BRITISH STANDARD

BS 4293:1983

Incorporating Amendment Nos. 1 and 2

Specification for

Residual current-operated circuit-breakers

UDC 621.316.57

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Power Electrical Engineering Standards Committee (PEL/-) to Technical Committee PEL/11 upon which the following bodies were represented:

Association for Short Circuit Testing Authorities
Department of Trade (Consumer Safety Unit, CS Division)
Electrical Installation Equipment Manufacturers' Association (BEAMA)
Electricity Supply Industry in England and Wales
Electronic Components Industry Federation
Health and Safety Executive
Institution of Electrical Engineers
National Economic Development Office
National Inspection Council for Electrical Installation Contracting

This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Committee, was published under the authority of the Board of BSI and comes into effect on 29 July 1983

First published March 1968
First revision July 1983

The following BSI references relate to the work on this standard:
Committee reference PEL/11
Draft for comment 81/31957 DC

ISBN 0 580 13386 9

Amendments issued since publication

Amd. No.	Date of issue	Comments
4851	May 1985	
6279	December 1990	Indicated by a sideline in the margin

Contents

Foreword

This revision of BS 4293 has been prepared under the authority of the Power Electrical Engineering Standards Committee. It revises the requirements for current-operated earth-leakage circuit-breakers previously given in the 1968 edition of BS 4293 to take account of developments in such circuit-breakers and to make the standard more suitable for certification purposes, BS 4293:1968 is now withdrawn.

The opportunity has been taken to adopt the internationally agreed name, i.e. residual current-operated circuit-breaker, for what have previously been known as current-operated earth-leakage circuit-breakers, but throughout this standard, for the sake of brevity, the term "circuit-breaker" is used.

The residual current-operated circuit-breakers covered by this British Standard are primarily intended to give protection by automatic disconnection of supply against the risk of dangerous and possibly lethal electric shocks and whilst the standard specifies the operational characteristics of these devices, details of how they should be selected and installed to provide the desired level of protection are prescribed in the "Regulations for Electrical Installations" Engineers (IEE) (see Appendix D). These regulations make reference to residual current devices and it should be noted that the residual current-operated circuit-breaker is a particular type of residual current device.

These circuit-breakers also provide a high degree of protection against the possibility of fire resulting from earth fault currents which can persist for lengthy periods but are of such magnitude that the overcurrent protective devices in the circuit concerned do not operate.

The circuit-breakers covered by this standard are suitable for use in household, agricultural, commercial and industrial electrical installations.

Three appendices have been included to assist users in the proper application of residual current-operated circuit-breakers and attention is particularly directed to Appendix D.

A typical circuit diagram for a residual current-operated circuit-breaker is given in Figure 3.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 14, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 Scope

This British Standard specifies the requirements for residual current-operated circuit-breakers (including circuit-breakers utilizing auxiliary sources and circuit-breakers with electronic circuitry) having a rated voltage not exceeding 660 V, a rated current not exceeding 125 A and a rated frequency not exceeding 400 Hz. Circuit-breakers complying with this standard are also suitable for use as isolators.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions and symbols

2.1 Definitions

For the purposes of this British Standard the definitions given in **2.1.1** and **2.1.2** apply.

2.1.1 General

2.1.1.1
residual current I_{Δ}

the r.m.s. value of the vector resultant of the instantaneous values of the currents flowing in the main circuit of the residual current-operated circuit-breaker

2.1.1.2
residual current-operated circuit-breaker (rccb)

a device for making and breaking a circuit, and for breaking a circuit automatically when the residual current exceeds a predetermined amount

NOTE For the purposes of this standard the term circuit-breaker includes both the mechanism for interrupting the circuit and also any associated residual current sensing devices.

2.1.1.3
tripping current $I_{o\Delta}$

the minimum value of residual current that causes the circuit-breaker to open

2.1.1.4
pole

the portion of a circuit-breaker associated exclusively with one electrically separated conducting path of its main circuit and provided with contacts intended to connect and disconnect the main circuit itself and excluding those portions which provide a means for mounting and operating all poles together

NOTE The term does not include any switched neutral.

2.1.1.5
switched neutral

contacts not intended to make or break current and arranged to close before and open after the main contacts

2.1.1.6
prospective current

the current (r.m.s. value of the a.c. component) that would flow in the circuit due to the applied voltage if each main current path of the circuit-breaker were replaced by a link of negligible impedance but without any other circuit change

NOTE For the purpose of this definition the term circuit-breaker includes the short length of cable used to connect the circuit-breaker to the test circuit (see **8.2**).

2.1.1.7
main contacts

the fixed and moving contacts in the main current carrying circuits

2.1.1.8
test device

a device to enable the protective function of the circuit-breaker to be checked

2.1.1.9
integral auxiliary source

an auxiliary source intended to supply the auxiliary circuit(s) which is derived from the same mains supply within the circuit-breaker as the load being protected.

2.1.1.10
separate auxiliary source

an auxiliary source intended to supply the auxiliary circuit(s) derived from a source separate from the mains supply feeding the load

NOTE See reference to separate auxiliary supply in Appendix D.

2.1.1.11
residual current-operated circuit-breaker with integral overcurrent protection

a residual current-operated circuit-breaker designed to perform the additional function of overload and/or short circuit protection

NOTE For the purpose of this standard, this includes a circuit-breaker with a socket outlet as an integral part of its construction which can supply a local load only through a fused plug.

