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SPECIFICATION FOR CURRENT-OPERATED EARTH LEAKAGE CIRCUIT BREAKERS

BUREAU OF CEYLON STANDARDS

SPECIFICATION FOR CURRENT-OPERATED EARTH LEAKAGE CIRCUIT BREAKERS (RESIDUAL CURRENT TYPE)

SLS 548 : 1982

Gr. 13

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SPECIFICATION FOR CURRENT-OPERATED EARTH LEAKAGE CIRCUIT BREAKERS (RESIDUAL CURRENT TYPE)

FOREWORD

This Sri Lanka Standard Specification was authorized for adoption and publication by the Council of the Bureau of Ceylon Standards on 1982-01-28,after the draft, finalized by the Drafting Committee on Current-Operated Earth Leakage Circuit Breakers, had been approved by the Electrical Engineering Divisional Committee.

This specification was prepared to standardize a device which is being used in domestic, commercial and industrial installations as one means of providing earth leakage protection.

The current-operated earth leakage circuit breakers which incorporate over current protection shall comply with the requirements of this specification and also with the relevant requirements given in the Publication 157-1 of the International Electrotechnical Commission (IEC).

All values in this specification are in SI units.

For the purpose of deciding whether a particular requirement of this specification is complied with, the final value, observed or calculated, expressing the result of a test or observation shall be rounded off in accordance with CS 102. The number of figures to be retained in the rounded off values shall be the same as that of the specified value in this specification.

In the preparation of this specification, the assistance derived from the publications of the International Electrotechnical Commission, British Standards Institution and Singapore Standards Institution is gratefully acknowledged.

1 SCOPE

This specification applies to a.c, current-operated earth leakage circuit breakers with or without overload tripping devices rated at voltages not exceeding 600 V and at currents preferably not exceeding 100 A at 50 Hz.

2 REFERENCES

IEC 85 Recommendations for the classification of materials for the insulation of electrical machinery and apparatus in relation to their thermal stability in service

IEC 157-1 Low-voltage switch gear and control gear

SLS 278 Standard test fingers and other accessibility probes

3 TERMINOLOGY

For the purpose of this specification the following definitions shall apply:

3.1 current-operated earth leakage circuit breaker: (Hereinafter referred to as e.l.c.b.) A device for making and breaking a circuit and for breaking a circuit automatically when the vector sum of the currents in all conductors feeding the circuit controlled by the e.l.c.b. differs from zero by a predetermined amount. For the purpose of this specification the term e.l.c.b. includes both the mechanism for interrupting the circuit and also any associated earth leakage sensing devices.

3.2 number of poles: The number of main conducting paths which the e.l.c.b. is required to open or close simultaneously.

3.3 rated tripping current: The nominal value of the out of balance current at which the e.l.c.b. will trip without intentional time delay under the prescribed conditions.

3.4 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 each pole of the e.l.c.b. were replaced by a link of negligible impedence but without any other circuit change.

NOTE - For the purpose of this definition the term e.l.c.b. includes the short length of cables used to connect the e.l.c.b. to the test circuit.

3.5 main contacts: The fixed and moving contacts in the main current carrying circuit.

3.6 rating of an e.l.c.b.: The values assigned by the manufacturer to define the working conditions for which the e.l.c.b. is made.

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

3.8 power operated trip coil: The operating coil if a power-operated tripping device to which the voltage is applied by a leakage trip coil (acting as a relay) for the purpose of tripping the e.l.c.b.

3.9 test facility: A device to enable the protective function of the e.l.c.b. to be checked.

3.10 type tests: Type tests are intended to prove that the quality and design of given type of e.l.c.b. are in accordance with this specification.

3.11 routine tests: Routine tests are made on all current operated e.l.c.b. to check that the e.l.c.b. are satisfactory in regard to certain requirements.

3.12 operating tripping time: The sum of the time interval between the application of the test current and the instant of contact separation and the arcing time.

3.13 trip free mechanism: An e.l.c.b. mechanism in which the moving contacts return to and remain in the open position when the 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 momentorily reach the closed position.

4 OPERATING CONDITIONS

4.1 Standard service conditions

An e.l.c.b. complying with this recommendation shall be capable of operating under the following standard conditions.

4.2 Ambient temperature

The ambient air temperature does not exceed + 40 °C and its average over a period of 24 hours does not exceed + 35 °C. The lower limit of the ambient air temperature is 10 °C.

4.3 Atmospheric conditions

The air is clean and its relative humidity does not exceed 96 per cent.

5 RATING

An e.l.c.b. shall be rated in terms of the following:

a) Number of poles ;

b) Voltage ;

c) Current ;

d) Tripping current ; and

e) Frequency.

6 ARRANGEMENT OF POLES

The arrangement of poles shall be one of the following:

Double pole - For single phase supply
Triple and solid neutral - For three phase supply

7 VOLTAGE RATINGS

The e.l.c.b. may be rated for voltages up to 600 V. The preferred voltage ratings are as given in Table 1.

TABLE 1 - Preferred voltage ratings

Voltage rating (V)	Voltage to earth (V)
230	230
400	230

8 CURRENT RATINGS

The e.l.c.b. may be rated at any current not exceeding 100 A. The preferred current ratings are 15, 30, 60, and 100 A.

9 RATED TRIPPING CURRENTS

The rated tripping current of the e.l.c.b. shall be less than one ampere. The preferred tripping currents are 6, 10, 30, 100, 300, and 500 mA.

10 RATED FREQUENCY

The rated frequency shall be 50 Hz.

