

Specification for

A.C. voltage-operated earth-leakage circuit breakers

UDC 621.316.57.025:621.316.9

Confirmed
January 2010

Co-operating organizations

The Electrical Industry Standards Committee under whose supervision this British Standard was prepared consists of representatives from the following Government departments and scientific and industrial organizations:

Associated Offices' Technical Committee
 Association of Consulting Engineers*
 Association of Mining Electrical and Mechanical Engineers*
 Association of Supervising Electrical Engineers*
 British Electrical and Allied Manufacturers' Association*
 British Railways Board*
 Cable Makers' Association*
 Crown Agents for Oversea Governments and Administrations*
 Electric Lamp Industry Council
 Electric Light Fittings Association
 Electrical Contractors' Association (Incorporated)*
 Electrical Contractors' Association of Scotland
 Electrical Research Association*
 Electricity Council, The Generating Board and the Area Boards in England and Wales*
 Electronic Engineering Association
 Engineering Equipment Users' Association*
 Independent Cable Makers' Association
 Institution of Electrical Engineers*
 Ministry of Aviation*
 Ministry of Defence, Army Department*
 Ministry of Defence, Navy Department*
 Ministry of Labour (H.M. Factory Inspectorate)*
 Ministry of Power*
 Ministry of Public Building and Works*
 Municipal Passenger Transport Association (Incorporated)
 National Inspection Council for Electrical Installation Contracting*
 National Physical Laboratory (Ministry of Technology)
 Oil Companies Materials Association*
 Post Office*
 Public Transport Association (Incorporated)
 South of Scotland Electricity Board*

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

Association of Short-circuit Testing Authorities
 Engineer Surveyors' Association
 Lloyd's Register of Shipping
 London Transport Board
 National Coal Board

This British Standard, having been approved by the Electrical Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 15 November 1965

First published June 1939
 First revision November 1965

© BSI 10-1999

The following BSI references relate to the work on this standard:
 Committee references ELE/10 and ELE/10/18
 Draft for comment D64/1587

ISBN 0 580 01330 8

Amendments issued since publication

Amd. No.	Date	Comments
3259	March 1980	Indicated by a sideline in the margin

Contents

	Page
Co-operating organizations	Inside front cover
Foreword	iii
<hr/>	
1 Scope	1
2 Definitions	1
3 Service conditions	1
4 Rating	1
5 Standard arrangement of poles	2
6 Standard voltage ratings	2
7 Standard current ratings	2
8 Frequency	2
9 Marking	2
10 Terminal identification	2
11 Temperature rise	2
12 Earth-leakage performance	3
13 Test device	3
14 Mains operated trip coils	3
15 Construction	3
16 Operating mechanism	4
17 Connection arrangements	4
18 Test requirements — general	4
19 Test certificates	4
20 Type tests	4
21 Temperature rise test	5
22 Operation of the test device	5
23 Endurance test	5
24 Making and breaking test	6
25 Through current test	6
26 Resistance to lightning surges	6
27 Routine tests	7
28 Performance test	7
29 Speed of operation	7
30 Performance of test device	7
31 Mains voltage test on tripping device	7
32 High-voltage test	7
<hr/>	
Appendix A Service conditions	8
Appendix B Application of earth-leakage circuit-breakers	8
Appendix C Method of installation	8
Appendix D Function of the test device	9
Appendix E Effect of earth-electrode resistance	10
<hr/>	

	Page
Figure 1 — Typical test circuit for through current test	11
Figure 2 — Circuit for surge test	12
Figure 3 — Typical voltage-operated earth-leakage circuit-breaker installation. Note insulated lead from “e” to earth electrode	13
Figure 4 — Typical voltage distribution in soil surrounding a 2 m rod electrode	14
<hr/>	
Table 1 — Voltage ratings	2
Table 2 — Current ratings	2
Table 3 — Temperature rise	3
Table 4 — Operating limits	3
Table 5 — Terminal capacities	4
Table 6 — Endurance test sequence	6
Table 7 — Prospective-current values	6

Foreword

This standard makes reference to the following British Standards:

BS 2757, *Classification of insulating materials for electrical machinery and apparatus on the basis of thermal stability in service.*

BS 3042, *Standard test finger (for checking protection against electric shock).*

This British Standard for voltage-operated air-break earth-leakage circuit-breakers is an extensive revision of the 1939 edition to take account of modern developments in earth-leakage protection and in the design and production of small circuit-breakers.

The voltage-operated type of earth-leakage circuit-breaker is intended to prevent a dangerous potential difference persisting between the general mass of earth and accessible installation metal work. The operation of the device will depend not only upon this potential difference but also upon the earth-leakage circuit-breaker earth-electrode resistance (see Appendix E).

A voltage-operated earth-leakage circuit-breaker may incorporate over-current protection. In such instances it is necessary for the earth-leakage circuit-breaker to comply with the requirements of this standard and also with the relevant requirements in the appropriate circuit-breaker standard. In this connection, attention is drawn to BS 3871-1¹⁾ and BS 862²⁾.

Appendices have been included to assist users in the proper application of voltage-operated earth-leakage circuit-breakers and attention is particularly directed to these.

A British Standard for the current-operated type of earth-leakage circuit-breaker is in the course of preparation and this type of circuit-breaker will be more suitable for low-values of earth-loop impedance.