2.1.1.12
time-delay circuit-breaker

a circuit-breaker which has its automatic opening intentionally delayed

2.1.1.13
earth fault breaking current

the value of current which the circuit-breaker, without the aid of any back-up protection, can satisfactorily break at rated voltage

2.1.2 Electrical characteristics

2.1.2.1
rated tripping current $I_{o\Delta n}$ (rated residual operating current)

the value of residual current, assigned by the manufacturer, at which the circuit-breaker opens under specified conditions

2.1.2.2
rated non-tripping current $I_{\phi\Delta n}$

the value of residual current, assigned by the manufacturer, at which the circuit-breaker does not open under specified conditions

2.1.2.3
rated current of a circuit-breaker I_n

the r.m.s. value of current, assigned by the manufacturer, which the main circuit of the circuit-breaker is capable of carrying continuously under specified conditions of use and behaviour

2.1.2.4
rated voltage U_n

The r.m.s. value of voltage, assigned by the manufacturer, to which the performance of the circuit-breaker is referred

2.1.2.5
rated voltage of the separate auxiliary source U_{an}

the value of the voltage of the separate auxiliary source by which the circuit-breaker is designated and to which the operating functions of the circuit-breaker are referred, under specified conditions

NOTE Circuit-breakers may have one or more values of rated voltage of the separate auxiliary source or one or more ranges of this source.

2.1.2.6 *Text deleted.*

2.2 Symbols

For the purposes of this British Standard the following symbols apply

I is the current

U is the voltage

qualified by the following subscripts:

n is rated

o is open

ϕ is non-opening

Δ is out-of-balance

a is auxiliary

3 General

3.1 Circuit-breakers incorporating overcurrent protection. If a circuit-breaker incorporates overcurrent protection as an integral part of its construction, such overcurrent protection shall comply with the requirements of the appropriate standard, as declared by the manufacturer.

3.2 Portable circuit-breaker units. Portable units incorporating socket outlets or plug and/or socket connections shall also comply with the relevant Parts of the appropriate British Standards for such plugs and sockets. An instruction label shall be fitted indicating the need to test such devices each time they are used.

NOTE Further requirements for portable units are under consideration.

4 Ratings

4.1 Rating of circuit-breakers. Circuit-breakers shall be rated in terms of the following:

a) number of poles;

b) voltage;

c) current;

d) tripping current;

e) frequency.

The rated tripping current shall not exceed 3 A. The rated frequency shall not exceed 400 Hz.

NOTE Preferred ratings for voltage, current, tripping current and frequency are given in Appendix A.

4.2 Arrangement of poles. The arrangement of poles shall be one of the following (see Figure 1):

a) a single pole with switched or solid neutral;

b) double pole;

c) double pole with switched or solid neutral;

d) three pole;

e) three pole with switched or solid neutral;

f) four pole.

5 Marking

Circuit-breakers shall be marked legibly and in a durable manner with the following particulars:

a) rated voltage;

b) rated current;

c) rated tripping current;

d) frequency, if other than 50 Hz;

e) manufacturer's or responsible vendor's name or distinguishing mark;

f) type reference where more than one type is manufactured;

g) country of manufacture;

h) the number of this British Standard, i.e. BS 4293[1)];

i) the details concerning the operation of the test device;

j) the details of the separate auxiliary source, if applicable;

k) the closed and open positions of the circuit-breaker (ON/OFF or I/O or both).

Particulars a), b), c) and k) shall be marked on the body of the circuit-breaker and also on the cover, if the cover is removable. These particulars and the identification of the test device i) shall also be readable on the front of the circuit-breaker when mounted in the normal service position.

The terminals for the connection of the neutral conductor shall be identified by the symbol N. Where it is necessary to distinguish between supply side and load side terminals, they shall be clearly identified.

A diagram of connections shall appear either on the circuit-breaker or be supplied with it.

Where a terminal is provided for the connection of protective conductors this shall be marked with an appropriate symbol.

NOTE It is intended that an indication should be given of the system fault level for which the circuit-breaker is suitable. Requirements to meet the system fault levels and requirements for conditional testing will be the subject of a future amendment.

Durability of marking shall be tested in accordance with **8.8**.

6 Service conditions

Circuit-breakers complying with this standard shall be suitable for use under the following conditions of service:

a) an ambient temperature range of – 5 °C to 40 °C, with an average value not exceeding 35 °C measured over any 24 h period;

b) an altitude not exceeding 2 000 m above sea level;

c) an atmosphere not subject to excessive pollution by smoke, chemical fumes, salt-laden spray, prolonged periods of high humidity or other abnormal conditions.

NOTE 1 Circuit-breakers complying with this standard may not be suitable for exposure to direct radiation from the sun or other source of heat likely to raise the temperature above the designated ambient, nor for subjection to excessive vibration.

NOTE 2 Where service conditions differ from those prescribed above the user should seek the advice of the manufacturer.

7 Design and construction

7.1 Temperature rise. The temperature rise at specified parts of the circuit-breaker when tested in accordance with **8.4** shall not exceed the value given below

a) For terminals for external conductors, 70 K.

b) For handles, operating devices and parts of enclosures likely to be handled when operating the circuit-breaker:

1) metallic parts, 30 K;

2) parts made of insulating material, 40 K.

c) For other external surface accessible in service, 50 K.

d) 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 circuit-breaker shall not be impaired. This shall be checked by external inspection.

7.2 Provision for testing earth fault operation. Provision shall be made for testing the automatic opening of the circuit-breaker by an integral test device.

Operation of the test device shall excite the current-balance transformer or transformers and the exciting ampere-turns produced by the test device shall not exceed 2.5 times the exciting ampere-turns produced by the rated tripping current flowing in one pole of the circuit.

The test device shall be arranged for external operation in such a way that the protection afforded by the cover or enclosure is not impaired. To safeguard against loss, the push button or the operating handle of the test device shall not be removable without the use of tools and until the cover has been removed from the circuit-breaker.

NOTE Appendix B gives information on the function of the test device.

7.3 Voltage limits for auxiliary source supplies. Circuit-breakers which depend on an integral or separate auxiliary source for operation shall perform their protective function at any value of the source between 0.70 and 1.1 times its rated voltage.

7.4 Construction. Circuit-breakers shall be designed to withstand reasonably rough usage without fracture or permanent distortion. The enclosure for the mechanism shall be sealed by the manufacturer to prevent access to the mechanism.

[1)] Marking BS 4293 on or in relation to a product is a claim by the manufacturer that the product has been manufactured to the requirements of the standard. The accuracy of such a claim is therefore solely the manufacturer's responsibility.

Provision shall be made for the effective earthing of all metal parts which may become live in the event of failure of insulation and which are capable of being touched during normal operation of the circuit-breaker. This shall be checked by the test of **8.10**.