11 MARKING

The following data for the e.l.c.b. shall be indelibly marked.

a) Rated Voltage ;
b) Rated Current ;
c) Rated Tripping Current ;
d) Rated Frequency ;
e) Degree of Protection ;

f) Manufacturer's name or Trade Mark ;
g) Manufacturer's type reference ;(where more than one type is manufactured)
h) Country of manufacture ;
j) The operation of the test device; and (This shall be clearly indicated)
k) Terminal identification. (This shall be clearly and permanently marked).

12 DESIGN AND CONSTRUCTION

12.1 Enclosure

Enclosure shall be manufactured according to the standard degrees of protection. (see Appendix D).

12.2 Encapsulation

Where any component of the e.l.c.b. is encapsulated, the encapsulating medium shall not flow during any test required by this specification.

12.3 Corrosion protection

All metallic parts shall be either inherently resistant or protected against atmospheric corrosion and deterioration due to condensation.

12.4 Provision for earthing

If there are any exposed non-current carrying metal parts effective earthing shall be provided. Earthing terminals shall be of brass or any suitable non-rusting materials.

12.5 Temperature rise

The temperature rises of the several parts of a e.l.c.b. measured during a test carried out under the conditions specified in 13.3.1 shall not exceed the limiting values stated in Table 2 and Table 3.

TABLE 2 - Temperature rise limits for insulated coils in air

Class of insulating material	Temperature rise limits (^{o}C)
A	85
E	100
B	110
F	135
H	160

NOTE - The classification of insulation is that given in Section II of IEC Publication 85.

TABLE 3 - Temperature rise limits for the various materials and parts

Type of material Description of part	Temperature rise-limit
Contact parts in air	
- Copper	45 °C
- Silver or silver faced	See note 1
- All other metals or sintered metals	See note 2
Metallic parts acting as springs	See note 3
Metallic parts in contact with insulating material	See note 4
Terminals for external insulated connections	70 °C
Manual operating means	
- Parts of metal	15 °C
- Parts of insulating material	25 °C

NOTES:

1 Limited solely by the necessity of not causing any damage to adjacent parts.

2 To be specified according to the properties of the metals used and limited by the necessity of not causing any damage to adjacent parts.

3 The resulting temperature shall not reach a value such that the elasticity of the material is impaired. For pure copper, this implies a total temperature not exceeding 75 °C.

4 Limited solely by the necessity of not causing any damage to insulating materials.

12.6 Provision for testing facility

An integral test device shall be incorporated in the e.l.c.b. to test the automatic tripping of the e.l.c.b. The test device shall be arranged for external operation and it shall return to the normal position when released.

The test device shall excite the current balance transformer or transformers. The exciting ampere-turns produced by the test device shall not exceed twice the exciting ampere-turns produced by rated tripping current following 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 e.l.c.b. (see Appendix A for the function of the test device).

12.7 Power operated trip coils

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

12.8 Operating mechanism

The e.l.c.b. shall be arranged for manual closing and opening and automatic tripping under earth fault conditions. An automatic release machanism shall be provided to open the circuit breaker independently of the means used to close it. The operating mechanism of the e.l.c.b. shall be trip free.

The *ON* and *OFF* positions of the e.l.c.b. shall be clearly and specifically indicated. It shall be readily possible for the operator to distinguish whether the e.l.c.b. is *ON* or *OFF* when it is mounted in the normal manner.

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

NOTE - If push buttons are used, the 'ON' button remaining clearly in the depressed position is deemed sufficient indication of the e.l.c.b. being 'ON'.

12.9 Terminal arrangement

The terminal arrangements shall be adequate to accomodate the current carrying conductors taking into consideration the ratings of the e.l.c.b. The current carrying conductors shall be securely clamped and once terminated, it shall not be possible to loosen these terminals except by the use of tools.

Terminals, screws and securing devices shall not damage the current carrying conductors.

The identification of terminals shall be clearly and indelibly marked to distinguish the incoming and outgoing circuit terminals.

13 GENERAL NOTES ON TESTS

13.1 There shall be two types of tests namely type tests which shall be made on samples of each type of apparatus and routine test which shall be made an each e.l.c.b. manufactured to this specification.

13.2 Unless otherwise specified, the samples shall be tested as delivered and installed as in normal use, at the operating conditions specified in 4 and at rated frequency.

13.3 Type tests

A sample e.l.c.b. shall be subjected to the following test duty sequence.

a)	Temperature rise test ;	(13.3.1)
b)	Transformer balance test ;	(13.3.2)
c)	Making and breaking test ;	(13.3.3)
d)	Temperature rise check ;	(13.3.4)
e)	Endurance test ;	(13.3.5)
f)	High-current earth leakage test ;	(13.3.6)
g)	Through-current test ;	(13.3.7)
h)	Earth leakage operation ;	(13.4.2)
j)	Speed of operation ;	(13.4.3)
k)	Performance test of test facility ;	(13.4.4)
l)	Degree of protection ;	(13.4.6)
m)	High voltage test ;	(13.4.1)
n)	Insulation test ; and	(13.4.5)
p)	Measurement of test facility ampere-turns.	(13.3.8)

NOTE - A fresh sample shall be subjected for the measurement of test facility ampere-turns.

13.3.1 *Temperature rise test*

The e.l.c.b. under test shall be so arranged that the main contacts carry the rated current for the period necessary for the e.l.c.b. to reach a steady temperature. For the purpose of this test steady temperature is defined as not changing by more than 1 °C in 30 minutes. The temperature rises shall not exceed the values specified in **12.5.**

13.3.2 *Transformer balance test*

The e.l.c.b. shall be closed three times on to a circuit such that each pole carries twice rated current, at any convenient test voltage. The e.l.c.b. shall not trip. The test current shall be maintained for 5 s. (see Appendix **B** regarding the purpose of the transformer balance test).

