB in the steel plate

a) the distance between the edges of the cut-out and the faces of the RCCB 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 RCCB if the RCCB 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 15 – Example of mounting and unenclosed RCCB for mechanical impact test (9.12.2.1)



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 RCCB in the steel plate

NOTE In particular cases the dimensions may be increased.

Figure 16 – Example of mounting of panel mounting type RCCB for the mechanical impact test (9.21.2.1)

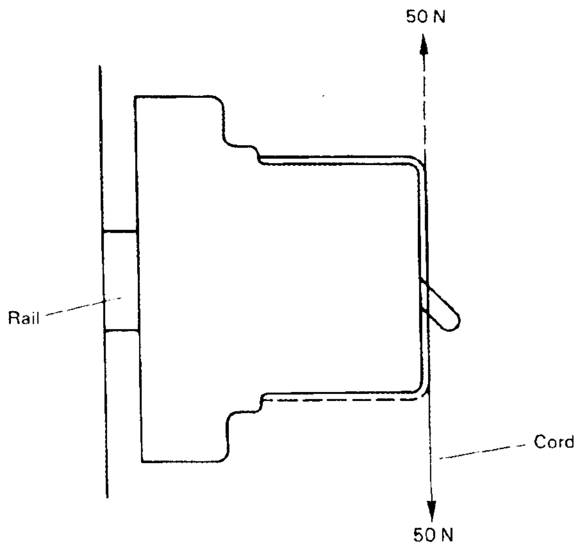


Figure 17 – Application of force for mechanical test of rail mounted RCCB (9.12.2.2)

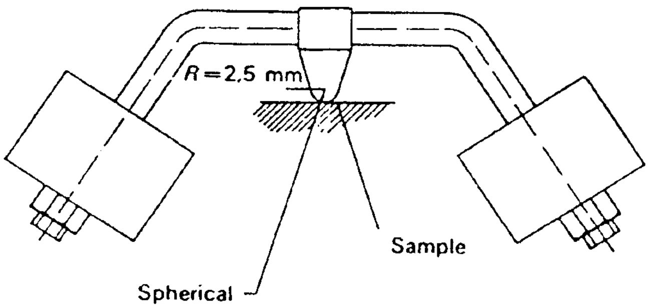
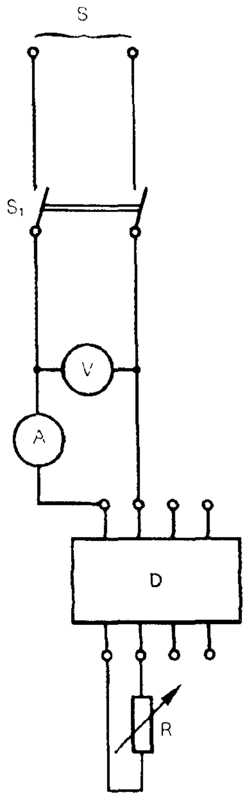


Figure 18 – Ball-pressure test apparatus (9.13.2)



S = Supply
S_1 = Two-pole switch
V = Voltmetre
A = Ammeter
D = RCCB under test
R = Variable resistor

Figure 19 – Test circuit for the verification of the limiting value of overcurrent in case of single-phase load through a three-pole RCCB (9.18.2)

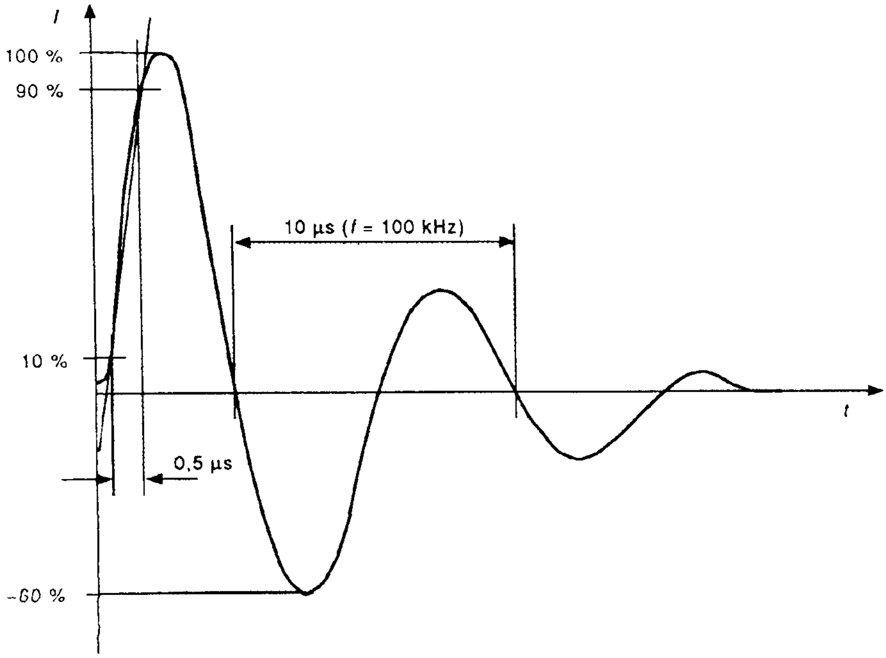
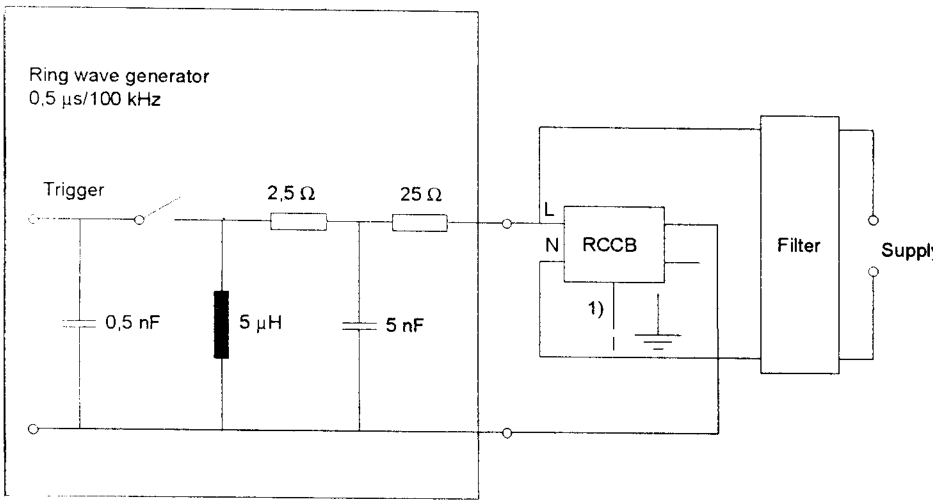