NOTE Small metal parts such as labels, rivets and nameplates which are unlikely to become live in service are excluded from this requirement.

Circuit-breakers, when installed as recommended by the manufacturer, shall be proof against humidity which may occur in normal use. This shall be checked by the test of **8.16**.

7.5 Operating mechanism. Circuit-breakers shall be arranged for manual closing and opening and automatic opening under earth fault conditions. An automatic release mechanism shall be provided to open the circuit-breaker independently of the means used to close it. It shall not be possible to hold the circuit-breaker closed by the operating mechanism under conditions in which tripping should occur. This shall be checked by inspection and by the test of **8.12**.

It shall be readily possible for the operator to distinguish whether the circuit-breaker is closed or open when it is mounted in the normal manner[2)]. It shall not be possible for the indicating device to assume the open position unless all moving contacts are also in the open position. This shall be checked by inspection and by the test of clause **9** b)

Open and close push buttons shall be coloured RED and GREEN respectively.

The circuit-breaker shall not be capable of unintentional reclosure. This could be caused, for example, by shock or vibration. Check by inspection that the circuit-breaker requires a positive and intentional manual action to close the contacts.

7.6 Connection arrangements. The terminal arrangements shall be such that the copper conductors specified in Table 2 can be adequately accommodated and securely clamped. This shall be checked by inspection.

Table 2 — Terminal capacities

Circuit-breaker rated current			Range of conductor cross sections to be clamped
A			mm^2
	Up to and including	10	1 to 2.5
Above 10	up to and including	16	1.5 to 4
Above 16	up to and including	25	1.5 to 6
Above 25	up to and including	32	2.5 to 10
Above 32	up to and including	50	4 to 16
Above 50	up to and including	80	6 to 25
Above 80	up to and including	100	10 to 35
Above 100	up to and including	125	16 to 50

Terminal screws shall thread into metal and if the conductors are secured by means of pinching screws, the screws shall be so shaped and the arrangement shall be such as to minimize damage to the conductors. This shall be checked by test and inspection.

Terminal screws shall either be made of a material which is inherently resistant to corrosion or they shall be treated for resistance to corrosion.

7.7 Circuit-breakers for use as isolators. Circuit-breakers with a rated voltage of 240 V used for the purpose of isolation shall provide in the open position an isolating distance of not less than 3 mm.

NOTE This requirement may be revised to specify isolating distances for circuit-breakers with rated voltages between 240 V and 660 V when BS 5419 is amended to specify actual values of isolating distance.

8 Tests

8.1 General. Tests shall be made to prove compliance with all the requirements of this standard. It is not intended, nor is it recommended, that every circuit-breaker shall be subjected to all the tests.

Two kinds of test are applicable, namely type tests, which shall be made on samples representing every type of apparatus designed in accordance with this standard, and routine tests which shall be made on every circuit-breaker manufactured bearing the number of this standard.

8.2 Type tests. Type tests shall be made at rated voltage ± 5 % unless otherwise stated, at rated frequency ± 10 % and at an ambient temperature of between 20 °C and 25 °C. The specified sequence shall be completed without any adjustment being made to the samples.

[2)] If push buttons are used, the close button remaining clearly in the depressed position is deemed sufficient indication of the circuit-breaker being closed.

The circuit-breaker shall be positioned and wired as in service unless otherwise stated and the method of fixing shall comply with any requirements published by the manufacturer.

Test cables used for the tests shall be of the appropriate size specified in Table 3 and each cable shall be above 0.55 m up to and including 0.6 m in length except for connecting cables between terminals on the circuit-breaker, which shall be above 1.1 m up to and including 1.2 m in length.

Table 3 — Test cables

Circuit-breaker rated current				Nominal cross section of test cable with copper conductor
A				mm^2
		Up to and including	10	1.5
Above	10	up to and including	16	2.5
Above	16	up to and including	25	4
Above	25	up to and including	32	6
Above	32	up to and including	50	10
Above	50	up to and including	63	16
Above	63	up to and including	80	25
Above	80	up to and including	100	35
Above	100	up to and including	125	50

Four samples shall be submitted for type testing. Each sample shall be in a clean new condition and shall have satisfactorily completed the routine tests of **8.17**. A separate sample shall be used for each test sequence.

The tests shall be performed in the order shown for each test sequence, except for g) h) and i) of test sequence 1 which may be performed in any order after completion of f).

In test sequence 4, test b) shall be carried out between 30 min and 60 min of removal of the sample from the test chamber after the completion of test a).

Test sequence 1

a) High voltage (**8.3**)
b) Temperature rise (**8.4**)
c) Transformer balance (**8.5**)
d) Making and breaking (**8.6**)
e) Speed of operation (**8.7**)
f) Condition of circuit-breaker after test (clause **9**)
g) Durability of marking (**8.8**)
h) Determination of test device ampere-turns (**8.9**)
i) Effective earthing (**8.10**)

Test sequence 2

a) Endurance (**8.11**)
b) Condition of circuit-breaker after test (clause **9**)
c) Sensitivity (**8.12**)

Test sequence 3

a) Circuit fault current (**8.13**)
b) Condition of circuit-breaker after test (clause **9**)

Test sequence 4

a) Resistance to humidity (**8.16**)
b) High voltage flash (**8.19**)
c) Sensitivity (**8.12**)
d) Earth fault breaking current test. (**8.15**)
e) Condition of circuit-breaker after test (clause **9**)
f) Tripping current (**8.14**)

8.3 High voltage test. Circuit-breakers shall withstand the test voltage specified in Table 4, this being applied for 1 min as follows.

a) Between all incoming terminals in turn with the circuit-breaker closed. If an auxiliary source is required to close the circuit-breaker this may be disconnected and the test shall be carried out with the circuit-breaker open followed by a second test between all outgoing terminals in turn.

b) Between all incoming terminals connected together and the corresponding outgoing terminals in turn with the circuit-breaker open.

c) Between all main and auxiliary circuit terminals connected together and any earthed metal.

d) Between all main and auxiliary circuit terminals connected together and any other metal parts unearthed and exposed in service. Small metal parts such as labels, rivets and nameplates, wholly insulated from live parts, and unlikely to become live in service, shall be excluded from this test.