13.3.3 *Making and breaking test*

The e.l.c.b. 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 one minute interval between each cycle of operations.

During the test each pole of the e.l.c.b. shall carry six times rated current at rated voltage ± 5 per cent (power factor unity).

At the conclusion of the test the e.l.c.b. shall be in good working order and shall comply with the requirements of **13.4.3.**

NOTE - Automatic tripping is permissible.

13.3.4 *Temperature rise check*

The e.l.c.b. shall successfully pass a temperature rise check made, in accordance with the conditions of test specified in 13.3.1.

The e.l.c.b. shall be deemed to have failed the test if it trips automatically during the test or if the temperature rise at the terminals, in the steady state, exceeds by more than 10 °C the temperature rise permitted in the clean new conditions. (See 12.5).

13.3.5 *Endurance test*

The e.l.c.b. shall be tested for endurance in accordance with the test sequence of Table 4.

a) By being switched *ON* and *OFF* by the manual operating mechanism (see Table 4 Column 1).

b) By being switched on manually and switched off by means of the test device (see Table 4 Column 2).

c) By being switched on manually and switched off by establishing an out of balance current equal to twice the rated tripping current (see Table 4 Column 3).

One cycle of operation is to consist of approximately 2 s *ON* and 13 s *OFF*.

TABLE 4 - Endurance test sequence

Rating Amperes (A)	1		2		3	
	MANUAL		TEST FACILITY		OUT OF BALANCE	
	Cycles of operation	Rate	Cycles of operation	Rate	Cycles of operation	Rate
Up to and including 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 including 100	1 000		500		500	

During the test each pole of the e.l.c.b. shall carry rated current at rated voltage ± 5 per cent (power factor 0.7 to 0.8 lagging).

At the conclusion of the test e.l.c.b. shall now have suffered any appreciable damage and shall be in good working order. It shall comply with the requirements of 13.4.3.

13.3.6 *High current earth leakage test*

A test at a prospective current of 500 A (250 A for e.l.c.b. rated at 15 A or below) at any convenient voltage shall be applied three times at one minute interval to each pole of the e.l.c.b. in turn. The e.l.c.b. shall operate satisfactorily each time.

At the conclusion of the test the e.l.c.b. shall be in good working order and shall comply with the requirements of **13.4.2**.

13.3.7 *Through current test*

This test is intended to check the ability of the e.l.c.b. 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. Double-pole e.l.c.b. shall be connected as shown in **Fig. 1** and e.l.c.b. with a greater number of poles shall be connected in a schematically similar manner. Each pole of the e.l.c.b. shall be connected in series with a silver wire fuse 85 mm long 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 value given in Table 5 at rated voltage ± 5 per cent (unity power factor) shall be applied to the combination of silver wire fuses and e.l.c.b., the diameter of the silver wire having the value given in Table 5.

The test shall be repeated six times at one minute intervals, the silver wire fuses being renewed for each test. Automatic tripping of the e.l.c.b. is permissible during this test.

At the conclusion of the test the e.l.c.b. shall be in good working order and shall trip when the test device is operated with rated voltage applied.

NOTE - Where e.l.c.b. fitted with over current releases, the test is not applied. (see Appendix C).

TABLE 5 - Prospective current values

Rated current (A)	Diameter of silver wire (mm)	Prospective current (A)
Up to and including 30	0.85	1 500
Over 30	1.2	3 000

13.3.8 *Measurement of test facility ampere turns*

Compliance with the requirements of **12.8** shall be checked in the following manner.

The e.l.c.b. shall be connected in a circuit at rated voltage ± 5 per cent and the exciting ampere-turns produced by the test device shall be determined.

During the measurement the tripping mechanism be rendered inoperative.

13.4 Routine tests

Every e.l.c.b. shall pass the following routine tests.

a) High voltage test; **(13.4.1)**

b) Earth leakage operation; **(13.4.2)**

c) Speed of operation; **(13.4.3)**

d) Performance of test facility; and **(13.4.4)**

e) Insulation test. **(13.4.5)**

13.4.1 *High voltage test*

e.l.c.b. shall withstand a test voltage of 2 000 V r.m.s. which shall be applied for 1 min as follows.

a) Between all incoming terminals with the e.l.c.b. closed. Connections to auxiliary devices, such as shunt trips or under voltage releases, may be removed for this test, provided that such device are not connected between incoming and outgoing terminals.

b) Between all incoming terminals and the earth terminals (if fitted) with the e.l.c.b. closed.

c) Between all incoming terminals and the corresponding outgoing terminals with the e.l.c.b. open.

d) Between terminals and any other metal parts unearthed and exposed in service. Small metal parts such as labels, rivets and name-plates, 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 Hz and 100 Hz and approximately of sine wave form.

NOTE - No flashover or breakdown shall occur during the test. Glow discharges without drop in voltage are neglected.

13.4.2 *Earth leakage operation*

With the e.l.c.b. fully closed, a test current shall be increased gradually in each pole in turn. The e.l.c.b. shall operate within the limits of 50 per cent and 100 per cent of the rated tripping current. Where e.l.c.b. fitted with a delibrate time delay device the lower limit of 50 per cent does not apply.

The test shall be repeated with the contacts of the e.l.c.b. just touching, unless the e.l.c.b. has a quick-make mechanism.

13.4.3 *Speed of operation*

Rated tripping current shall be switched on to each pole in turn. In each case the e.l.c.b. shall open within 0.1 s.

13.4.4 *Performance of test facility*

With the e.l.c.b. fully closed and connected to a supply at 0.85 times rated voltage ± 5 per cent, the test device shall be operated. The e.l.c.b. shall open within 0.1 s.