Figure 19a – Current ring wave 0,5 μs/100 kHz



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

Figure 19b – Test circuit for the ring wave test at RCCBs

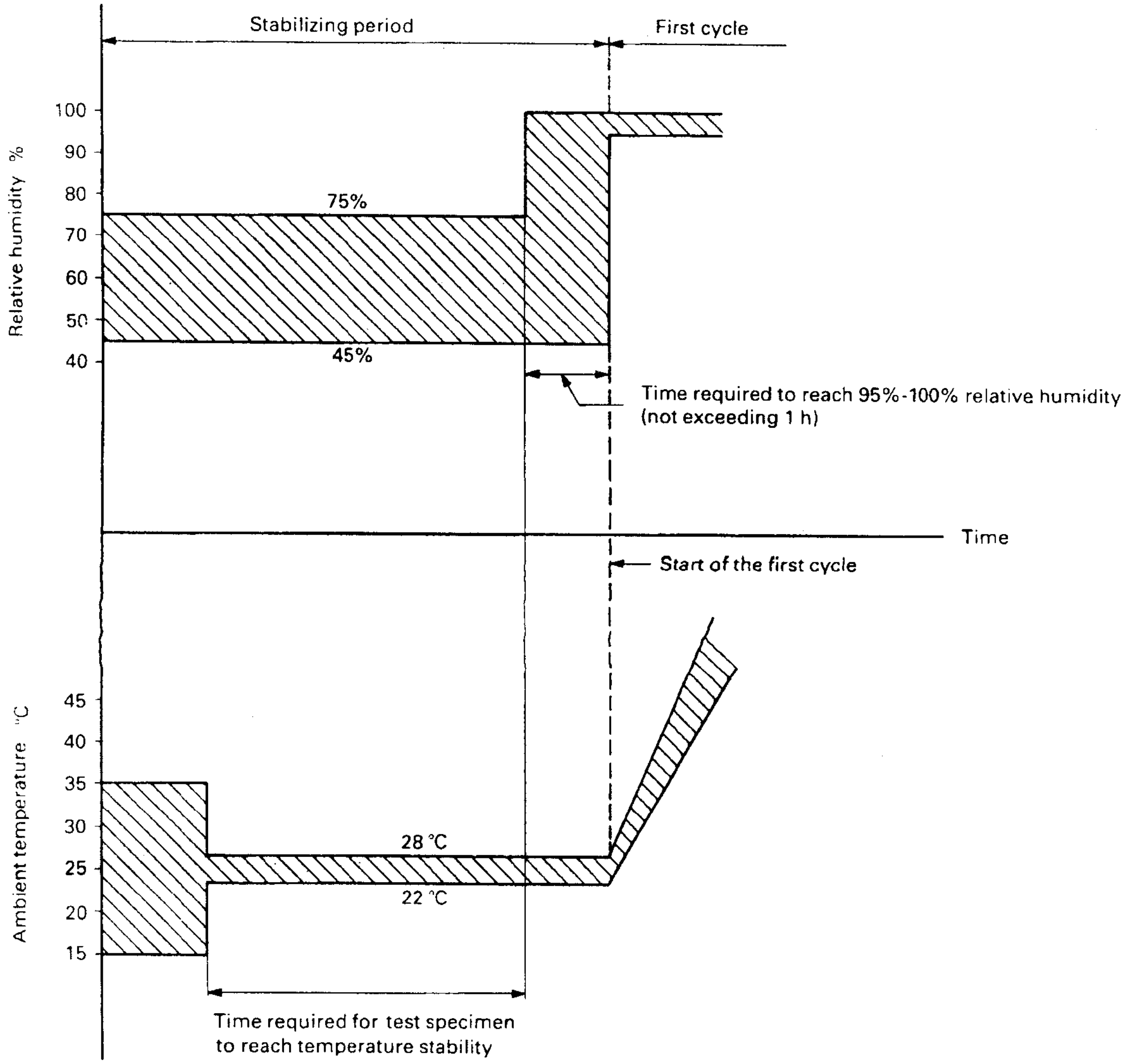


Figure 20 – Stabilizing period for reliability test (9.22.1.3)

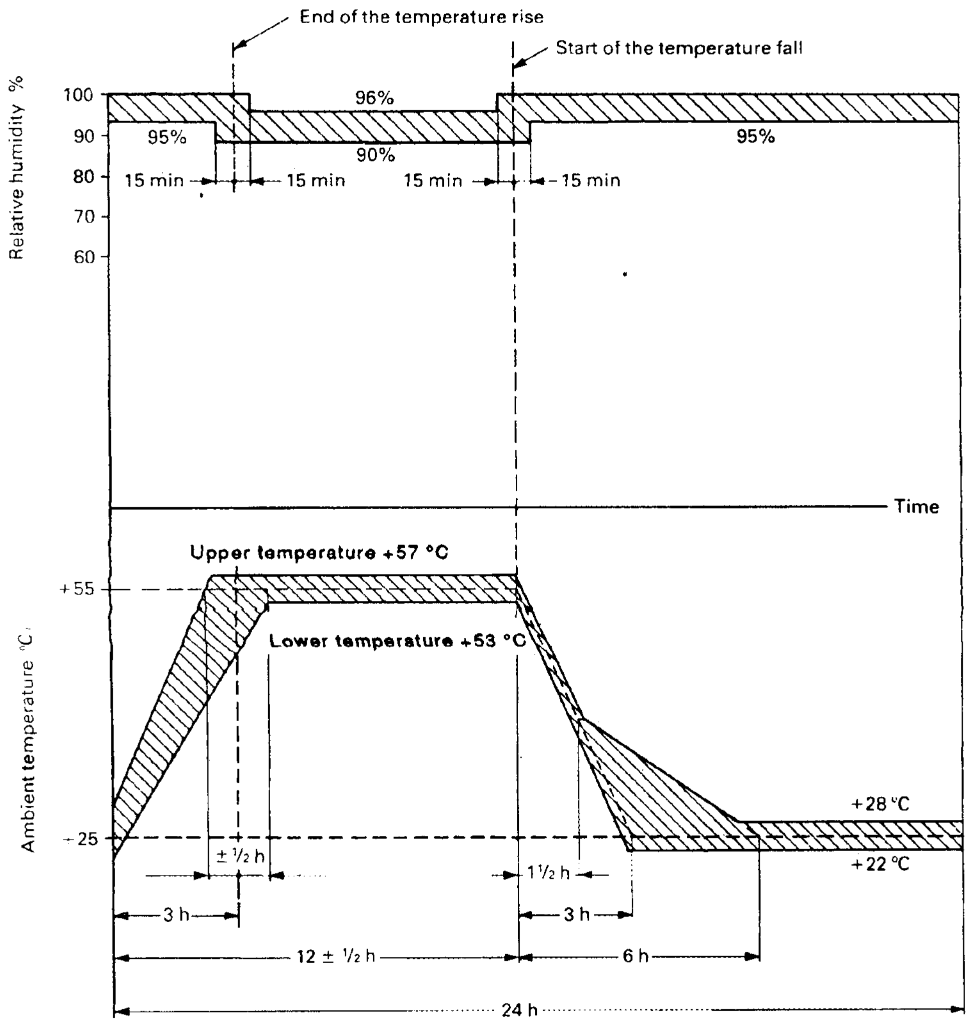


Figure 21 – Reliability test cycle (9.22.1.3)