NOTE 1 Connections to auxiliary devices such as shunt trips, under-voltage releases or electronic devices may be removed for this test.

Table 4 — High voltage test values

Rated voltage U_n	Dielectric a.c. test voltage (r.m.s)
V	V
$U_n \leq 60$	1 000
$60 < U_n \leq 300$	2 000
$300 < U_n \leq 660$	2 500

The test voltage shall be alternating and of any available frequency between 25 Hz and 100 Hz and approximately of sinusoidal waveform.

Initially, not more than half the prescribed voltage shall be applied; then it shall be raised rapidly to the full value.

NOTE 2 It is permissible for the circuit-breaker to close during the test.

8.4 Temperature rise test. The circuit-breaker shall be mounted individually, vertically and in free air in an ambient temperature between 20 °C and 25 °C and shall be protected against undue external heating or cooling, it shall be wired with the appropriate cable specified in Table 3 and shall be fixed on a dull black painted plywood board of about 20 mm thickness, the method of fixing complying with any requirements relating to the means of mounting recommended by the manufacturer.

A current equal to the rated current of the circuit breaker is passed simultaneously through all the poles of the circuit breaker 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. The test may be performed at any convenient voltage.

For four-pole devices the test is first made by passing the specified current through the three main 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 the test the temperature rise shall not exceed the values shown in **7.1**.

The test cables connected between terminals shall have a minimum length as follows:

a) 1.2 m for cross sections up to and including 10 mm^2;

b) 2.0 m for cross sections larger than 10 mm^2.

8.5 Transformer balance. The circuit-breaker shall be closed three times on to a circuit such that each pole carries twice the rated current at any convenient test voltage. The circuit-breaker shall not trip. The test current shall be maintained for 5 s.

NOTE Appendix C gives information on the purpose of the transformer balance test.

8.6 Making and breaking test. The circuit-breaker shall be switched on and off six times. There shall be no deliberate time delay between the ON and OFF operation but there shall be a 1 min interval between each cycle of operations.

During the test, each pole of the circuit-breaker shall carry six times the rated current + 5, – 0 % at rated voltage ± 5 % (power factor 0.95 ± 0.05).

NOTE Automatic tripping is permissible.

8.7 Speed of operation. Five times the rated tripping current shall be applied to each pole in turn.

In each case the circuit-breaker shall open within 0.04 s unless it incorporates an intentional time delay, in which case it shall not open in less than 50 % of the rated (or declared) time delay and shall open in not more than the rated time delay plus 0.04 s.

8.8 Durability of marking. The durability of marking (see clause **5**) shall be checked by inspection and by rubbing the marking by hand for 15 s with a piece of cloth soaked in water and again for 15 s with a piece of cloth soaked in petroleum spirit. After testing the marking shall be easily legible; it shall not be possible to remove easily any marking plates and they shall show no curling.

NOTE 1 A revision of the test for checking durability of marking is under consideration.

NOTE 2 In considering the durability of marking, the effects of normal use should be taken into account. Thus, for example, marking by means of ink or paint on parts that are likely to be cleaned frequently, may not be durable.

8.9 Determination of the test device ampere-turns. The test device ampere-turns shall be determined either by measurement or by calculation and shall not exceed the value specified in **7.2**. During the measurement the tripping mechanism may be rendered inoperative.

8.10 Test to prove effective earthing. A current equal to 1.5 times the rated current or 25 A, whichever is the greater, derived from an a.c. source having a no-load voltage not exceeding 12 V, shall be passed between the earthing point and each of the metal parts referred to in **7.4** in turn.

The voltage drop between the earthing point and the accessible metal part shall be measured and the resistance calculated from the current and the voltage drop.

In no case shall the resistance exceed 0.05 Ω.

NOTE Care should be taken to ensure that the contact resistance between the tip of the measuring probe and the metal part under test does not influence the test results.

8.11 Endurance test. The circuit-breaker shall be tested for endurance in accordance with the test sequence of Table 5, as follows:

a) by being switched on and off by the manual operating mechanism;

b) by being switched on manually and switched off by means of the test device;

c) by being switched on manually and switched off by establishing an out-of-balance current equal to twice the rated tripping current.

The circuit-breaker shall be operated at 240 ± 30 cycles per hour. One cycle of operation shall consist of approximately 2 s on and 13 s off.

During the test each pole of the circuit-breaker shall carry rated current at rated voltage ± 5 % (power factor 0.75 ± 0.05 lagging).

NOTE Circuit-breakers having integral overcurrent releases will require further samples for testing in accordance with the relevant standards.

Table 5 — Endurance test sequence

Type of operation	Number of cycles of operation
Manual	1 000
Test switch	500
Out-of-balance	500

8.12 Sensitivity. The rated tripping current shall be switched on to each pole in turn. In each case the circuit-breaker shall open within 0.2 s, in addition to any intentional time delay.

For a type test only and for a circuit-breaker not fitted with a quick make mechanism, the test shall be repeated with the contacts of the circuit-breaker just touching.

For a type test, in test sequence 2 only, and in addition to the test at an ambient temperature of between 20 °C and 25 °C, the test shall also be carried out at an ambient temperature of – 5 °C or below and at an ambient temperature of 40 °C or above.

For a type test, in test sequence 2 only, and for circuit breakers that depend on an integral or separate auxiliary source for operation, the test shall be carried out with the source voltage equal to or less than 0.70 times its rated voltage and also with the source voltage equal to or greater than 1.1 times its rated voltage.

8.13 Circuit fault current test. This test is intended to check the ability of the circuit breaker, and in particular of the transformer primary windings, to withstand the thermal and electromagnetic stresses which may occur under through fault conditions before the back-up protection clears.

The circuit-breaker shall be connected as shown in Figure 1. Each pole except the neutral of the circuit-breaker shall be connected in series with a silver wire fuse 85 mm in length having a silver content of not less than 99.9 % and a diameter in accordance with Table 6.