13.4.5 *Insulation test*

The insulation resistance shall be measured, with a direct voltage not less than 500 V applied the measurement being made 5 s after application of the voltage for following parts.

a) Between live terminals and any metal parts which would be exposed to personal contact when the e.l.c.b. is in its normal operating position. The e.l.c.b. shall be in the *ON* position.

b) Between incoming terminals and outgoing terminals with the e.l.c.b. in the *OFF* position.

c) Between all live terminals with the e.l.c.b. in the *ON* position.

The insulation resistance values shall not be less than 10 M Ω

13.4.6 *Degree of protection*

Conformity to the code of degree of protection marked on the sample shall be checked by subjecting the sample to the appropriate test(s) given under D.6 or D.7.

APPENDIX A

FUNCTION OF THE TEST DEVICE

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

Tripping the e.l.c.b. by means of the test device establishes the following:

a) The integrity of the electrical and mechanical elements of the tripping device.

b) The e.l.c.b. 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 earthing load, the earth continuity conductor the earth electrode or any other part of the line to earth circuit.

APPENDIX B

TRANSFORMER BALANCE TEST

In the ideal case if the primary windings each had the same number of turns, and the vector sum of 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 e.l.c.b. there may be sufficient inherent unbalance between the windings to cause the e.l.c.b. 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 as may be encountered in practice.

APPENDIX C

BACK-UP PROTECTION

The basic function of an e.l.c.b. is to protect against earth faults. Protection against overloads and short-circuit faults is usually provided by means of another circuit protective device, such as a fuse which is connected in series with the e.l.c.b. The second device is then said to provide back-up protection for the e.l.c.b.

In practice, the functions of these two protective devices may tend to overlap, and in certain fault conditions both devices may attempt to clear the fault. This may occur, for example, by a severe earth-fault producing a current akin to short-circuit currents; or by a short-circuit fault and an earth fault occurring simultaneously; or by the inherent out-of-balance in the primary windings of the balance transformer, (see Appendix B), causing the e.l.c.b. to trip on heavy overloads or short-circuit.

This Sri Lanka Standard therefore incorporates a number of tests, such as the making and breaking test at six times rated current; the high-current earth-leakage test and the through-current test to ensure satisfactory operation in such conditions.

Alternatively, the e.l.c.b. may itself incorporate overcurrent and short-circuit protection features, in which event the e.l.c.b. is also tested to the relevant requirements of IEC 157-1.

APPENDIX D

DEGREES OF PROTECTION OF ENCLOSURES

D.1 GENERAL

This Appendix covers the following: standard degrees of protection provided by enclosures, as regards;

a) protection of persons against contact with live or moving parts inside the enclosure and protection of equipment against ingress of solid foreign bodies,

b) protection of equipment against ingress of liquid,

- marking regarding these degrees of protection.

- tests to be performed to prove that the equipment meets the requirements of this Appendix.

This Appendix does not apply to special degrees of protection, of equipment in an explosive atmosphere. Such equipment must comply with the recommendations prepared by IEC. Technical Committee No. 31 Electrical apparatus for explosive gas atmospheres. Neither does it cover protection against other unusual service conditions such as fungus and corrosive vapours.

This Appendix is intended to serve as a guide to the requirements for protective enclosures. The tests, however, are applicable only where practicable and where agreed between manufacturer and user.

The effects of stresses occurring during short-circuit operations are not covered by this Appendix.

D.2 MARKING

Markings used to indicate the degree of protection consist of the letters IP, followed by two characteristic numerals signifying respectively conformity to the codes described in **D.3.** and **D.4.**

The first characteristic numeral designates the degree of protection of persons against contact with live or moving parts inside the enclosure and of equipment against ingress of solid foreign bodies.

NOTE - A single characteristic numeral is used to designate the two means of protection mentioned above since it is understood that protection against ingress of solid foreign bodies implies a certain amount of protection of persons against contact with live or moving parts inside the enclosure and vice versa.

The second characteristic numeral designates the degree of protection against ingress of liquid.

D.3 PROTECTION OF PERSONS AGAINST CONTACT WITH LIVE OR MOVING PARTS INSIDE THE ENCLOSURE AND PROTECTION OF EQUIPMENT AGAINST INGRESS OF SOLID FOREIGN BODIES

Protection against contact with moving parts inside the enclosure is limited to contact with moving parts inside the enclosure which might cause danger to persons.

First characteristic numeral	Degree of protection
0	No protection of persons against contact with live or moving parts inside the enclosure. No protection of equipment against ingress of solid foreign bodies.
1	Protection against accidental or inadvertent contact with live or moving parts inside the enclosure by a large surface of the human body, for example, a hand but not protection against deliberate access to such parts. Protection against ingress of large solid foreign bodies. See degree of protection 1, **D.6**.
2	Protection against contact with live or moving parts inside the enclosure by fingers. Protection against ingress of medium size solid foreign bodies. See degree of protection 2, **D.6**.
3	Protection against contact with live or moving parts inside the enclosure by tools, wires or such objects of thickness greater than 2.5 mm. Protection against ingress of small solid foreign bodies. See degree of protection 3, **D.6**.
4	Protection against contact with live or moving parts inside the enclosure by tools, wires or such objects of thickness greater than 1 mm. Protection against ingress of small solid foreign bodies. See degree of protection 4, **D.6**.
5	Complete protection against contact with live or moving parts inside the enclosure. Protection against harmful deposits of dust. The ingress of dust is not totally prevented, but dust cannot enter in an amount sufficient to interfere with satisfactory operation of the equipment enclosed. See degree of protection 5, **D.6**.
6	Complete protection against contact with live or moving parts inside the enclosure. Protection against ingress of dust. See degree of protection 6, **D.6**.