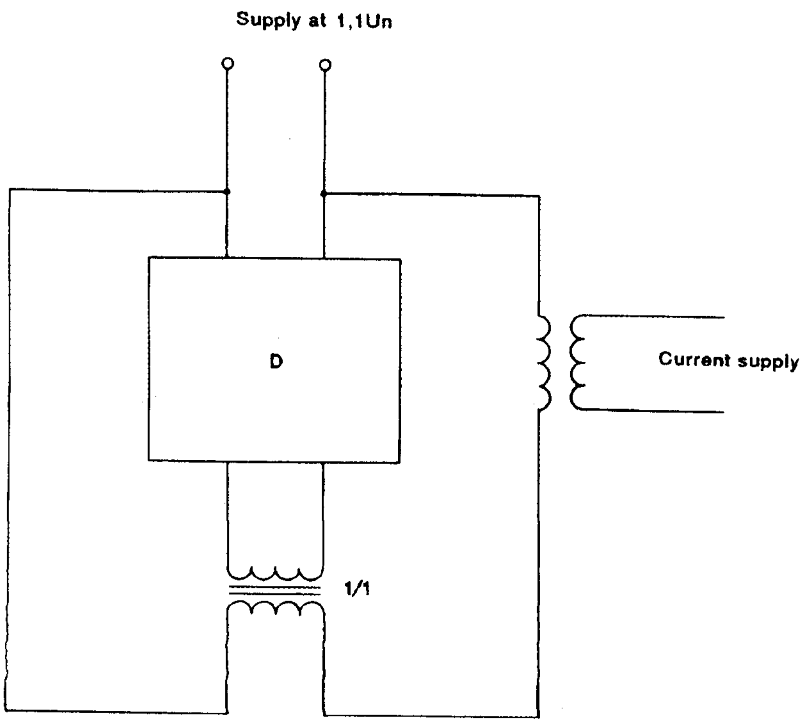


Figure 22 – Example for test circuit for verification of ageing of electronic components (9.23)

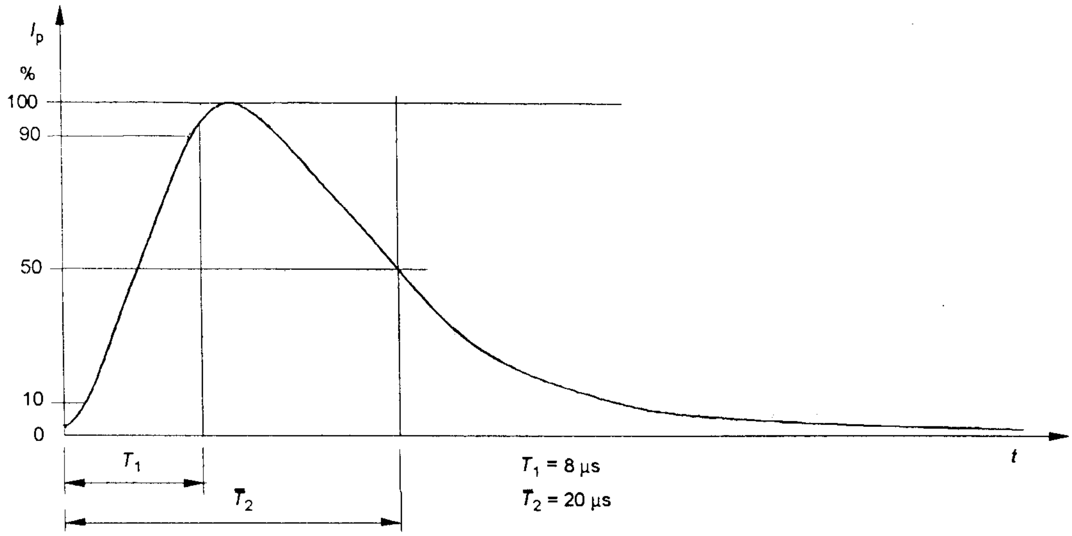
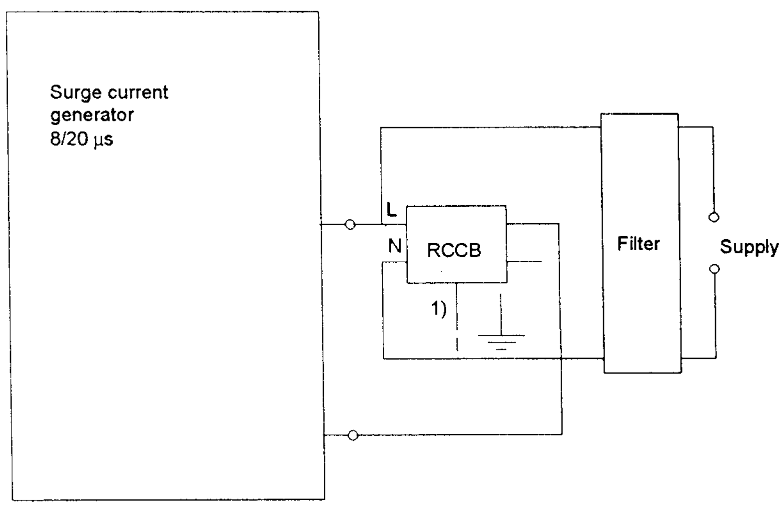


Figure 23 – Surge current impulse 8/20 µs



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

Figure 24 – Test circuit for the surge current test at RCCBs

Annex A
(normative)

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

The term certification denotes:

- either manufacturer's declaration of conformity, or
- third party certification, e.g. by an independent testing station.

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 sequence		*Clause or subclause*	*Test (or Inspection)*
A		*6*	*Marking*
		8.1.1	*General*
		8.1.2	*Mechanism*
		9.3	*Indelebility of marking*
		8.1.3	*Clearance and creepage distances (external parts only)*
		9.15	*Trip-free mechanism*
		9.4	*Reliability of screws, current-carrying parts and connections*
		9.5	*Reliability of terminals for external conductors*
		9.6	*Protection against electric shock*
		9.13	*Resistance to heat*
		8.1.3	*Clearances and creepage distances (internal parts)*
		9.14	*Resistance to abnormal heat and to fire*
B		*9.7*	*Test of dielectric properties*
		9.8	*Temperature rise*
		9.20	*Resistance of insulation against impulse voltages*
		9.22.2	*Reliability at 40 °C*
		9.23	*Ageing of electronic components*
C		*9.10*	*Mechanical and electrical endurance*
D	D_0	*9.9*	*Residual operating characteristics*
	D_1	*9.17*	*Behaviour in the case of failure of the line voltage*
		9.19	*Unwanted tripping*
			Behaviour in the case of surge currents.
		9.21	*DC components*
		9.11.2.3	*Performance at* $I_{\Delta m}$
		9.16	*Test device*
		9.12	*Resistance to mechanical shock and impact*
		9.18	*Non-operating current under overcurrent conditions*
E		*9.11.2.4 a)*	*Coordination at* I_{nc}
		9.11.2.2	*Performance at* I_m
F		*9.11.2.4 b)*	*Coordination at* I_m
		9.11.2.4 c)	*Coordination at* $I_{\Delta c}$
G		*9.22.1*	*Reliability (climatic tests)*

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

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

If all samples submitted 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.

For RCCBs having only one rated current but more than one residual operating current, two separate sets of samples shall be submitted to each test sequence: one adjusted to the highest residual operating current, the other adjusted to the lowest residual operating current.