Any part of the circuit-breaker intended to be earthed shall be connected to earth via a fine wire fuse. This fuse (for indicating earth faults) shall be copper wire of 0.1 mm diameter and not less than 50 mm long. If necessary, a resistor (see Figure 1) shall be connected between the fuse and the neutral point of the supply to limit the value of the earth fault current to about 100 A.

The method of earthing the test circuit shall be stated in the test report (see Figure 1, note 2).

A test at the prospective current value given in Table 6 at rated voltage ± 5 % (power factor 0.95 ± 0.05) shall be applied to the combination of silver wire fuse and circuit-breaker, except that where a residual current operated circuit-breaker is fitted with integral overcurrent protection (see **3.1**) the circuit-breaker shall be tested as supplied without the external silver wire fuse being fitted.

Table 6 — Prospective current values

Rated current	Prospective current	Nominal wire diameter of silver wire fuse
A	A	mm
Up to 16	1 500	0.33
Over 16 up to 25	1 500	0.67
Over 25 up to 40	2 000	0.85
Over 40	3 000	1.2

The following test sequence shall be performed:

0 –*t* –CO

with the 0 test being performed with the initiation of short-circuit current at a voltage zero ± 10° for single and double pole circuit-breakers and with random initiation for 3 and 4 pole circuit-breakers,

where

0 represents a breaking of the circuit following the short-circuit initiation by the making switch (Figure 1);

t represents a time interval of 3 min or the inherent resetting time of any integral overcurrent protection;

CO represents a making operation of the circuit-breaker followed by the breaking of the circuit.

For tests on circuit-breakers not fitted with integral over-current protection the silver wire fuse in series with each pole shall be renewed in the 3 min interval between the breaking and making operations. In any event the time interval shall be recorded.

The break may be effected either by the operation of the fuse or the automatic opening of the circuit-breaker. It is permissible for the circuit-breaker to open automatically during this test. After arc extinction the recovery voltage shall be maintained for a period not less than 0.1 s.

During all circuit fault current tests cheesecloth shall be applied to the exterior of the circuit-breaker as indicated below.

The cheesecloth shall be clean and dry, bleached, plain cotton, approximately 30 g/m^2 to 40 g/m^2. When placed in position, the cheesecloth shall be folded loosely in such a manner that cut or torn edges will not be exposed directly to the arc or flash.

There shall be no ignition of the cheesecloth.

NOTE The cheesecloth may be changed during the series of tests.

a) For circuit-breakers intended to be used in an enclosure, cheesecloth shall be placed on the outside of the enclosure at all openings, handles, etc. and inside the enclosure wherever insulated conductors may be located, care being taken not to block the vents.

b) For circuit-breakers not intended to be used in an enclosure, cheesecloth shall be placed at all openings, handles, etc. and wherever insulated conductors may be located, care being taken not to block the vents.

c) Circuit-breakers so constructed that they may or may not be fitted in an enclosure shall be tested as in b) above.

At the conclusion of the test sequence the fine wire fuse shall be intact and the circuit-breaker shall trip when the test device is operated with rated voltage applied.

8.14 Tripping current test. With the circuit-breaker fully closed, a test current shall be increased gradually through each pole in turn. The circuit-breaker shall operate at a value above 50 % but not exceeding 100 % of the rated tripping current but shall not operate at any value up to and including 50 % of the rated tripping current.

8.15 Earth fault breaking current test. The circuit-breaker shall be connected as shown in Figure 2.

Any part of the circuit-breaker intended to be earthed shall be connected to earth via a fine wire fuse. This fuse (for indicating earth faults) shall be copper wire of 0.1 mm diameter and not less than 50 mm long. If necessary, a resistor (see Figure 2) shall be connected between the fuse and the neutral point of the supply to limit the value of the earth fault current to about 100 A.

The method of earthing the test circuit shall be stated in the test report (see Figure 2, note 4).

A test at a prospective current of 500 A – 0, + 5 % (250 A – 0, + 5 % for circuit-breakers rated at 16 A or below) at rated voltage to earth ± 5 % and power factor 0.95 ± 0 05 shall be applied to each pole three times at 1 min intervals. The circuit-breaker shall open satisfactorily each time.

At the conclusion of the test the fine wire fuse shall be intact.

8.16 Resistance to humidity test. The humidity treatment shall be 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 samples are placed shall be maintained within ± 1 °C of any convenient temperature between 20 °C and 30 °C.

The samples shall be kept in the cabinet for two days.

NOTE 1 The sample should be kept at test temperature for 4 h before the humidity treatment.

NOTE 2 A relative humidity between 91 % and 95 % can be obtained by placing in the humidity cabinet a saturated solution of sodium sulphate ($Na_2 SO_4$) or potassium nitrate (KNO_3) in water having a sufficiently large contact surface with the air.

NOTE 3 In order to achieve the specified conditions within the cabinet it is necessary to ensure constant circulation of the air within and in general to use a cabinet which is thermally insulated.

8.17 Routine tests. Each circuit-breaker in a clean new condition shall withstand the following routine tests, which can be carried out in any order:

a) tripping current (see **8.14**);

b) sensitivity (see **8.12**);

c) performance of test device (see **8.18**);

d) high-voltage flash test (see **8.19**).

8.18 Performance of test device test. With the circuit-breaker fully closed and connected to a supply at 0.85 times rated voltage ± 5 % the test device shall be operated. The circuit-breaker shall open.

8.19 High voltage flash test. The requirements of **8.3** a), b) and c) shall apply except that the test shall be applied for 1 s instead of 1 min.

9 Condition of the circuit-breaker after test

After the appropriate tests as given in **8.2**, the circuit-breaker shall fulfil the following conditions.

a) The circuit-breaker shall be capable, without maintenance, of withstanding a voltage equal to twice its rated voltage applied for 1 s as follows.

1) Between all incoming terminals in turn with the circuit-breaker closed. If an auxiliary source is required to close the circuit-breaker, this test shall be carried out with the circuit-breaker open followed by a second test between all outgoing terminals in turn.