D.4 PROTECTION OF EQUIPMENT AGAINST INGRESS OF LIQUID

Second characteristic numeral	Degree of protection
0	No protection.
1	Protection against drops of condensed water: Drops of condensed water falling on the enclosure shall have no harmful effect. See degree of protection 1, **D.7.**
2	Protection against drops of liquid: Drops of falling liquid shall have be harmful effect when the enclosure is tilted at any angle up to 15^{o} from the vertical. See degree of protection 2, **D.7.**
3	Protection against rain; Water falling in rain at an angle equal to or smaller than 60^{o} with respect to the vertical shall have no harmful effect. See degree of protection 3, **D.7.**
4	Protection against splashing: Liquid splashed from any direction shall have no harmful effect. See degree of protection 4, **D.7.**
5	Protection against water-jets: Water projected by a nozzle from any direction under stated conditions shall have no hramful effect. See degree of protection 5, **D.7.**
6	Protection against conditions on ships'decks (deck water-tight equipment): Water from heavy seas shall not enter the enclosures under prescribed conditions. See degree of protection 6, **D.7.**
7	Protection against immersion in water: It must not be possible for water to enter the enclosure under stated conditions of pressure and time. See degree of protection 7, **D.7.**
8	Protection against indefinite immersion in water under specified pressure: It must not be possible for water to enter the enclosure See degree of protection 8, **D.7.**

D.5 DEGREES OF PROTECTION

The table below gives the most frequently used, degrees of protection in accordance with the descriptions given in D.3 and D.4.

It is recommended that the characteristic letters and numerals be marked on the enclosure.

Characteristic letters	First characteristic number protection against contact and ingress of foreign bodies	Second characteristic numeral Protection against ingress of liquid								
		0	1	2	3	4	5	6	7	8
	0	IP00	-	-	-	-	-	-	-	-
	1	IP10	IP11	IP12	-	-	-	-	-	-
	2	IP20	IP21	IP22	IP23	-	-	-	-	-
	3	IP30	IP31	IP32	IP33	IP34	-	-	-	-
	4	IP40	IP41	IP42	IP43	IP44	-	-	-	-
	5	IP50	-	-	-	IP54	IP55	-	-	-
	6	IP60	-	-	-	-	IP65	IP66	IP67	IP68

D.6 TESTS TO PROVE PROTECTION OF PERSONS AGAINST CONTACT WITH LIVE OR MOVING PARTS INSIDE THE ENCLOSURE AND PROTECTION OF EQUIPMENT AGAINST INGRESS OF SOLID FOREIGN BODIES

These tests are type tests.

First characteristic numeral	Test conditions
0	No test is required.
1	The test is made with a sphere of 52.5 mm diameter. The test is deemed satisfactory if the sphere cannot touch live or moving parts inside the enclosure.

First characteristic numeral	Test conditions
2	The test is made using a flexible Test Finger specified in SLS 278 connected by an incandescent lamp to one pole of a supply of at least 40 V, the other pole of the supply being connected to the parts intended to be live in normal service, electrically connected together. The protection is deemed satisfactory if the lamp does not light when an attempt is made to touch the bare live parts or insufficiently insulated parts, with the test finger placed in every possible position and pushed without undue force. For these tests, the insufficiently insulated parts will be covered with a metal foil connected to those parts alive in normal service. Conducting parts covered only with varnish or enamel or protected by oxydation or by a similar process shall be considered as insufficiently insulated. In addition, the enclosure must not admit a ball of 12.5 mm diameter.
3	The test is made with a steel wire of 2.4 mm diameter. The test is deemed satisfactory if the wire cannot enter the enclosure.
4	The test is made with a steel wire of 1 mm diameter. The test is deemed satisfactory if the wire cannot enter the enclosure.
5	The test should preferably be made using the equipment shown in **Fig. 2** consisting of a closed test chamber in which talcum powder is maintained in suspension by an air current. The talcum powder used is to pass a square-meshed sieve whose nominal wire diameter is 50 μ and the nominal width between wires is 75 μ. The amount of talcum powder to be used is 2 kg per cubic meter of the test chamber. The equipment under test is hung inside the chamber and its enclosure is connected to a vacuum pump which maintains inside the enclosure a different pressure equivalent to not more than a head of 200 mm water.

First characteristic numeral	Test conditions
5	The test is stopped at the end of two hours if the volume of the air drawn in during this period is from 80 to 120 times the volume of air in the enclosure under test. If, with the vacuum equivalent to a head of 200 mm water, it is not possible to draw in 80 times the volume of air indicated above, the test must be continued until that value is attained; in no case should the test be longer than eight hours. The permissible amount of talcum powder penetration inside the enclosure is subject to agreement between manufacturer and user.
6	The test should preferably be made under the same conditions as given above for degree of protection 5. The test is deemed satisfactory if no deposit of dust is observable inside the enclosure at the end of the test.

D.7 TESTS TO PROVE PROTECTION OF EQUIPMENT AGAINST INGRESS OF LIQUID

These tests are type tests.

Second characteristic numeral	Test conditions
0	No test is required.
1	(Under consideration)
2	The test should preferably be made by means of the equipment shown in Fig. 3 using water, and adjusted so that the discharge is 3 mm of water per minute. The equipment under test is placed in its normal operating position under the dripping equipment the base of which must be larger than that of the equipment under test.