NOTE In place of the customary, but incorrect use of the ounce as a unit of force, the unit called ounce-force (abbreviation ozf) has been used in this standard. This is the force which, when acting on a body of mass one ounce, gives it an acceleration equal to that of standard gravity.

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 to iv, pages 1 to 14 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⁾ BS 3871, "Miniature and moulded-case circuit-breakers", Part 1, "Miniature air-break circuit-breakers for a.c. circuits".

²⁾ BS 862, "Air-break circuit-breakers (including totally enclosed and flameproof types) for voltages not exceeding 660 volts".

1 Scope

This British Standard specifies requirements for a.c. voltage-operated earth-leakage circuit-breakers having rated voltages not exceeding 500 volts and rated currents not exceeding 200 amperes (see Appendix B, Appendix C and Appendix E).

2 Definitions

For the purposes of this British Standard the following definitions apply:

2.1

voltage-operated earth-leakage circuit-breaker (hereinafter referred to as circuit-breaker)

a device for making and breaking a circuit, and for breaking a circuit automatically when the potential difference between protected metal work of the electrical installation and the general mass of earth exceeds the values specified in Clause 12

2.2

number of poles

the number of main conducting paths which the circuit-breaker is required to open or close simultaneously

2.3

switched neutral

contacts not intended to make or break current and arranged to close before and open after the main contacts for the purpose of isolating the neutral

2.4

prospective current

the current (r.m.s. value of the a.c. component) that would flow in a circuit due to the applied voltage if the circuit-breaker were replaced by a link or links 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.

2.5

main contacts

the fixed and moving contacts in the main current-carrying circuit

2.6

auxiliary contacts

contacts working in conjunction with, and actuated by the circuit-breaker, and serving to control the operation of auxiliary devices such as trip coils or audible alarms

2.7

leakage trip coil

a coil energized directly by voltage between earth and the protected metal work and which directly or indirectly operates the mechanism when this voltage exceeds a specified value

2.8

mains-operated trip coil

a coil energized by the supply voltage controlled by a leakage trip coil (acting as a relay) to operate the mechanism

2.9

test device

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

2.10

rating of a circuit-breaker

the values assigned by the manufacturer to define the working conditions for which the circuit-breaker is made

2.11

applied voltage

the r.m.s. value of the voltage applied to a test circuit immediately before the initiation of current

3 Service conditions

(See Appendix A)

Voltage-operated earth-leakage circuit-breakers shall be suitable for use in the following conditions of service:

- 1) An ambient temperature not less than $-5\text{ }^{\circ}\text{C}$ and not exceeding $35\text{ }^{\circ}\text{C}$ and having an average value not exceeding $30\text{ }^{\circ}\text{C}$ measured over a 24-hour period.

NOTE Circuit-breakers complying with this standard may not be suitable for exposure to direct radiation from the sun or other sources of heat likely to raise temperature above the designated ambient.

- 2) An earth-loop impedance not exceeding 500 ohms.
- 3) An altitude not exceeding 2 000 m above sea level.
- 4) An atmosphere not subject to conditions giving rise to excessive pollution.

4 Rating

Circuit-breakers shall be rated in the following terms:

- 1) Number of poles.
- 2) Voltage.
- 3) Current.
- 4) Frequency.

5 Standard arrangements of poles

The following arrangements of poles shall be standard:

Single pole and switched neutral	} For single phase supply
Double pole	
Triple pole	} For three phase supply
Triple pole and switched neutral	
Four pole	

6 Standard voltage ratings

The voltage ratings contained in Table 1 shall be standard.

Table 1 — Voltage ratings

Standard voltage rating	Voltage to earth
240	240
415	240

7 Standard current ratings

The current ratings contained in Table 2 shall be standard.

Table 2 — Current ratings

Amperes
15
30
60
100
200

8 Frequency

The frequency for the purposes of this standard shall be 50 cycles per second.

NOTE Circuit-breakers having voltage, current or frequency ratings other than the values given in Clauses 6, 7 and 8 may be considered as standard provided that they comply in all other respects with the specification.

9 Marking

Circuit-breakers shall be marked indelibly with the following particulars:

- 1) Rated voltage.
- 2) Rated voltage to earth if other than 240 volts.
- 3) Rated current.
- 4) Frequency.
- 5) "A.C." or "~".
- 6) Manufacturer's name or distinguishing mark.

7) Manufacturer's type reference when more than one type is manufactured.

8) Country of manufacture.

9) BS 842.

10) The operation of the test device. (This shall be clearly indicated.)

When the marking is on a cover which is not sealed in position by the manufacturer the marking of the rated current shall also appear on the main body of the circuit-breaker.

10 Terminal identification

The terminals of the circuit-breaker shall be clearly and permanently marked for identification. When in addition, the design of the circuit-breaker is such as to make it necessary to distinguish between the line and load terminals, the former shall be indicated by arrows pointing towards the circuit-breaker and the latter by arrows pointing away from the circuit-breaker.

A diagram showing the correct method of connecting the circuit-breaker shall be formed on, or secured to, each circuit-breaker.

NOTE It is not intended that this diagram should take the form of an internal wiring diagram. It may be formed on the inside of a cover removable for installation purposes.

The following terminal markings shall be used:

Neutral	Frame	Earth
N	<i>f</i> or F or frame	<i>e</i> or E or earth
NOTE For clarity lower case letters <i>f</i> and <i>e</i> are desirable.		