Table A.2

Test sequence [a]	Number of samples	Minimum number of accepted samples [b]	Number of samples for repeated tests [c]
A	1	1	–
B	3	2	3
C	3	2	3
D	3	2 [d]	3
E	3	2 [d]	3
F	3	2 [d]	3
G	3	2	3

a) In total a maximum of three test sequences may be repeated.

b) It is assumed that a sample which has not passed a 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 test results must be acceptable.

d) All samples shall meet the requirements in 9.9.2, 9.9.3, and 9.11.2.3, as appropriate. In addition, permanent arcing or flashover between poles or between poles and frame shall not occur in any sample during tests of 9.11.2.2, 9.11.2.4 a), 9.11.2.4 b) or 9.11.2.4 c).

A.3 Number of samples to be submitted for simplified test procedures in case of submitting simultaneously a range of RCCBs of the same fundamental design

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

NOTE For the purposes of this annex the same fundamental design comprises a series of rated current (I_n), a series of rated residual operating currents ($I_{\Delta n}$) and/or different number of poles.

RCCBs can be considered to be of the same fundamental design if

1) they have the same basic design: in particular voltage dependent types and voltage independent types shall not occur together in the same range;
2) the residual current operating means have identical tripping mechanism and identical relay or solenoid except for the variations permitted in c) and d);
3) the materials, finish and dimensions of the internal current carrying parts are identical other than the variations detailed in a) below;
4) the terminals are of similar design (see b) below);
5) the contact size, material, configuration and method of attachment are identical;
6) the manual operating mechanism, materials and physical characteristics are identical;
7) the moulding and insulating materials are identical;
8) the method, materials and construction of the extinction device are identical;
9) the basic design of the residual current sensing device is identical, for a given type of characteristic other than the variations permitted in c) below;
10) the basic design of the residual current tripping device is identical except for the variations permitted in d) below;
11) the basic design of the test device is identical except for the variations permitted in e) below.

The following variations are permitted provided that the RCCBs comply in all other respects to the requirements detailed above:

a) cross sectional area of the internal current carrying connections, and lengths of the toroid connections;
b) size of terminals;
c) number of turns and cross sectional area of the windings and the size and material of the core of the differential transformer;
d) the sensitivity of the relay and/or the associated electronic circuit, if any;
e) the ohmic value of the means to produce the maximum ampere turns necessary to conform to the tests of 9.16. The circuit may be connected across phases or phase to neutral.

A.3.2 For RCCBs having the same classification according to behaviour due to d.c. components (4.6) and the same classification according to time delay (4.7), the number of samples to be tested may be reduced, according to table A.3.

Table A.3

Test sequence	Number of samples according to number of poles a)		
	2 poles b) c)	3 poles d) f)	4 poles e)
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	3 max. rating I_n min. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$
C	3 max. rating I_n min. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$
$D_0 + D_1$	3 max. rating I_n min. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$
D_0	1 for all other ratings of $I_{\Delta n}$		
E	3 max. rating I_n min. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$
F	3 max. rating I_n min. rating $I_{\Delta n}$ 3 g) min. rating I_n max. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$ 3 g) min. rating I_n max. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$ 3 g) min. rating I_n max. rating $I_{\Delta n}$
G	3 max. rating I_n min. rating $I_{\Delta n}$ 3 g) min. rating I_n max. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$ 3 g) min. rating I_n max. rating $I_{\Delta n}$	3 max. rating I_n min. rating $I_{\Delta n}$ 3 g) min. rating I_n 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 RCCBs are submitted, this column shall also apply to a set of samples with the smallest number of poles.

c) Also applicable to 1-pole RCCBs with uninterrupted neutral and to 2-pole RCCBs with 1 protected pole.

d) Also applicable to 3-pole RCCBs with 2 protected poles.

e) Also applicable to 3-pole RCCBs with uninterrupted neutral and to 4-pole RCCBs with 3 protected poles.

f) This column is omitted when 4-pole RCCBs have been tested.

g) If only one value of $I_{\Delta n}$ is submitted, these sets of samples are not required.

Annex B
(normative)

Determination of clearances and creepage distances

In determining clearances and creepage distances, it is recommended that the following points should be considered.

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

Individual sections 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);
  - are measured along the shorter of the two following paths: along 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:

- figures B.1, B.2 and B.3 indicate the inclusion or exclusion of a groove in a creepage distance;
- figures B.4 and 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;
- figures B.7, B.8, B.9 and B.10 illustrate how to determine the creepage distance in the case of fixing means situated in recesses in insulating parts of insulating material.