Second characteristic numeral	Test conditions
2	The equipment under test is tilted up to an angle of ± 15° in respect to its normal operating position successively in two planes at right angles. The total duration of the test is 10 minutes. The test is deemed satisfactory if, on its conclusion, the amount of water which has entered the interior of the equipment is not capable of interfering with its satisfactory operation, and if no water has accumulated near the cable-end or entered the cable.
3	The test should preferably be made by means of the equipment shown in **Fig. 4.** It consists of an oscillating tube formed into a semi-circle, the radius of which is as small as possible taking into account the dimensions of the equipment under test. This tube is oscillated so as to describe an angle of 60° from vertical in both directions. The duration of a simple oscillation is about two seconds. The water pressure corresponds to a head of about 10 m water. The equipement under test is mounted in its normal position on a turntable, the axis' of which is vertical and the height of which may be regulated, located near the centre of the semicircle formed by the oscillating tube. The duration of the test is ten minutes. The test is deemed satisfactory if, on its conclusion, the amount of water which has entered the interior of the equipment is not capable of interfering with its satisfactory operation, and if no water has accumulated near the cable-end or entered the cable.
4	The test should preferably be made as described above for degree of protection **3.** The oscillating tube oscillates through an angle of almost 180° with respect to the vertical in both directions and at a speed of 90° per second. Moreover, the support for the equipment under test is grid-shaped, in order not to act as a baffle.

Second characteristic numeral	Test conditions
4	The test is deemed satisfactory if, on its conclusion, the amount of water which has entered the interior of the equipment is not capable of interfering with its satisfactory operation and if no water has accumulated near the cable-end or entered the cable.
5	The test should preferably be made by applying a stream of water from a nozzle of 12.5 mm inside diameter on the equipment in all directions at a pressure corresponding to a head of about 10 m of water. The nozzle should be held at a distance of three metres away from the equipment under test. The duration of the test is 15 minutes. The test is deemed satisfactory if, on its conclusion, the amount of water which has entered the interior of the equipment is not capable of interfering with its satisfactory operation and if no water has accumulated near the cable-end or entered the cable.
6	The test should preferably be made by applying a stream of water from a nozzle of 12.5 mm inside diameter on the equipment in all directions at a pressure corresponding to a head of about 10 m of water. The nozzle should be held at a distance of 1.5 metre away from the equipment under test. The duration of the test is 15 minutes. The test is deemed satisfactory if, on its conclusion, no water has entered the interior of the equipment.
7	The test should preferably be made by completely immersing the equipment under test in water so that the head of water above the equipment is one metre. The duration of the test is 30 minutes. The test is deemed satisfactory if, on its conclusion, no water has entered the interior of the equipment and if no water has accumulated near the cable-end or entered the cable. By agreement between manufacturer and user, this test can be replaced by the following one: The enclosure should be tested with an inside air-pressure corresponding to a head of about one metre of water.

Second characteristic numeral	Test conditions
7	The duration of the test is one minute. The test is deemed satisfactory if no air leaks out during the test. Air leakage may be detected either by submersion, the water just covering the equipment, or by the application of a solution of soap in water.
8	The test should preferably be subject to agreement between manufacturer and user.

NOTE - For the tests according to degrees of protection 5, 6 *and* 7, *the temperature of the equipment should not differ by more than* 5 °C *from that of the water.*