11 Temperature rise

The temperature rise at specified locations in a circuit-breaker tested in accordance with Clause 21 shall not exceed the values given below:

- 1) Terminals of circuit-breakers fitted with copper contacts: 35 degC
- 2) Terminals of circuit-breakers fitted with contacts having adequate and durable facings of silver or similar materials not subject to progressive deterioration: 50 degC
- 3) Handles, operating devices and parts of enclosures likely to be handled when operating the circuit-breaker: 35 degC
- 4) Insulating material not likely to be handled in service, including that of the leakage trip coil: as given in Table 3

Table 3 — Temperature rise

Insulating material	Maximum temperature rise
	degC
Class Y	55
Class A	70
Class E	85
Class B	95
Class F	120
Class H	145

NOTE Details of insulating materials covered by the classes specified in Table 3 are contained in BS 2757, "Classification of insulating materials for electrical machinery and apparatus on the basis of thermal stability in service".

12 Earth-leakage performance

Circuit-breakers shall operate within the limits specified in Table 4 when tested in accordance with Clause 28.

Table 4 — Operating limits

External resistance in series with trip coil	Maximum voltage across trip coil and external resistance
ohms	volts
200	24
500	40

13 Test device

Circuit-breakers shall be provided with a test device which shall first open the connection between one side of the leakage trip coil and the frame terminal and then connect this side of the coil through a current limiting resistor to one of the line conductors.

The arrangement shall be such that the opening of the circuit-breaker shall automatically isolate the leakage trip coil from the incoming supply.

The connection between the leakage trip coil and the frame terminal shall automatically be restored when the operating means of the test device is released.

The test device shall ensure a reliable connection between the leakage trip coil and the frame terminal, and the contacts for this purpose shall be of silver or other metal not subject to progressive oxidation likely to cause an increase in contact resistance.

The closing force at each pair of contacts shall be not less than 1.1 N.

If ferrous springs are used they shall be of non-rusting steel or shall be coated with corrosion resistant material.

Any helical spring associated with the test device shall be in compression, and shall be so secured that in the event of breakage the separated parts shall not become detached and liable to make accidental contact with any live metal.

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.

The value of the current-limiting resistor shall be such that the test switch shall operate the circuit-breaker satisfactorily over the voltage range of 180 volts to 250 volts with a 500 ohm resistor in series with the leakage trip coil.

The value of this resistor shall also be such that when the circuit-breaker is tested at 200 volts with a 500 ohm resistor in series with the earth-leakage trip coil, the current through the trip coil shall not exceed the limits specified in clause 22.

NOTE For circuit-breakers intended for use on voltages to earth having values outside the normal voltage range of 200–240 volts the value of the current limiting resistors and test voltages should be modified accordingly.

14 Mains operated trip coils

Mains operated trip coils, when fitted, shall operate satisfactorily between the limits of 40 per cent and 110 per cent of the rated voltage of the trip coil.

15 Construction

Circuit-breaker enclosures shall be made of insulating material incapable of supporting combustion and shall be designed to withstand reasonably rough usage without fracture or permanent distortion. The enclosure for the mechanism shall either be sealed by the manufacturer to prevent access to the mechanism, or means shall be provided for such sealing.

Circuit-breakers shall be so constructed that, when fixed and wired as in normal use, there are no free openings³⁾ in their enclosures.

The operating handle or other external means of operation may be of insulating material or metal; if of metal, it shall be enclosed in a substantial casing of insulating material.

³⁾ Small gaps such as those between enclosures and conduits or cables may be neglected. Gaps between the covers and the operating means should be as small as practicable.

When the circuit-breaker is mounted as in actual service with all covers in place, live parts shall not be accessible to the standard test finger specified in BS 3042⁴⁾ without the use of a tool.

All metallic parts shall be either inherently resistant to or protected against atmospheric corrosion.

NOTE If, for reasons of mechanical or climatic protection, an additional metal enclosure is required, special precautions should be taken to guard against the possibility of the external case becoming live.

16 Operating mechanism

Circuit-breakers shall be arranged for manual closing and opening and automatic tripping under 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.

The ON and OFF positions of the circuit-breaker shall be clearly and specifically indicated. It shall be readily possible for the operator to distinguish whether the circuit-breaker is ON or OFF when it is mounted in the normal manner.

NOTE If push-buttons are used, the ON button remaining clearly in the depressed position is deemed to be sufficient indication of the circuit-breaker being ON.

It shall not be possible for the indicating device to assume the OFF position unless all moving contacts are also in the OFF position.

17 Connection arrangements

The terminal arrangements shall be such that the copper conductors specified in Table 5 shall be adequately accommodated and securely clamped.

Table 5 — Terminal capacities

Rating	To accommodate and clamp copper conductors of size		
	Main terminals		Earth and frame terminals
	Minimum	Maximum	
A	mm ²	mm ²	mm ²
15	1.0	6.0	2.5
30	2.5	10.0	2.5
60	6.0	25.0	2.5
100	16.0	50.0	2.5
200	50.0	95.0	2.5

Terminal screws shall thread into metal and if the conductors are secured by means of pinching screws, the ends of the screws shall be rounded and the arrangement shall be such as to prevent damage to the conductors.

Circuit-breakers intended for use without any additional enclosure shall have cable entries which will allow the introduction of the insulation and sheath of the cable.

18 Test requirements — 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 therefore recognized, namely type tests which shall be made on a representative sample or samples of each type of apparatus, and routine tests which shall be made on each circuit-breaker manufactured to this standard.

