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BSI Group
389 Chiswick High Road
London, W4 4AL
United Kingdom

T: +44 20 845 086 9001
F: +44 20 8996 7400
cservices@bsigroup.com
bsigroup.com

British Standards Limited
Registered in England no: 07864997
Registered address: 389 Chiswick High Road
London, W4 4AL, United Kingdom

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BRITISH STANDARD SPECIFICATION

OIL CIRCUIT-BREAKERS

FOR ALTERNATING CURRENT SYSTEMS

B.S. 116 : 1952

Price 15/- net.

BRITISH STANDARDS INSTITUTION
Incorporated by Royal Charter
Telegrams : Standards, Sowest, London Telephone : Abbey 3333
Sales Branch Telephone : Victoria 0522
24 VICTORIA STREET, LONDON, S.W.1

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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 31st December, 1952.

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

A complete list of British Standards, numbering over 1800, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook, price 7s. 6d.

This standard makes reference to the following British Standards :—

B.S. 148. Insulating oils for electrical purposes (excluding cables).
B.S. 162. Electric power switchgear for indoor and outdoor installations up to and including 220 000 volts.
B.S. 168. Industrial electric motors and generators.
B.S. 170. Electrical performance of fractional horse-power electric motors and generators with class A insulation.
B.S. 223. Electrical performance of high-voltage bushing-insulators.
B.S. 229. Flameproof enclosure of electrical apparatus.
B.S. 923. Impulse-voltage testing.
B.S. 936. Oil circuit-breakers for alternating-current circuits up to and including 660 volts.
B.S. 1086. Code of practice for the maintenance of electrical switchgear.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

ELE/10/1

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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 :—

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*Association of Consulting Engineers, Incorporated
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*British Electrical and Allied Manufacturers' Association
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BRITISH STANDARD SPECIFICATION FOR

OIL CIRCUIT-BREAKERS

FOR ALTERNATING-CURRENT SYSTEMS

FOREWORD

The previous edition of this British Standard, issued in 1937, as B.S. 116 Parts 1 and 2, conformed to the rules for short-circuit conditions in the first edition of Publication No. 56 on Alternating-current Circuit-Breakers issued by the International Electrotechnical Commission, except for some deviations in Part 2 in connection with the larger circuit-breakers.

This revision applies to oil circuit-breakers only and continues to be based on the I.E.C. Publication No. 56, but as the result of progress in the art of circuit-breaking, and of experience with B.S. 116 : 1937, it contains some modifications and additions to that standard. In order to avoid unnecessary complication and repetition it has been considered desirable to issue the present British Standard in one volume which supersedes B.S. 116 : 1937, Parts 1 and 2, so far as the provisions of oil circuit-breakers are concerned.

Oil switches and oil isolating-switches will continue to be covered by the relevant portions of B.S. 116 : Part 1 : 1937 until superseded.

The present standard is one of a series of British Standards relating to switchgear equipment, during the preparation of which it has been found that a large amount of research will be necessary before all the conditions of short-circuit can be laid down with certainty. Research is still being conducted by the British Electrical and Allied Industries Research Association, by supply-undertakings, and by switchgear manufacturers. It is expected that in due course additions will be made to the specification, based, for example, on further investigation of the performance of circuit-breakers, and the numerical values of the rate-of-rise of restriking-voltage likely to exist at typical points in a supply-network and their influence on the selection of suitably rated circuit-breakers.

As some time must elapse before every circuit-breaker supplied can be certified to comply in all respects with this revision of the standard, its application should be subject to mutual agreement between contracting parties. Additional testing may be necessary, but circuit-breakers complying with B.S. 116 : 1937 are not necessarily inadequate.

SPECIFICATION

SECTION ONE : GENERAL

SCOPE

1. This British Standard applies to all oil circuit-breakers (as defined in Definition 1 of Clause 4) for single-phase and three-phase A.C. systems, except oil circuit-breakers up to 660 volts intended for use in those electrically remote parts of a system where marked asymmetry of fault-current cannot occur and where the restriking-voltage conditions are not severe (see B.S. 936, 'Oil circuit-breakers for alternating current circuits up to and including 660 volts'). Further, it does not apply to combinations of circuit-breakers and fuses in series, oil isolators, oil selectors, oil switches, contactors, or circuit-breakers required to make and break circuits frequently at short intervals (e.g. starting-switches), neither does it include the additional requirements necessary in connection with flameproof switchgear as given in B.S. 229, 'Flameproof enclosure of electrical apparatus'.