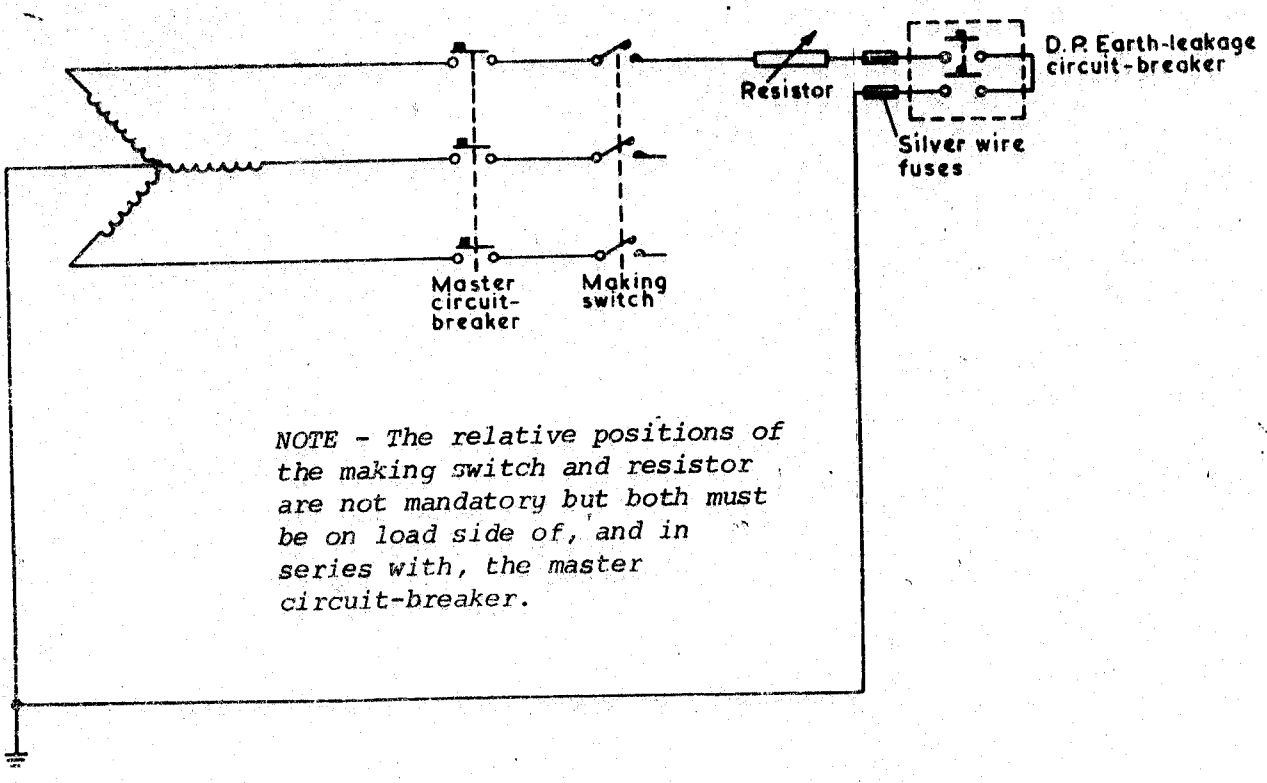


FIGURE 1 - Typical test circuit for through-current test

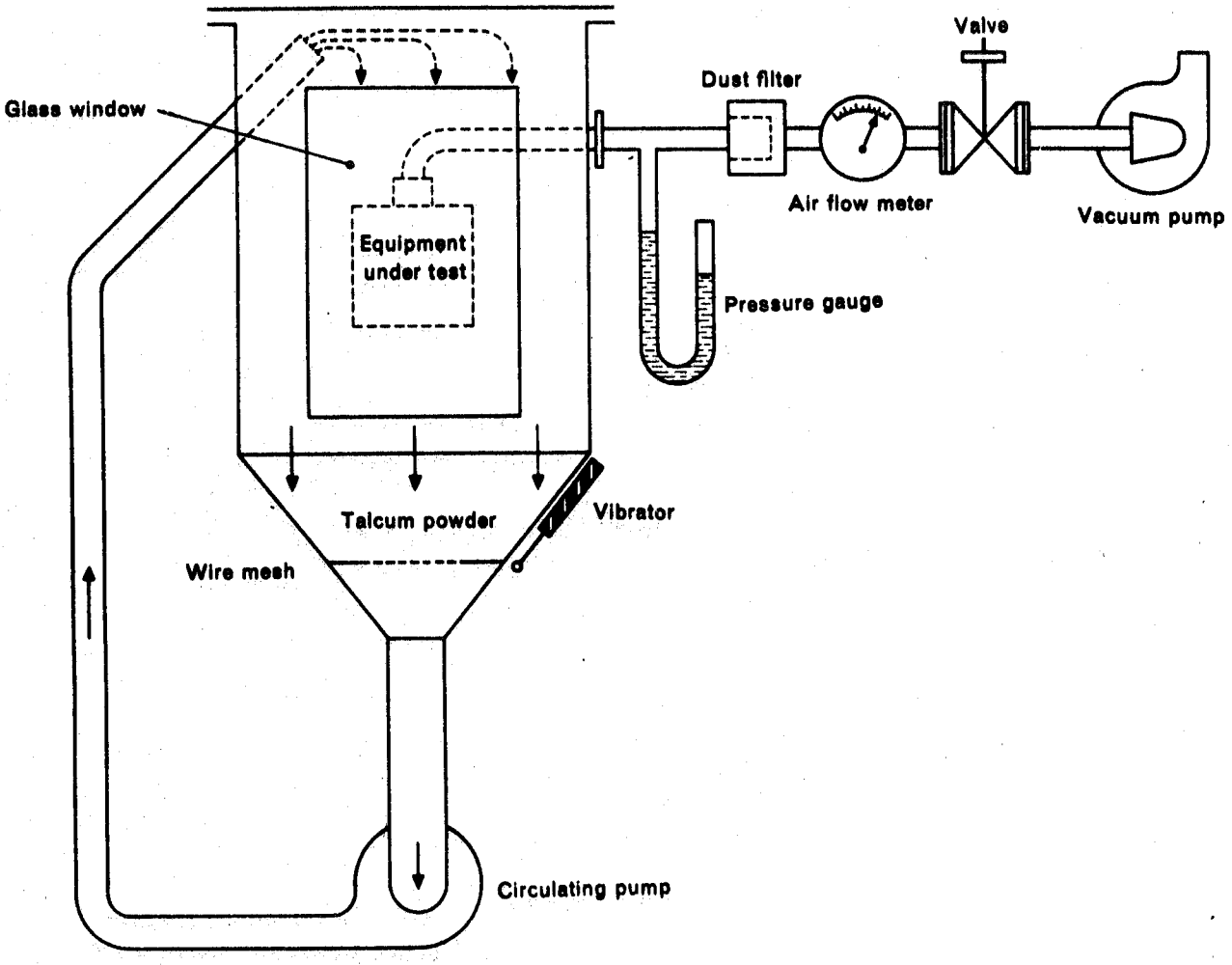
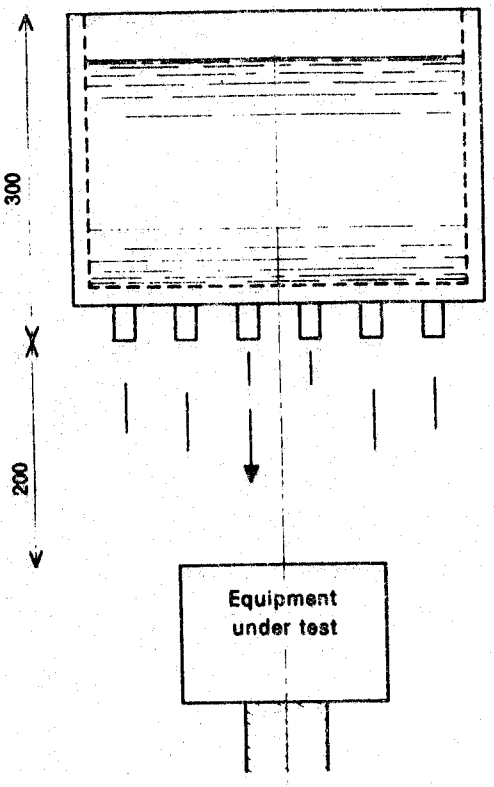
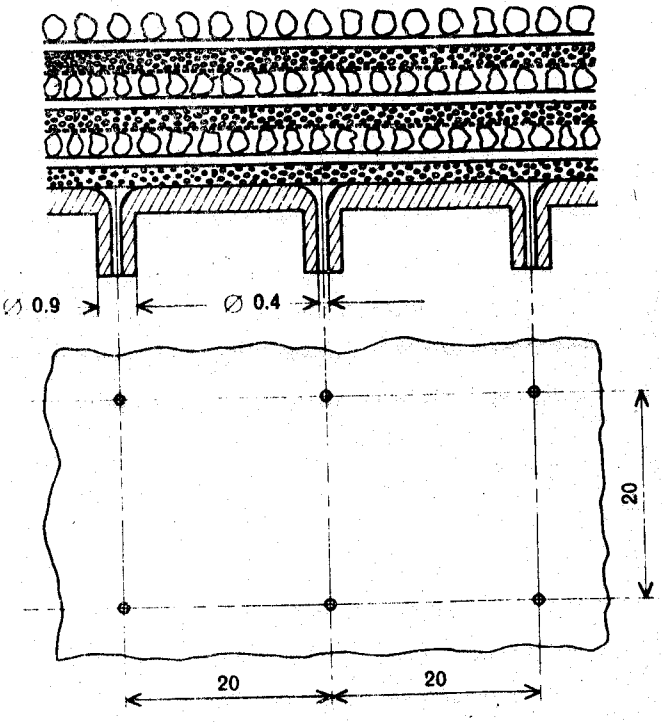