19 Test certificates

If specified when inviting tenders, certificates giving records of type tests on a circuit-breaker identical in all respects with the one being purchased shall be furnished by the manufacturer. Certificates of all type tests, with certified detailed drawings of the type of circuit-breaker, shall be held available by the manufacturer, together with a record of any alterations, whether essential or not, which have been made to the circuit-breaker since the tests.

20 Type tests

The manufacturer shall arrange for a recognized testing authority to make any type tests for which he himself is not equipped.

Type tests shall be made on a circuit-breaker in a clean new condition, at the rated supply frequency ± 10 per cent, and at an ambient temperature of between 20 °C and 25 °C.

The circuit-breaker shall be positioned and wired as in service. It shall be fixed to a metal support and the method of fixing shall comply with any requirements published by the manufacturer.

The following type tests shall be made:

- 1) Temperature rise test (Clause 21).
- 2) Operation of test device (Clause 22).
- 3) Endurance test (Clause 23).
- 4) Making and breaking test (Clause 24).
- 5) Through-current test (Clause 25).
- 6) Resistance to lightning surges (Clause 26).

⁴⁾ BS 3042, "Standard test finger (for checking protection against electric shock)".

21 Temperature rise test

The circuit-breaker under test shall be connected in a circuit in such a manner that the main contacts carry the rated current for the period necessary for the circuit-breaker to reach a steady temperature. For the purpose of this test *steady* temperature is defined as not changing by more than 1 degC in 30 minutes. The temperature rise shall not exceed the values specified in Clause 11.

Alternating current at rated frequency shall be used for this test.

Conductors shall be of the appropriate maximum size specified in Table 5, and each conductor shall be at least 0.6 m long.

The temperature rise of insulating material associated with the leakage trip coil shall be determined in the following manner:

The circuit-breaker shall be operated 10 times by applying a steadily rising test voltage to the leakage trip coil, the operating current being measured each time.

The average value of the operating current determined in this manner shall then be used as the test current for the purpose of a temperature rise test on the leakage trip coil.

The temperature rise test on the leakage trip coil shall be made simultaneously with the temperature rise test on the circuit-breaker.

NOTE During the temperature rise test it is necessary that the tripping mechanism be rendered inoperative.

22 Operation of the test device

A 500 ohm resistor shall be connected between terminal *e* and the outgoing N terminal. Operation of the test device shall trip the circuit-breaker when a test voltage of 180 volts is applied to the incoming terminals of the circuit-breaker. With the 500 ohm resistor still in circuit, and with a test voltage of 200 volts, the leakage trip coil current shall be measured. The value of this current shall not exceed 150 per cent of the average value of operating current, measured when the circuit-breaker is tested at the value of test voltage and corresponding resistance selected from Table 4 of Clause 12, which will allow the minimum current to flow.

With terminal *e* connected directly to outgoing N terminal, and with a voltage of 250 volts applied to the incoming terminals, the circuit-breaker shall be tripped by means of the test device 10 times at two-second intervals. After this test the circuit-breaker shall not have suffered any damage which would affect its future use.

23 Endurance test

Circuit-breakers shall be tested for endurance in accordance with Table 6 as follows:

- 1) by being switched on and off by the manual operating mechanism (see Table 6, Column 1);
- 2) by being switched on as above, but switched to the OFF position by means of the test device, a 500 ohm resistor being connected in series with the trip coil as in Clause 22 (see Table 6, Column 2).
- 3) by being switched on as above but switched to the OFF position by applying 30 volts to the trip coil connected in series with a 200 ohm resistor as in Clause 29 (see Table 6, Column 3).

At the conclusion of the test, the circuit-breaker shall not have suffered any appreciable damage and shall be in good working order. It shall comply with the requirements of Clause 29.

Table 6 — Endurance test sequence

Rating	1		2		3	
	Mechanical		Test switch		Number of applied faults	
	Cycles of operation	Rate	Cycles of operation	Rate	Cycles of operation	Rate
amp Up to and inc. 30	2 000	240 ± 30 cycles per hour	500	240 ± 30 cycles per hour	1 500	240 ± 30 cycles per hour
Above 30 and up to and inc. 100	1 000	240 ± 30 cycles per hour			500	240 ± 30 cycles per hour
Above 100 and up to and inc. 200	500	120 ± 15 cycles per hour	500	120 ± 30 cycles per hour	200	120 ± 15 cycles per hour

During the test, each pole of the circuit-breaker shall carry rated current at rated voltage ± 5 per cent (power factor 0.7 to 0.8 lagging).

At the conclusion of the test the circuit-breaker shall not have suffered any appreciable damage. It shall, without reconditioning, be capable of making and breaking its rated current at rated voltage. It shall also be capable of carrying rated current with a temperature rise measured at wiring terminals not greater than 10 degC in excess of the temperature rise permitted for the circuit-breaker in a clean new condition.

24 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 one minute interval between each cycle of operation.

During the test, each pole of the circuit-breaker shall carry six times rated current at rated voltage ± 5 per cent (power factor unity).

At the conclusion of the test the circuit-breaker shall be in working order and shall comply with the requirement of Clause 29.

25 Through current test

Double-pole circuit-breakers shall be connected as shown in Figure 1; circuit-breakers with other numbers of poles being connected in a schematically similar manner. Each pole of the circuit-breaker shall be connected in series with a silver wire fuse 85 mm long and having a silver content of not less than 99.9 per cent. Each fuse shall be mounted horizontally in free air.