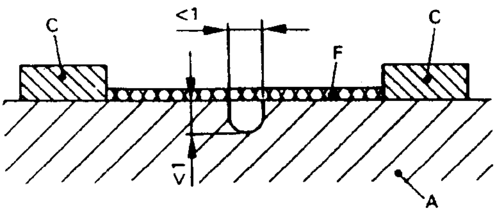


FIGURE B1

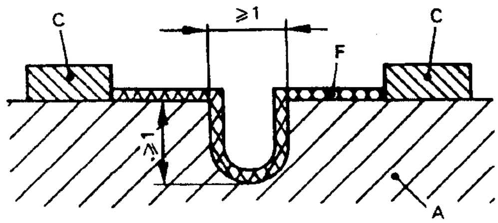


FIGURE B2

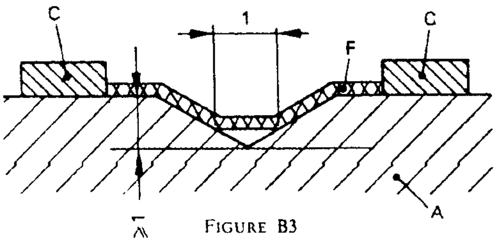


FIGURE B3

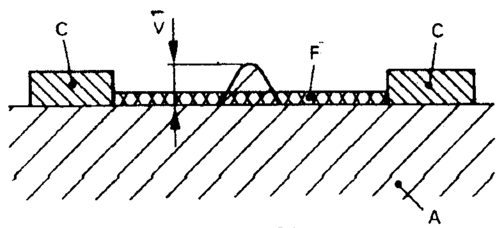


FIGURE B4

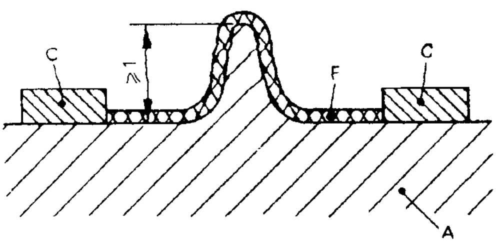


FIGURE B5

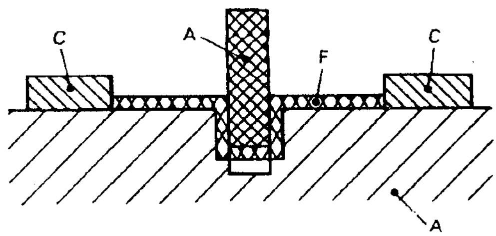


FIGURE B6

Figures B.1 to B.10 – Illustrations of the application of creepage distances

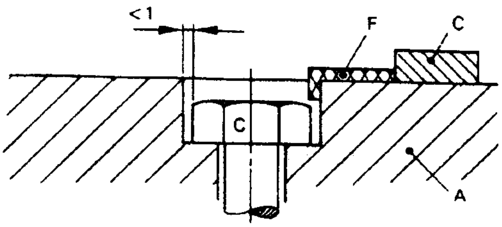


FIGURE B7

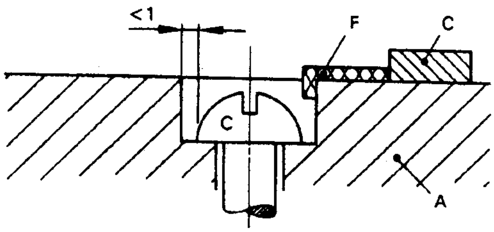


FIGURE B8

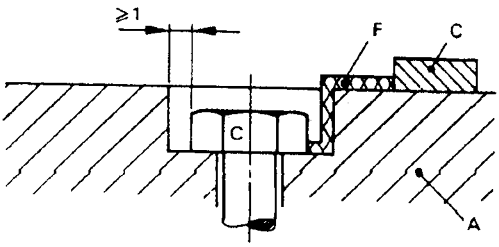


FIGURE B9

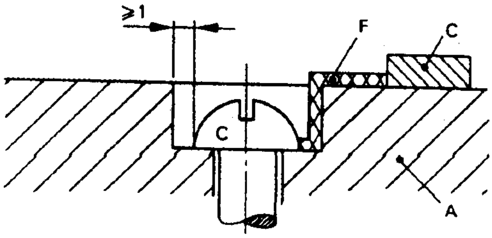


FIGURE B10

Figures B.1 à B.10 – Illustrations of the application of creepage distances

Annex C
(normative)

Arrangement for the detection of the emission of ionized gases during short-circuit tests

The device under test is mounted as shown in figure C.1 which may require adapting to the specific design of the device, and in accordance with the manufacturer's instructions.

When required (i.e. during "O" operations), a clear polyethylene sheet (0.05 ± 0.01) mm, of a size at least 50 mm larger, in each direction, than the overall dimensions of the front face of the device, but not less than 200 mm × 200 mm, is fixed and reasonably stretched in a frame, placed at a distance of 10 mm from

- *either the maximum projection of the operating means of a device without recess for the operating means;*
- *or the rim of a recess for the operating means of a device with recess for the operating means.*

The sheet should have the following physical properties:

Density at 23 °C:	*0,92 ± 0,05 g/cm³*
Melting point:	*110 – 120 °C.*

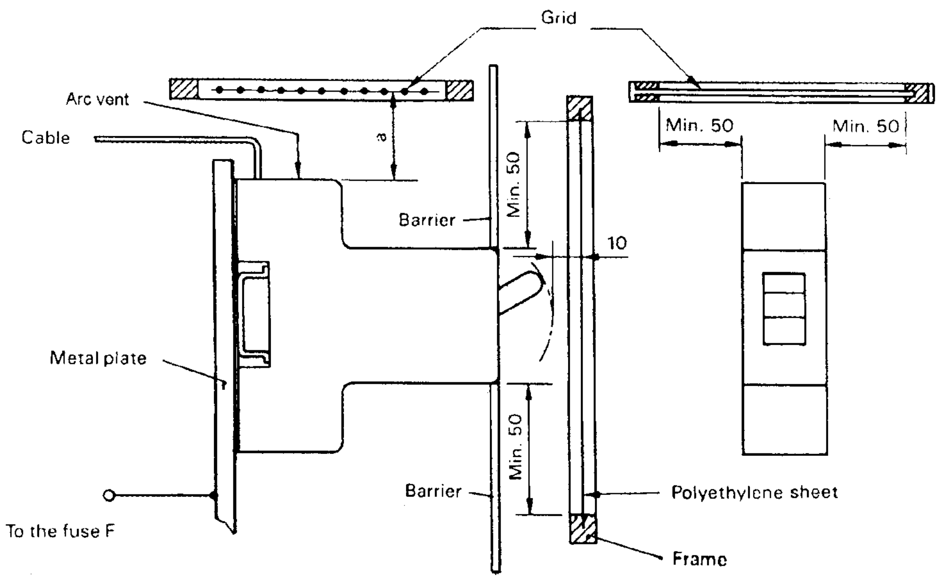
When required, a barrier of insulating material, at least 2 mm thick, is placed, as shown in figure C.1, between the arc vent and the polyethylene foil to prevent damage of the foil due to hot particles emitted from the arc vent.

When required, a grid (or grids) according to figure C.2, is (are) placed at a distance of "a" mm from each arc vent side of the device.

The grid circuit (see figure C.3) shall be connected to the points B and C.

The parameters for the grid circuit(s) are as follows:

Resistor R':	*1,5 Ω*
Copper wire F':	*length 50 mm, and diameter in accordance with 9.11.2.1 f1).*



Dimensions in millimetres

Figure C.1 – Test arrangement

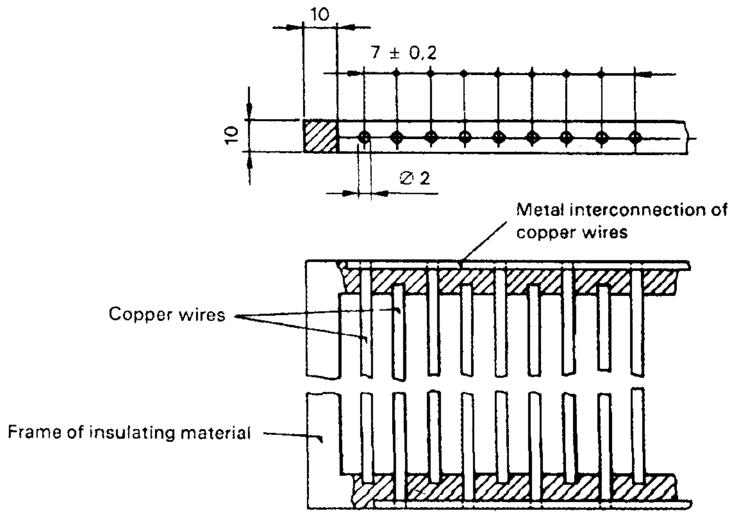


Figure C.2 – Grid

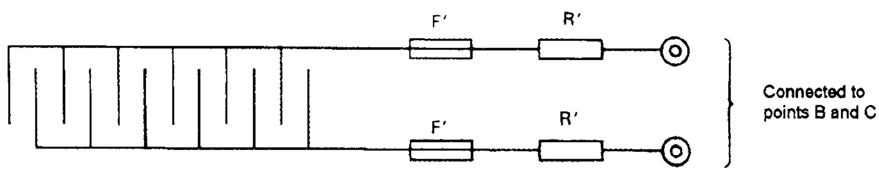


Figure C.3 – Grid circuit

Annex D
(normative)

Routine tests

The tests specified in this standard are intended to reveal, as far as safety is concerned, unacceptable variations in material or manufacture.

In general, more tests have to be made to ensure that every RCCB conforms with the samples that withstood the tests of this standard, according to the experience gained by the manufacturer.

D.1 Tripping test

A residual current is passed through each pole of the RCCB in turn. The RCCB shall not trip at a current less than or equal to 0,5 $I_{\Delta n}$*, but it shall trip at* $I_{\Delta n}$ *within a specified time (see table 1).*

The test current shall be applied at least five times on each RCCB and shall be applied at least twice on each pole.