NOTE 1 It is permissible for the circuit-breaker to close during this test.

2) Between all incoming terminals connected together and each outgoing terminal in turn, with the circuit-breaker open.

3) Between all terminals connected together and any earthed metal connected to the earth terminal if one is provided.

NOTE 2 Connections to electronic devices may be removed for this test.

b) It shall be demonstrated immediately after the test that the circuit-breaker will close and open satisfactorily during a no-load close/open operation.

c) The contacts shall be in a suitable condition to carry the rated current. A temperature-rise test in accordance with **8.4** shall be carried out at rated current on the same circuit-breaker: the measured temperature rises shall not exceed by more than 10 K the values given in **7.1**, nor result in damage to adjacent parts.

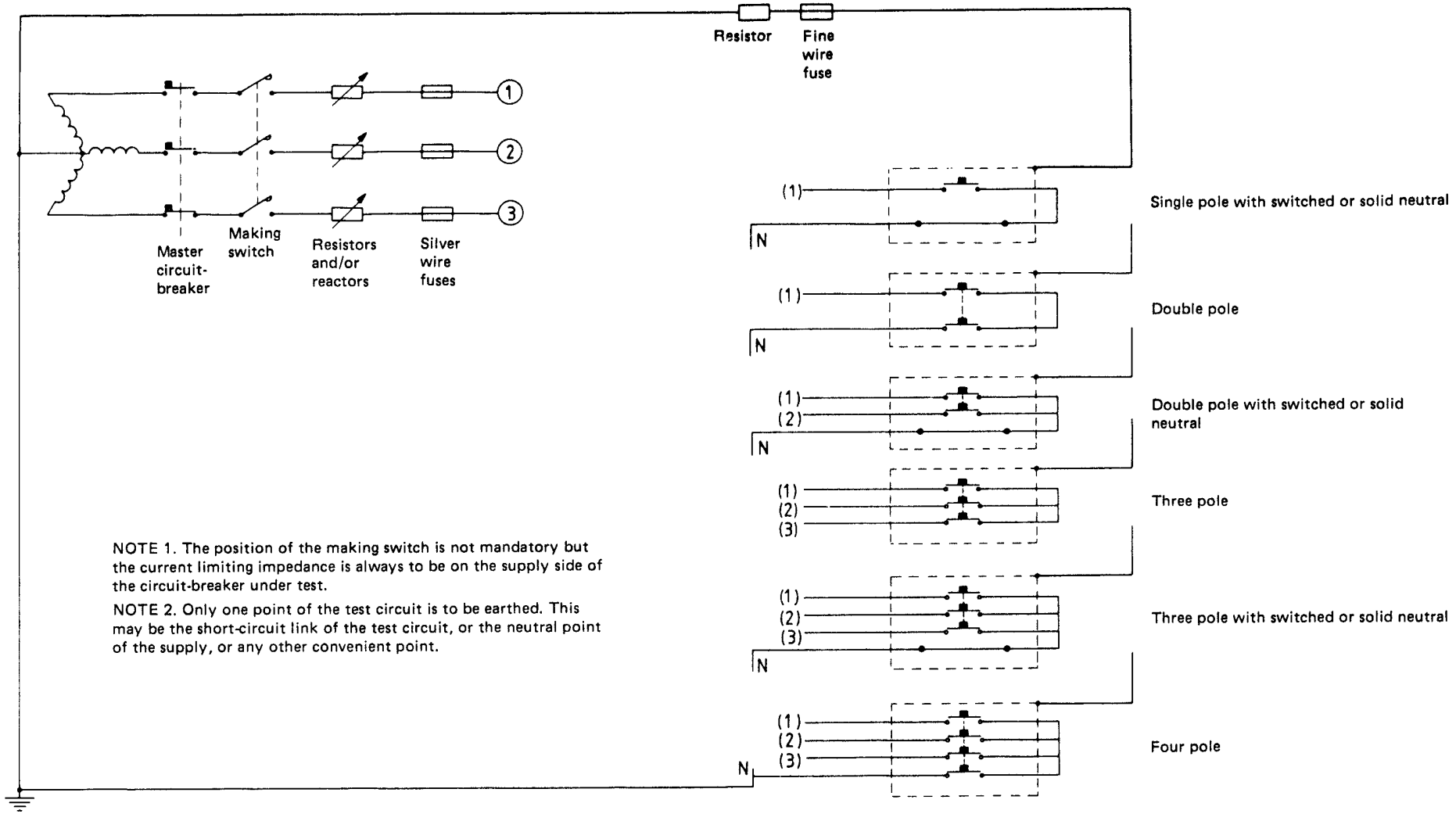
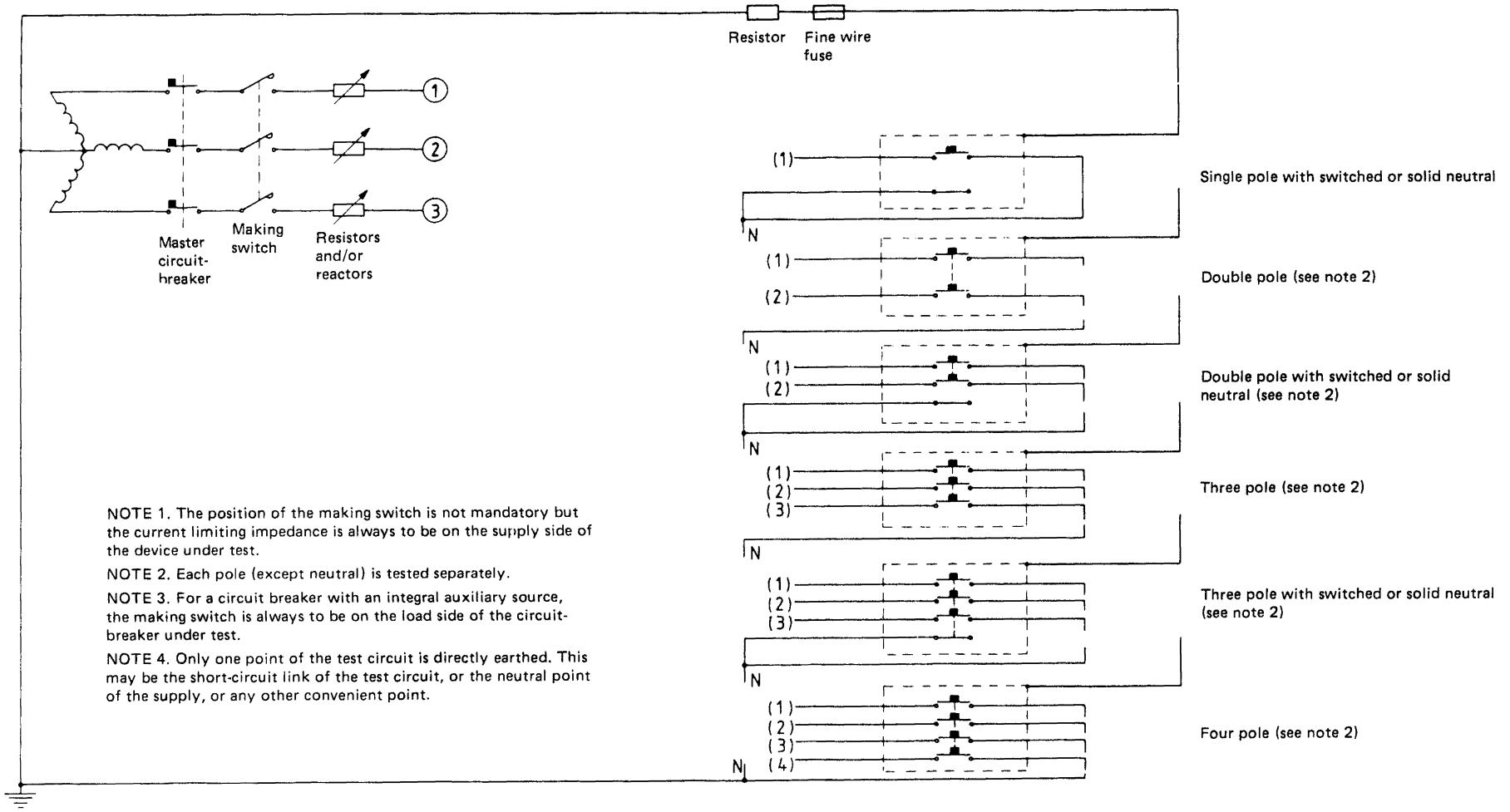