A test at the prospective current values given in Table 7 at rated voltage ± 5 per cent shall be applied (power factor shall be approximately unity) to the combination of silver wire fuses and circuit-breaker, the diameter of the silver wire having the value given in Table 7. This test shall be repeated six times at one-minute intervals, the silver wire fuses being renewed between tests.

Where overcurrent protection is incorporated it should be rendered inoperative during the through-current test.

At the conclusion of the test the circuit-breaker shall be in working order and shall comply with the requirements of Clause 29.

Table 7 — Prospective-current values

Amperes	Diameter of silver wire	Prospective current
	mm	amp
Up to and including 30	0.85	1 500
Over 30	1.2	3 000

26 Resistance to lightning surges

The circuit-breaker shall be connected to an impulse generator as shown in Figure 2. Generating capacitor C1 shall have a capacitance of 3 microfarads; wave-front capacitor C2 shall have a capacitance of 0.001 microfarad; and resistor R1 shall have a resistance of 1 500 ohms.

The impulse generator spark gap SG1 shall be set to discharge C1 at approximately 5 kV.

Ten impulses shall be applied to the frame terminal of the circuit-breaker with an interval of 2 minutes between each impulse.

At the conclusion of the test the circuit-breaker shall be in working order and shall comply with the requirements of Clause 29.

27 Routine tests

Each circuit-breaker shall withstand the following routine tests:

- 1) Performance test (Clause 28).
- 2) Speed of operation (Clause 29).
- 3) Performance of test device (Clause 30).
- 4) Mains voltage test on tripping device (Clause 31).
- 5) High-voltage test (Clause 32).

28 Performance test

With the circuit-breaker fully closed and one end of a resistor connected to terminal *e*, the appropriate test voltage shall be applied between terminal *f* and the other end of the resistor. The circuit-breaker shall open.

For this test the values of the test voltage and corresponding resistance shall be those from Table 4 which will allow the minimum current to flow.

The test shall be repeated with the contacts of the circuit-breaker just touching and the test voltage raised gradually to the selected value. The circuit-breaker shall open.

29 Speed of operation

With one end of a 200 ohm resistor connected to terminal *e*, 30 volts r.m.s. shall be applied between terminal *f* and the other end of the resistor. The circuit-breaker shall open within 0.1 second.

30 Performance of test device

With the circuit-breaker fully closed and with a resistor of 500 ohms connected between terminals *e* and N, a test voltage of any convenient value not exceeding 250 volts shall be applied to the incoming terminals. The circuit-breaker shall open when the test device is operated.

31 Mains voltage test on tripping device

Terminal *f* shall be connected to an outgoing line terminal, and terminal *e* shall be connected to the outgoing N terminal. With the circuit-breaker closed, a voltage of 250 volts shall be applied to the corresponding incoming line and N terminal to trip the circuit-breaker. The test shall be made three times.

The circuit-breaker shall withstand the tests without such damage as would affect its normal operation.

32 High-voltage test

The circuit-breakers shall withstand a test voltage of 2 000 volts r.m.s. which shall be applied momentarily as follows:

- 1) between all incoming terminals with the circuit-breaker closed;
- 2) between all incoming terminals and terminal *e* with the circuit-breaker closed;
- 3) between all incoming terminals and the corresponding outgoing terminals with the circuit-breaker open;
- 4) between terminals 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.

The test voltage shall be alternating and of any available frequency between 25 cycles per second and 100 cycles per second and approximately of sine-wave form.

Appendix A Service conditions

Under normal conditions of service there are natural atmospheric variations of temperature, and hence the maximum temperature occurs only occasionally during the hot season, and on those days when it does occur it does not persist for long periods.

Meteorological records indicate that temperatures at least 10 degC below the maximum temperature will occur within the same 24 hour period, and that the average temperature taken over any 24 hour period will be at least 5 degC below the maximum value. The requirements of Clause 3 are based on these conditions. When, however, the normal conditions of service do not comply with those stated above and are such that the cooling air remains at a practically steady temperature, the ratings assigned to the apparatus only apply when this temperature does not exceed 30 °C.

As moderate changes in ambient temperature do not materially affect the temperature rise of the apparatus it may be measured at the normal temperature of the test room.

Local atmospheric and climatic conditions. In some situations atmospheric conditions are particularly unfavourable to electrical equipment on account of dust, smoke, chemical fumes, salt-laden spray, high humidity, etc. Where such adverse conditions are known to exist the manufacturer should be notified in order that special consideration may be given to the design of the parts of the circuit-breaker normally exposed to the atmosphere.

Appendix B Application of earth-leakage circuit-breakers

Voltage-operated earth-leakage circuit-breakers are intended to be used where it is not practicable to meet the requirements of the Wiring Regulations of the Institution of Electrical Engineers by direct earthing, or alternatively, where additional protection is desirable.

Voltage-operated units are designed to give protection against earth-leakage shock risk and provided that the method of installation is in accordance with Appendix C they will perform this function. Should connections other than that through the earth-leakage circuit-breaker exist between protected metalwork and earth, and provided that the circuit-breaker is correctly installed it will operate in the event of the leakage being such as to cause a dangerous rise of voltage on the protected metal work.

The value of leakage current required to produce operation of the earth-leakage circuit-breaker under these circumstances will depend upon the impedance of the parallel earth connection, in relation to the other impedances in the earth fault circuit. If the only connection to earth is through the earth-leakage circuit-breaker, leakage currents of the order of 50 mA will produce immediate isolation.