D.2 Electric strength test

A voltage of substantially sinusoidal wave form of value 1 500 V having a frequency of 50 Hz/60 Hz is applied for 1 s between the following parts:

a) *with the RCCB in the open position, between each pair of terminals which are electrically connected together when the RCCB is in the closed position;*
b) *for RCCBs not incorporating electronic components, with the RCCB in the closed position, between each pole in turn and the others connected together;*
c) *for RCCBs incorporating electronic components, with the RCCB in the open position, either between all incoming terminals of poles in turn or between all outgoing terminals at poles in turn, depending on the position of the electronic components.*

No flashover or breakdown shall occur.

D.3 Performance of the test device

With the RCCB in the closed position, and connected to a supply at the appropriate voltage, the test device, when operated, shall open the RCCB.

Where the test device is intended to operate at more than one value of voltage, the test shall be made at the lowest value of voltage.

Annex E
(normative)

List of tests, additional test sequences and numbers of samples for verification of compliance of RCCBs with the requirements of electromagnetic compatibility (EMC)

This annex indicates all tests and test sequences to be performed on RCCBs for verifying their electromagnetic compatibility.

Clause E.1 reports the references of the tests already contained in IEC 61008-1 and included in the test sequences and minimum performances conditions specified in annex A.

Clause E.2 specifies the additional tests, the number of samples, the test sequences and the minimum conditions required for the complete verification of compliance of RCCBs with the EMC *requirements*.

Test conditions and EMC performance criteria are indicated in the EMC product family standard for RCDs: IEC 61543.

Electromagnetic compatibility of RCCBs

E.1 EMC tests already included in the product standard

Table E.1 gives in the third column, the tests already included in the test sequences of annex A ensuring an adequate level of immunity from the electromagnetic disturbances indicated in the second column. The first column gives the corresponding references of tables 1 and 2 of the IEC 61543.

Table E.1

Reference ot tables 1 and 2 of IEC 61543	Electromagnetic phenomena	Tests of IEC 61008-1
T 1.3	Voltage amplitude variations	9.9.5 and 9.17
T 1.4	Voltage umbalance	9.9.5 and 9.17
T 1.5	Power frequency variations	9.2
T 1.8	Radiated magnetic fields	9.11 and 9.18
T 2.4	Current oscillatory transients	9.19

E.2 Additional tests of EMC product family standards to be applied

The following tests of IEC 61543 shall be carried out according to table E.2.

Unless otherwise specified, each test sequence is carried out on three new samples.

If all samples submitted according to the fifth column of table E.2 pass the tests, compliance with the standard is met. If only the minimum number given in the sixth column passes the tests, additional samples as shown in the seventh column shall be tested and all shall then satisfactorily complete the test sequence.

Table E.2

Test sequence	Table of IEC 61543	Reference condition of IEC 61543	Phenomena	Number of samples	Minimum number of samples which shall pass the tests	Maximum number of samples for repeated tests
E.2.1 *	4 4 5	1.1 1.2 2.3	Harmonics, interharmonics Signalling voltage Conducted unidirectional transients of the ms and µs time scale	3 $I_{\Delta n\ min}$ any I_n	2	3
E.2.2	5 5	2.1 et 2.5 2.2	Conducted oscillatory voltages or currents Conducted unidirectional transients of the ns time scale (burst)	3 $I_{\Delta n\ min}$ any I_n	2	3
E.2.3	6	3.1	Electrostatic discharges	3 $I_{\Delta n\ min}$ any I_n	2	3

* For devices containing a continuously operating oscillator, the test of CISPR 14 shall be carried out on the samples prior to the tests of this sequence.

NOTE On request of the manufacturer the same set of samples may be subjected to more than one test sequence.

Annex IA
(informative)

Methods of determination of short-circuit power-factor

There is no uniform method by which the short-circuit power-factor can be determined with precision. Two examples of acceptable methods are given in this annex.

Method I - Determination from d.c. components

The angle ϕ may be deterined from the curve of the d.c. component of the asymmetrical current wave between the instant of the short-circuit and the instant of contact separation as follows:

IA.1 The formula for the d.c. component is:

$$i_d = i_{do} \cdot e^{-Rt/L}$$

where

i_d is the value of d.c. components at the instant t;

i_{do} is the value of the d.c. component at the instant taken as time origin;

L/R is the time-constant of the circuit, in seconds;

t is the time, in seconds, taken from the initial instant;

e is the base of the Neperian logarithms.

The time-constant L/R can be ascertained from the above formula as follows:

a) measure the value of i_{do} at the instant of short-circuit and the value of i_d at an other instant t before the contact separation;
b) determine the value of $e^{-Rt/L}$ by dividing i_d by i_{do};
c) from a table of values of e^{-x} determine the value of $-x$ corresponding to the ratio of i_d/i_{do};
d) the value x represents Rt/L from which L/R is obtained.

IA.2 Determine the angle from:

$$\phi = \text{art tan } \omega \text{ L/R}$$

where ω is 2 π times the actual frequency.

This method should not be used when the currents are measured by current transformers.

Methods II – Determination with pilot generator

When a pilot generator is used on the same shaft as the test generator, the voltage of the pilot generator on the oscillogram may be compared in phase first with the voltage of the test generator and then with the current of the test generator.

The difference between the phase angles between pilot generator voltage and main generator voltage on the one hand and pilot generator voltage and test generator current on the other hand gives the phase-angle between the voltage and current of the test generator, from which the power-factor can be determined.

Annex IB
(informative)

Glossary of symbols

Rated current	I_n
Residual current	I_Δ
Rated residual operating current	$I_{\Delta n}$
Rated residual non-operating current	$I_{\Delta no}$
Rated voltage	U_n
Rated operational voltage	U_e
Rated insulation voltage	U_i
Rated making and breaking capacity	I_m
Rated residual making and breaking capacity	$I_{\Delta m}$
Rated conditional short-circuit current	I_{nc}
Rated conditional residual short-circuit current	$I_{\Delta c}$
Limiting value of the line voltage at which a RCCB functionally dependent on line voltage still operate	U_x
Limiting value of the lines voltage below which a RCCB, functionally dependent on line voltage opens automatically	U_y

Annex IC
(informative)

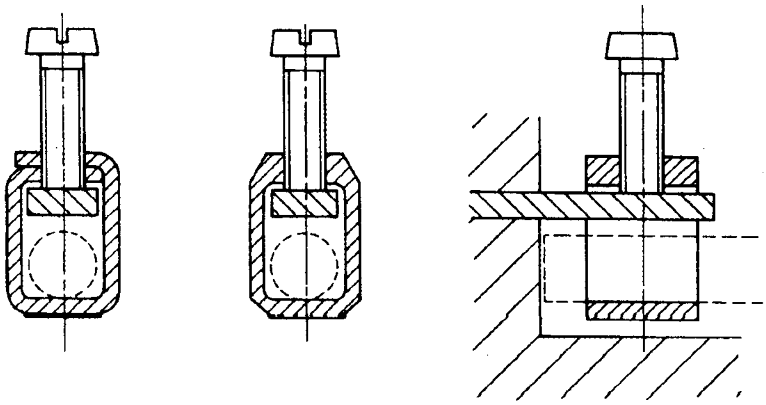
Examples of terminal designs

In this annex some examples of design of terminals are given.