Figure 1 — Test circuit for circuit fault current test (see **8.13**)



NOTE 1. The position of the making switch is not mandatory but the current limiting impedance is always to be on the supply side of the device under test.

NOTE 2. Each pole (except neutral) is tested separately.

NOTE 3. For a circuit breaker with an integral auxiliary source, the making switch is always to be on the load side of the circuit-breaker under test.

NOTE 4. Only one point of the test circuit 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.

Figure 2 — Earth fault breaking current test (see **8.15**)

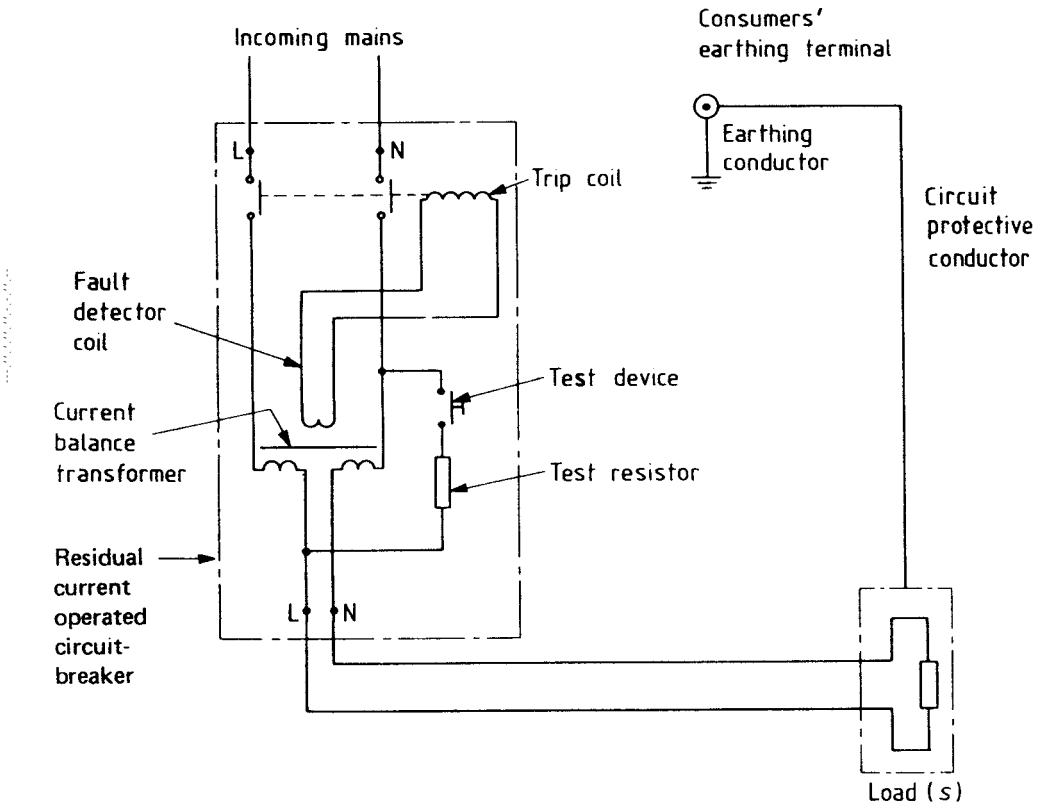


Figure 3 — Typical circuit diagram for a residual current-operated circuit-breaker

Appendix A Preferred ratings for voltage, current, tripping current and frequency

A.1 Voltage ratings. The voltage ratings are not standardized, but preferred values are given in Table 7.