As earth-leakage currents may introduce a fire risk, a correctly installed voltage-operated earth-leakage circuit-breaker provides a measure of protection against such risk.

Attention is directed to the need for periodical inspection and test (e.g. not less than once in three months).

Appendix C Method of installation

The correct way to connect earth-leakage circuit-breakers is shown in Figure 3. The first important point to note is that the earth leakage circuit-breaker earth electrode must be out of the effective resistance area of any parallel earth paths on the installation. Secondly, the earthing lead from terminal *e* to this electrode must be an insulated one. Both these fundamental requirements are laid down in IEE Wiring Regulations and are intended to prevent the trip coil being short-circuited as this would render the earth-leakage circuit-breaker ineffective.

The IEE requirement that the earth-leakage circuit-breaker earth electrode be sited outside the effective resistance area of other earthed metalwork is not normally too difficult to meet in practice. From Figure 4, it is clear that, with a 2 m rod electrode, about 90 per cent of the total voltage to earth is dropped in the first 2.5 m of adjacent soil. The tripping voltage limits specified in this British Standard are 24 V to earth if the earth-leakage circuit-breaker earth electrode has a resistance of 20 ohms; and 40 V if it has a resistance of 500 ohms. Thus, if the earth-leakage circuit-breaker earth electrode has a resistance of 200 ohms and is so situated that only 80 per cent of the total voltage is detected, anything more than 30 volts between installation metal work and earth will cause the earth-leakage circuit-breaker to trip. With a 500 ohms electrode, in practice an extremely high figure, anything more than 50 V would be reliably detected. It is clear that an acceptable level of shock-risk protection will be afforded, provided the earth-leakage circuit-breaker earth electrode is out of the immediate vicinity of other earthed metalwork. This point should normally be checked by an electrical test, but a separation distance of 2.5 m to 3 m should be adequate.

When installing an earth-leakage circuit-breaker earth electrode, care must be taken to avoid using any metalwork which may in the future become electrically linked to the installation metalwork, as this would short-circuit the trip coil. An example of this would be the addition of an immersion heater to an installation in which the incoming metal water pipe had been used as the earth-leakage circuit-breaker earth electrode. For this reason the use of water pipes as the earth electrode is deprecated. If a separate earth-leakage circuit-breaker electrode properly isolated from other metalwork had been used, the immersion heater would simply provide a parallel connection between installation metalwork and earth and the level of the shock risk protection would remain virtually unaltered.

Appendix D Function of the test device

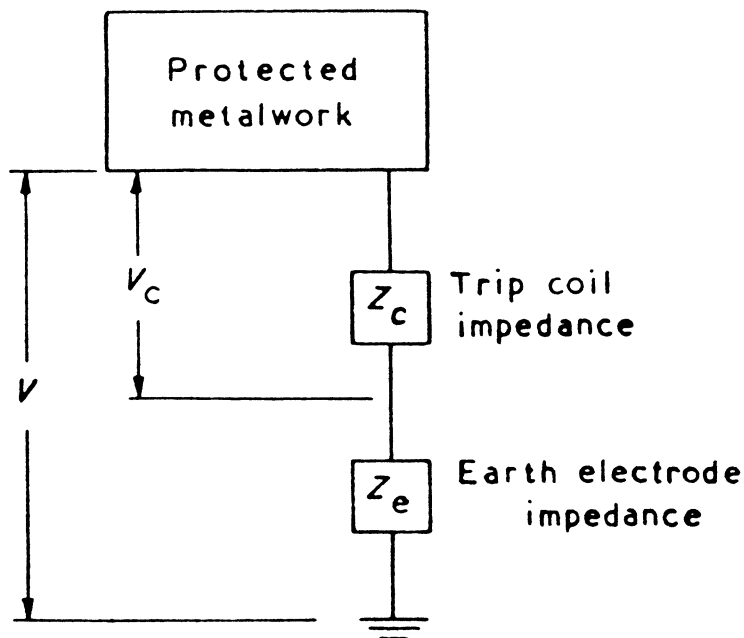
A test device is provided to enable the protective function of the circuit-breaker to be checked. Operation of this device first disconnects the trip coil from the frame terminal and then connects this coil through a test resistor to one of the outgoing line terminals. This action avoids applying a dangerous potential to the protected metalwork during the test.

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

- 1) The supply is correctly connected to the line and neutral terminals of the circuit-breaker.
- 2) The circuit containing the test resistor, test-device contacts, trip-coil and circuit-breaker earth-electrode is continuous and the earth-electrode resistance is not too high.
- 3) 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 the continuity of the earth continuity conductor (Figure 3) connecting the installation metal work to the frame terminal *f*, nor does it check for a condition where by the trip coil is short-circuited (see Appendix C).

Appendix E Effect of earth-electrode resistance



The shock-risk voltage V exists across a circuit consisting of the trip-coil impedance Z_c and the earth-electrode impedance Z_e in series between the protected metalwork and earth. The portion of this voltage available to trip the circuit-breaker is

$$V_c = \frac{Z_c}{Z_c + Z_e} \cdot V$$

It follows that increasing the value of Z_e will increase the value of V necessary to trip the circuit-breaker, for example if the trip-coil can be regarded as a resistance of 250 ohms and its operating voltage is 10 volts, then with an earth electrode resistance of 200 ohms the shock-risk voltage should be 18 volts. If the earth electrode resistance increased to 500 ohms the shock-risk voltage would become 30 volts.