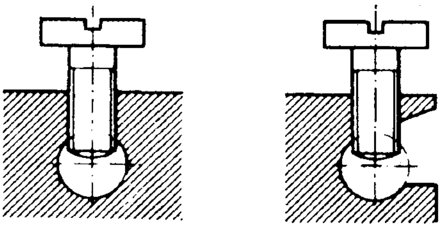
The conductor locations shall have a diameter suitable for solid rigid conductors and a cross-sectional area for accepting rigid stranded conductors.

EXAMPLES OF TERMINALS

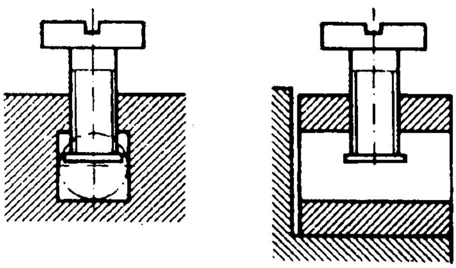
In this annex some examples of designs of terminals are given. The conductor location shall have a diameter suitable for accepting solid rigid conductors and a cross-sectional area suitable for accepting rigid stranded conductors (see 7.1.5)



Terminals with stirrup



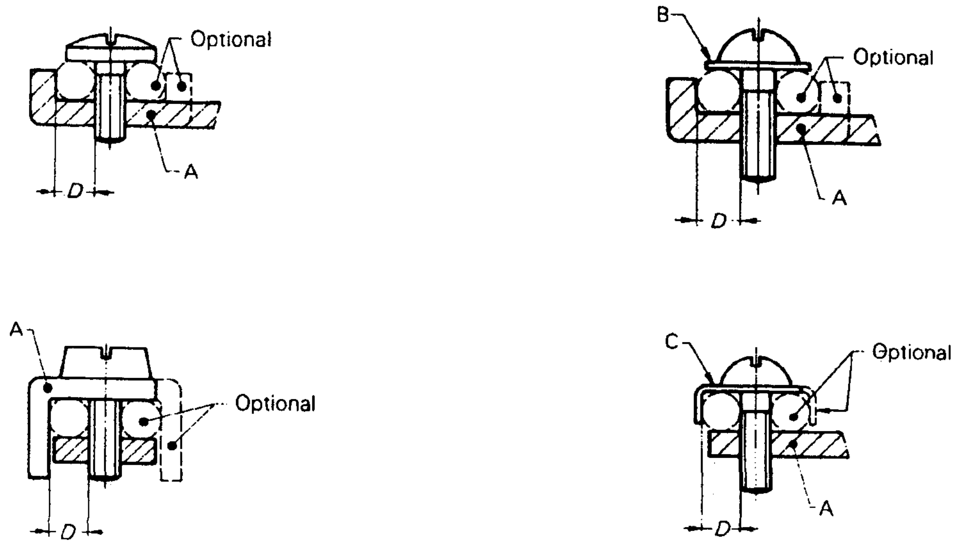
Terminals without pressure plate



Terminals with pressure plate

The part of the terminal containing the threaded hole and the part of the terminal against which the conductor is clamped by the screw may be two separate parts, as in the case of a terminal provided with a stirrup.

Figure IC.1 – Examples of pillar terminals



Screw terminals

Screw not requiring washer or clamping plate

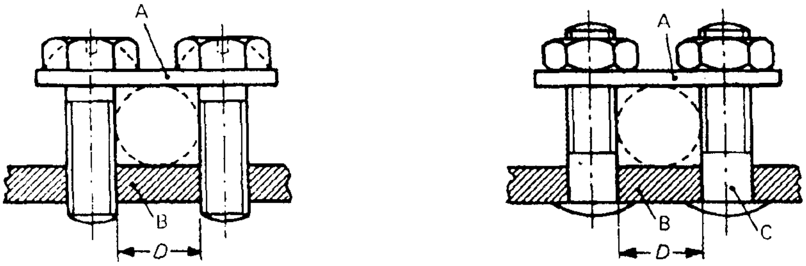
Screw requiring washer, clamping plate or anti-spread device

Stud terminals

A Fixed part
B Washer or clamping plate
C Anti-spread device
D Conductor space
E Stud

The part which retains the conductor in position may be of insulating material, provided the pressure necessary to clamp the conductor is not transmitted through the insulating material.

Figure IC.2 – Examples of screw terminals and stud terminals

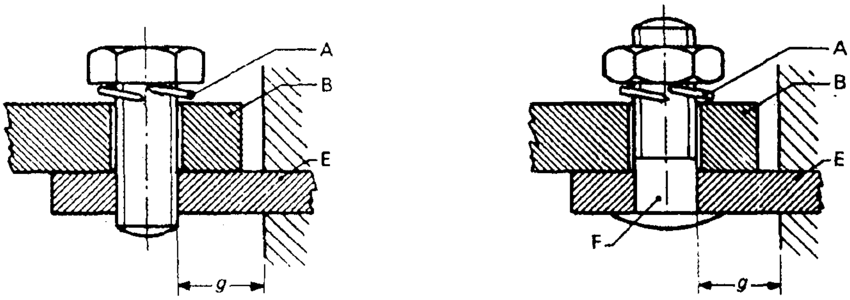


A Saddle
B Fixed part
C Stud
D Conductor space

The two faces of the saddle may be of different shapes to accommodate conductors of either small or large cross-sectional area, by inverting the saddle.

The terminals may have more than two clamping screws or studs.

Figure IC.3 – Examples of saddle terminals



A Locking means
B Cable lug or bar
E Fixed part
F Stud

For this type of terminal, a spring washer or equally effective locking means shall be provided and the surface within the clamping area shall be smooth.

For certain types of equipment, the use of lug terminals of sizes smaller than that required is allowed.

Figure IC.4 – Examples of lug terminals

Annex ID
(informative)

Correspondance between ISO and AWG copper conductors

ISO size mm²	AWG	
	Size	Cross-sectional areae mm²
1,0	18	0,82
1,5	16	1,3
2,5	14	2,1
4,0	12	3,3
6,0	10	5,3
10,0	8	8,4
16,0	6	13,3
25,0	3	26,7
35,0	2	33,6
50,0	0	53,5

In general, ISO sizes apply.

Upon request of the manufacturer, AWG sizes may be used.

Annex IE
(informative)

Follow-up testing program for RCCBs

IE.1 General

In order to guarantee the keeping of the quality level of products, follow-up inspection procedures on the manufacturing process have to be set up by the manufacturers.

This annex gives an example of follow-up procedure to be applied when manufacturing RCCBs.

It may be used as a guide by manufacturers for adapting their specific procedures and organization aiming at keeping the required quality level of the product output.

In particular, any provision of the supplying follow-up as well as the manufacturing follow-up may be taken to guarantee the quality of the manufactured products on which the safe operation of the residual current device depends.

IE.2 Follow-up testing program

The follow-up testing program includes two series of tests.

IE.2.1 Quarterly follow-up testing program

See table IE.1, test sequence Q.

IE.2.2 Annual follow-up testing program

See table IE.1, test sequences Y1 to Y3.

NOTE The annual follow-up testing may be combined with the quarterly follow-up testing.