FIGURE 2 - Equipment to prove protection against dust



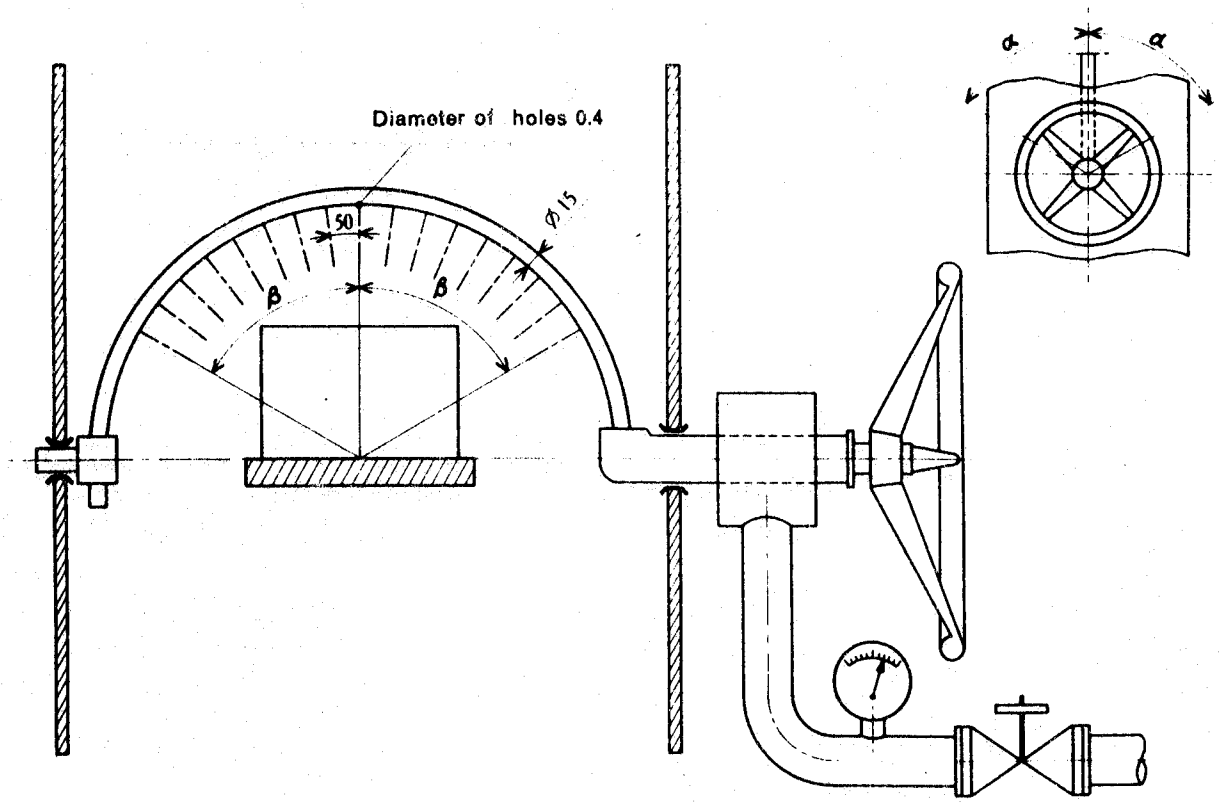
Layers of sand and gravel to regulate flow of water, these layers being separated by metallic gauze and blotting paper.



NOTE - The support must be smaller than the equipment under test.

Dimensions in millimetres

FIGURE 3 - Equipment to prove protection against drops of liquid



Second characteristic numeral		3	4
	α =	± 60°	± 180°
Open holes within half an angle of	β =	± 60°	± 90°

Dimensions in millimetres

FIGURE 4 - Equipment to prove protection against rain and splashing

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