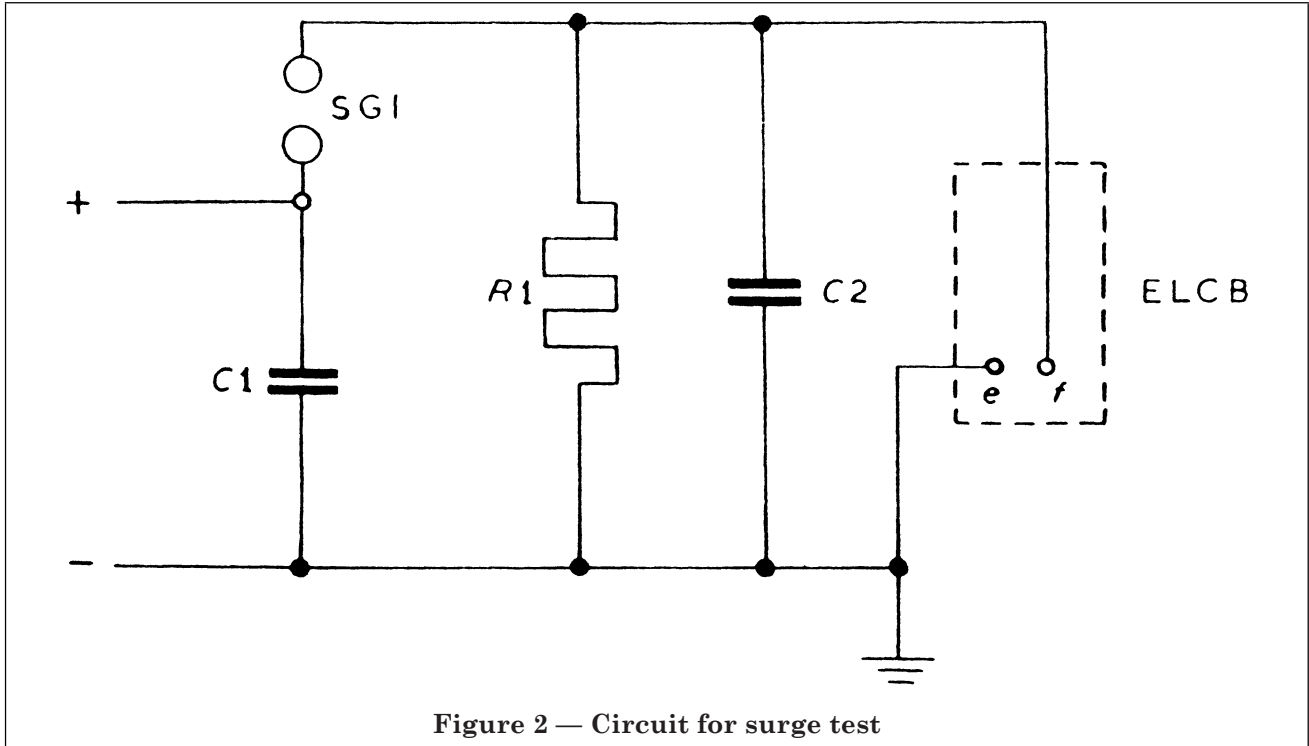
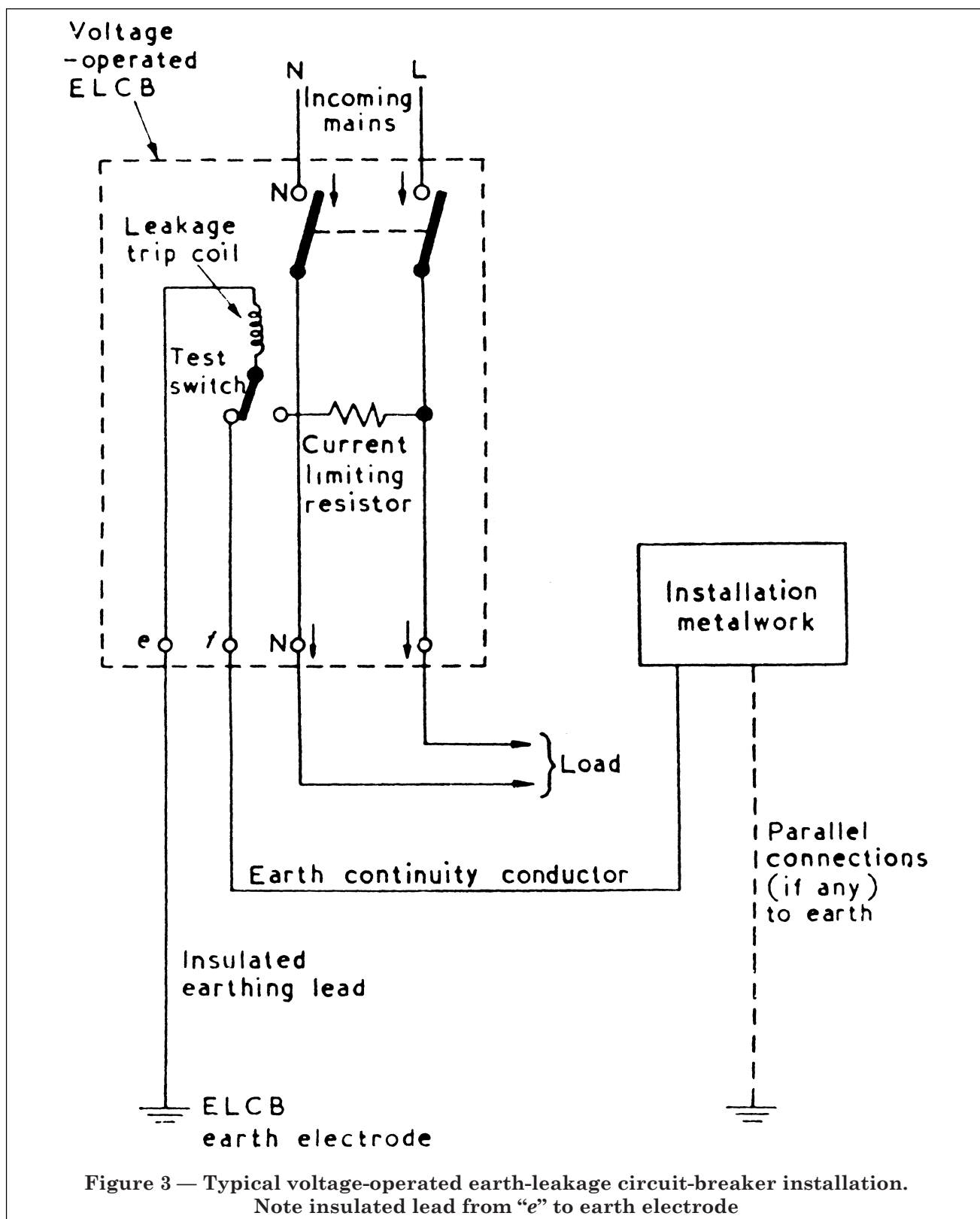