Table IE.1 – Test sequences during follow-up inspections

Test sequence	Clause or subclause	Test	Comments
Q	9.16	Test device	Items b) and c) only except the verification of the test circuit ampere turns
	9.9.2.1	Residual operating characteristics	
	9.9.2.3	Residual operating characteristics	
	9.20	Resistance of insulation against impulse voltages	Also carried out between each pole in turn
Y1	9.9.4	Residual operating characteristics	
	9.7	Test of dielectric properties	
	9.10	Mechanical and electrical endurance	
Y2	9.22.1	Reliability (climatic test)	
Y3	9.23	Resistance to ageing	

IE.2.3 Sampling procedure

IE.2.3.1 Quarterly testing program

For the purpose of the quarterly testing program the following inspection levels are applied:

- normal inspection;
- tightened inspection.

Normal inspection will be used for the first follow-up inspection.

For successive inspections, normal or tightened inspection, or stopping of the production is applied, depending on the results of the on-going tests.

The following criteria for switching over from one level of inspection to another shall be applied:

- Stay at normal level

  When normal inspection is applied, normal level is maintained if all six samples pass the test sequence (see table IE.2, sequence Q). If five samples pass the test sequence, the subsequent inspection is made one month only after the preceding one with the same number of samples and the same test sequence.
- Normal to tightened

  When normal inspection is applied, tightened inspection shall be applied when only four samples pass the test sequence.
- Normal to production stop

  When normal inspection is applied and less than four samples pass the test sequence, the production shall be discontinued pending action to improve the quality.
- Tightened to normal

  When tightened inspection is applied, normal inspection shall be applied when at least 12 samples pass the test sequence (see table IE.2).
- Stay at tightened level

  When, being at tightened level, 10 or 11 samples only pass the test sequence, the tightened level is maintained and the subsequent inspection is made one month after the preceding one with the same number of samples and the same test sequence.
- Tightened to production stop

  In the event that four consecutive inspections remain on the tightened level or when less than 10 samples pass the test sequence, the production shall be discontinued pending action to improve the quality.
- Restart production

  The production can restart after appropriate and confirmed corrective action. The restart shall be made under tightened inspection conditions.

IE.2.3.2 Annual testing program

For the purpose of the annual testing program the following inspection levels are applied:

- normal inspection;
- tightened inspection.

Normal inspection will be used for the first follow-up inspection.

For successive inspections, normal or tightened inspections are applied, depending on the results of the on-going tests.

The following criteria for switching-over from one level of inspection to another shall be applied.

– Stay at the normal level

  When normal inspection is applied, normal level is maintained if all samples pass the test sequence. If two samples pass the test sequence Y1 and no failure occurs during test sequences Y2 and Y3, the subsequent inspection is made three months after the preceding one with the same number of samples and the same test sequences.

– Normal to tightened

  When normal inspection is applied, tightened inspection shall be applied when either:

  - only one sample passes the sequence Y1;
  - or one failure occurs during any one of test sequences Y2 or Y3.

The subsequent inspection shall be effected within three months of the preceding one, at tightened level for any sequence in which the failure occurred and at normal level for the other test sequences.

– Normal to production stop

  When normal inspection is applied and no sample passes the test sequence Y1, or more than one failure occurs during test sequences Y2 or Y3, the production shall be discontinued pending action to improve the quality.

– Tightened to normal

  When tightened inspection is applied, normal inspection shall be applied when:

  - at least five samples pass the test sequence Y1; and
  - no failure occurs during the test sequence Y2 or Y3.

– Stay at tightened level

  When, being at tightened level, four samples only pass the test sequence Y1 and no failure occurs during test sequences Y2 or Y3, the tightened level is maintained and the following inspection is made three months after the preceding one with the same number of samples and the same test sequences.

– Tightened to production stop

  In the event that four consecutive inspections remain on the tightened level or when during one annual inspection one of the following failures occurs:

  - less than four samples pass test sequence Y1;
  - more than one failure occurs during test sequences Y2 or Y3;

  the production shall be discontinued pending action to improve the quality.

– Restart production

  The production can restart after appropriate and confirmed corrective action. The restart shall be made under tightened inspection conditions.

IE.2.4 Number of samples to be tested

The number of samples for the various inspection levels is given in table IE.2.

Table IE.2 – Number of samples to be tested

Inspection sequence	Number of samples for normal inspection	Number of samples for tightened inspection
Q	6	13
Y1, Y2, Y3	3 each	6 each

Out of each series of RCCBs of the same fundamental design only one set of samples need be tested, irrespective of the ratings.

For the purpose of this follow-up testing program, RCCBs are considered to be of the same fundamental design if they belong to the same classification according to 4.1, and

- the residual current operating means have identical tripping mechanism and identical relay or solenoid, except for:
  - the number of turns and cross-sectional area of the windings;
  - the sizes and material of the core of the differential transformer;
  - the rated residual current; and
- the electronic part, if any, is of the same design and uses the same components, except for variations so as to achieve different $I_{\Delta n}$.

Annex IF
(informative)

SCPDs for short-circuit tests

IF.0 Introduction

For the verification of the minimum I^2t and I_p values to be withstood by the RCCB as given in table 15, short-circuit tests have to be performed. The short-circuit tests shall be made by the use of a fuse or a silver wire using the test apparatus shown in figure 10 or by the use of any other means producing the required I^2t and I_p values.

IF.1 Silver wires

For the purpose of verifying the minimum I^2t and I_p values to be withstood by the RCCB, in order to obtain reproducible test results, the SCPD, if any, may be a silver wire using the test apparatus shown in figure 10.

For silver wires with at least 99,9 % purity, table IF.1 gives an indication of the diameters according to the rated current I_n and the short-circuit currents I_{nc} and $I_{\Delta c}$.

Table IF.1 – Indication of silver wire diameters as a function of rated currents and short-circuit currents

I_{nc} and $I_{\Delta c}$	I_n A								
	≤ 16	≤ 20	≤ 25	≤ 32	≤ 40	≤ 63	≤ 80	≤ 100	≤ 125
	Silver wire diameter* mm								
500	0,30	0,35	0,35	0,35					
1000	0,30	0,35	0,40	0,50					
1500	0,35	0,40	0,45	0,50	0,65	0,85			
3000	0,35	0,40	0,45	0,50	0,60	0,80	0,95	1,05	1,15
4500	0,35	0,40	0,45	0,50	0,60	0,80	0,90	1,05	1,15
6000	0,35	0,40	0,45	0,50	0,60	0,75	0,90	0,95	1,00
10000	0,35	0,40	0,45	0,50	0,60	0,70	0,85	0,90	0,95

* The silver wire diameter values are essentially based on peak current (I_p) considerations (see table 15).

The silver wire shall be inserted in the appropriate position of the test apparatus shown in figure 10, horizontally and stretched. The silver wire shall be replaced after each test.

IF.2 Fuses

For the purpose of verifying the minimum I^2t and I_p values to be withstood by the RCCB, in order to obtain reproducible test results, the SCPD, if any, may be a corresponding fuse.

The rating of the fuse must not be smaller than the rating of the RCCB. Higher ratings of fuses may be used to obtain the I^2t and I_p values of table 15.

Intermediate values can be achieved by adding fuses in parallel.

IF.3 Other means

Other means may be used provided that the values of table 15 are fulfilled.

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