A.2 Current ratings. The current ratings are not standardized, but preferred values are 5, 6, 10, 15, 16, 20, 25, 30, 32, 40, 50, 60, 63, 80, 100 and 125 A.

A.3 Tripping current ratings. The tripping current ratings are not standardized, but preferred values are 0.005, 0.01, 0.02, 0.03, 0.1, 0.3, 0.5, 1.0 and 2.0 A.

A.4 Frequency. The frequency is not standardized, but the preferred value is 50 Hz and this value should be assumed unless otherwise specified.

Table 7 — Voltage ratings

Voltage rating	Nominal voltage to earth
V	V
240	240
415	240

Appendix B Function of the test device

A test device is provided to enable the operation of the circuit-breaker to be checked. Operation of this device creates an out-of-balance condition simulating an earth fault.

Tripping the circuit-breaker by means of the test device establishes the following:

a) the integrity of the electrical and mechanical elements of the tripping device;

b) the circuit-breaker is operating at approximately the correct order of sensitivity.

It should be noted that the test device does not provide a means of checking:

1) the continuity of the earthing conductor and the circuit protective conductors;

2) the earth electrode or other means of earthing;

3) any other part of the earthing circuit.

Appendix C Transformer balance test

In the ideal case if the primary windings each had the same number of turns, and the vector sum of the currents in all the primary windings were zero, there would be no magnetic flux acting on the secondary winding of the current balance transformer.

In practice, the flux balance may be affected by leakage flux in the air between windings, so that some flux acts on the secondary winding. As a result, there is a possibility that with heavy surges of current passing through the circuit-breaker, there may be sufficient inherent unbalance between the windings to cause the circuit-breaker to trip without there being any leakage current to earth.

The transformer balance test which is included in this standard is therefore intended to ensure that any such inherent unbalance in the transformer is not enough to cause nuisance tripping, either at full load currents or on moderate current surges such as may be encountered in practice.

Appendix D Application of residual current-operated circuit-breakers

The IEE "Regulations for Electrical Installations" recognize two forms of shock hazard, "indirect contact" and "direct contact".

The most commonly used protective measure against indirect contact is termed "main equipotential bonding and automatic disconnection of supply" and irrespective of the type of protective device used the aim is to prevent dangerous voltages persisting on accessible conductive parts which become live under earth fault conditions. These conductive parts may be "exposed conductive parts", e.g. the metallic enclosure of electrical equipment, which are defined as parts which can be touched and which are not live parts but may become live under fault conditions. They may also be "extraneous conductive parts" which are defined as being liable to transmit a potential including earth potential but not forming part of the electrical installation, e.g. water and gas pipes.

When protection against indirect contact is to be given by a residual current-operated circuit-breaker the IEE "Regulations for Electrical Installations" prescribe the basic requirement that the product of its rated residual operating current (rated tripping current) in amperes and the earth fault loop impedance in ohms shall not exceed 50.

It is stated in the IEE "Regulations for Electrical Installations" that the use of residual current devices is preferred where the earth fault loop impedance is too high for overcurrent protective devices to be used but in an installation which is part of a TN system any socket outlet intended specifically to supply equipment outdoors has to be protected by a residual current device. Where a house-hold or similar installation is part of a TT system all socket outlet circuits have to be so protected.

In both cases the rated residual operating current has to be 30 mA or less. The IEE "Regulations for Electrical Installations" require that, when possible, it should be verified that the vectorial sum of the leakage currents of equipment supplied by an installation or part of an installation protected by a residual current device is less than one-half of the rated residual operating current of that device and point out that it may be necessary to sub-divide the earthing arrangements for this reason. Where the operation of a residual current device relies upon a separate auxiliary supply external to the device, the IEE "Regulations for Electrical Installations" require that either the device shall be of a type that will operate automatically in case of failure of the auxiliary supply or the device shall incorporate (or be provided with) a supply which shall be available automatically upon failure of the auxiliary supply.

The principal use of a residual current device is to provide protection against indirect contact, i.e. in the event of a fault, but the Wiring Regulations recognize that if such a device has a rated residual operating current not exceeding 30 mA and an operating time of 40 ms or less at a residual current of 250 mA it will reduce the risk associated with direct contact (contact with live parts) in case of failure of other protective measures. It is essential that a residual current device is not used as the sole means for protection against direct contact.

It is further emphasized that the value of leakage current which can flow before the circuit-breaker has operated can be higher than the rated tripping current, I_{on}, of the circuit-breaker, the actual value being determined by the impedance of the circuit on which the fault occurs. The rated tripping current, I_{on}, is the value of residual current, assigned by the manufacturer, at which the circuit-breaker opens under specified conditions. It should also be noted that the speed of operation will not be significantly affected by the value of leakage current.

The IEE "Regulations for Electrical Installations" generally require circuits to be provided with overload and short circuit protection, this being by means of a fuse or miniature circuit-breaker which is in series with the residual current device. The overcurrent protective device is then said to provide back-up protection for the residual current device but in practice the functions of these two devices may tend to overlap and under certain fault conditions both may attempt to clear the fault.

This may occur, for example, when a severe earth fault produces a current of similar magnitude to that under short circuit conditions or when an earth fault and short circuit occur simultaneously. Another possible cause is the inherent out-of-balance in the primary windings of the balance transformer (see Appendix C) causing the residual current device to trip on heavy overloads or short circuits.

This British Standard therefore incorporates a number of tests, such as the making and breaking test (**8.6**) at six times the rated current, the high current earth fault test (**8.15**) and the circuit fault current test (**8.13**).

The residual current device may itself incorporate over-current protective features and in that event the device is also tested to the other relevant standards.

Where a residual current-operated circuit-breaker is used as an isolator (see clause **1**), attention is drawn to the requirements of the IEE "Regulations for Electrical Installations" relating to the provision of the means of isolation.

In particular, attention is drawn to the requirements in those Regulations that adequate provision shall be made to prevent any equipment from being unintentionally energized.

Publications referred to

BS 5419, *Specification for air-break switches, air-break disconnectors, air-break switch disconnectors and fuse combination units for voltages up to and including 1 000 V a.c. and 1 200 V d.c.*.

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