Figure 2 — Circuit for surge test



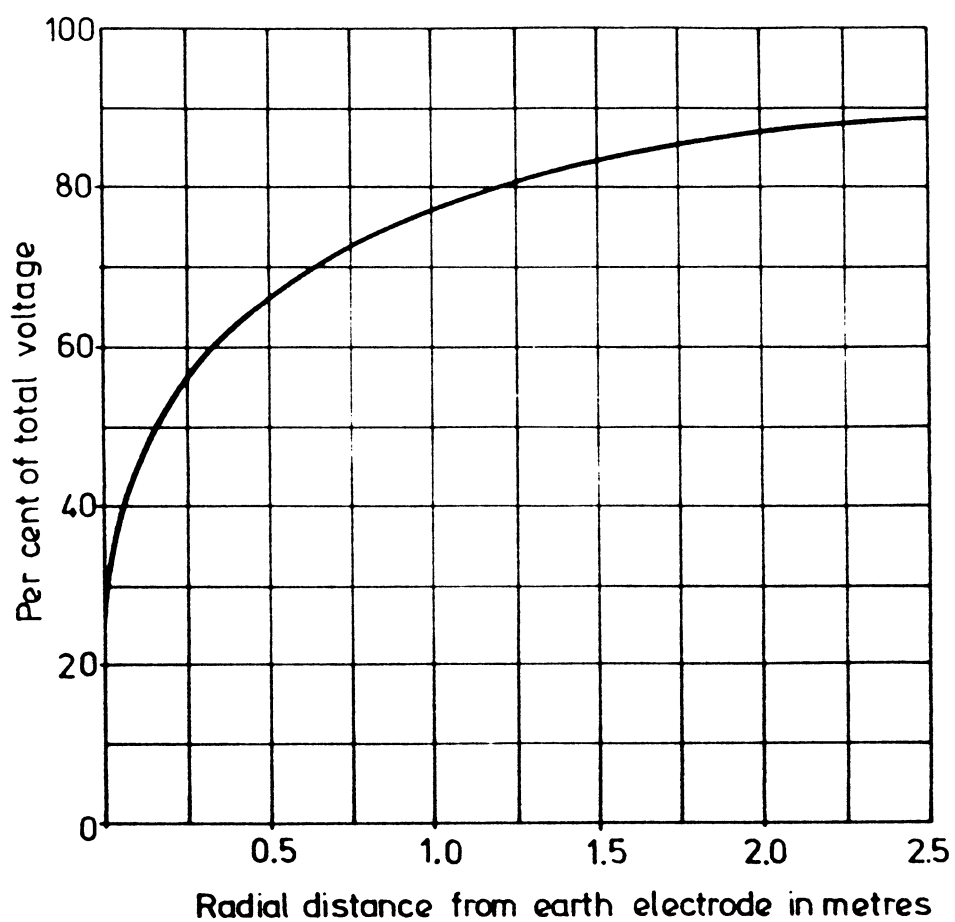


Figure 4 — Typical voltage distribution in soil surrounding a 2 m rod electrode

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: 020 8996 9000. Fax: 020 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: 020 8996 9001. Fax: 020 8996 7001.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: 020 8996 7111. Fax: 020 8996 7048.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: 020 8996 7002. Fax: 020 8996 7001.

Copyright

Copyright subsists in all BSI publications. BSI also holds the copyright, in the UK, of the publications of the international standardization bodies. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI.

This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols, and size, type or grade designations. If these details are to be used for any other purpose than implementation then the prior written permission of BSI must be obtained.

If permission is granted, the terms may include royalty payments or a licensing agreement. Details and advice can be obtained from the Copyright Manager. Tel: 020 8996 7070.