Those characteristics of oil circuit-breakers which are associated with resistance switching are not completely dealt with in this standard. Further requirements for the construction, rating and performance of oil circuit-breakers incorporating this method of switching are still under review, but in the meantime the specification shall apply in all essentials.

NOTE. The requirements of oil switches, oil isolators and oil selectors will be specified later.

BASIS OF SPECIFICATION

2. *a. General.* The specification sets out standards suitable for circuit-breakers, both of the smaller sizes, i.e. with rated breaking capacities up to 500 MVA, which are type-tested with a recovery-voltage approximating to the rated service-voltage, and also of the larger sizes, i.e. with rated breaking-capacities above 500 MVA, which are type-tested with a recovery-voltage less than the rated service-voltage to a degree depending upon their size.

The specification is based on the use of values of short-circuit current (such as making-current at a specified service-voltage, breaking-current at a specified recovery-voltage, and short-time current during a specified time) to express the rating of a circuit-breaker and the results obtained during type-tests. A typical oscillogram showing the varying values of currents and voltages in a test of a three-phase circuit-breaker as functions of time is given in Fig. 1 for guidance when reading the specification.

b. Prospective current. Certain types of circuit-breakers have the property of exercising a modifying effect upon the short-circuit current. An example is a circuit-breaker fitted with series over-current trip-coils of relatively high electrical impedance. The basis for the assessment of the breaking-capacity of the circuit-breaker in such a case is not the reduced

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value of the current which it actually interrupts either in service or on tests, but the prospective current, that is, the full value of the current which would flow in the circuit if each pole of the circuit-breaker were replaced by a link of negligible impedance.

c. MVA rating. For the practical convenience of specifying standard MVA breaking-capacity ratings of circuit-breakers, and for comparing a given rating with the MVA values of short-circuit at any given point in a supply network, the fundamental symmetrical breaking-capacity rating in kilo-amperes assigned to a circuit-breaker is converted into an MVA rating by multiplying it by the rated service-voltage in kilovolts and by the phase-factor.

d. Severity of duty. The specification standardizes generally accepted criteria of severity of duty under which type-tests are made and ratings are assigned. It is generally recognized that, in addition, the severity of the duty imposed upon a circuit-breaker also depends upon the form of the restriking-voltage. This specification conforms to I.E.C. Publication No. 56 which specifies factors which control only the amplitude of the restriking-voltage. There is general agreement that the restriking-voltage characteristics obtainable in testing-stations produce a severity of duty more onerous than normally obtains under service-conditions.

e. Active recovery-voltage. In order to facilitate the testing of circuit-breakers rated at over 500 MVA it is permitted to increase the D.C. component in excess of 20 per cent of the A.C. component specified in Clause 47 for symmetrical tests ; this is allowed for in the evaluation of such tests by the active-recovery-voltage based on D.C. component and power factor, as both these components have appreciably the same effect in altering the point on the voltage wave which corresponds to current zero. The curves in Fig. 10 are calculated to make the necessary correction required by the severity of the tests.

CLASSIFICATION OF CIRCUIT-BREAKERS

3. *a. Groups.* For the purpose of this specification circuit-breakers are classified in two groups as follows :—

Group A. Those having three-phase breaking-capacity ratings up to 500 MVA, and those having single-phase breaking-capacity ratings up to 290 MVA, i.e. $\left(\frac{500}{\sqrt{3}}\right)$

Group B. Those having three-phase breaking-capacity ratings above 500 MVA.

b. Characteristics. Unless otherwise stated the clauses in this specification apply to circuit-breakers of both groups referred to in

Sub-clause 3*a*. There are, however, some circuit-breakers in each group with such inherent characteristics as to warrant special consideration, particularly in respect of short-circuit testing.

For these circuit-breakers suitable reference is made in the relevant clauses of the specification to take account of the circuit-breaking characteristics.

Circuit-breakers with characteristics referred to above are mainly those fitted with series trip-coils, making-current releases or other overcurrent releases which may cause one or more of the following effects :—

(i) Such rapid operation that the duration of the short-circuit current is too short to allow it to be properly measured or that the first major loop of short-circuit current is distorted from sine wave form.

(ii) A reduction of short-circuit current to a value appreciably below that which would otherwise be reached, e.g. due to the inherent impedance of series trip-coils.

(iii) Operation in times which prevent the control of the D.C. component. In this case the initiation of tripping and time of operation depend entirely on the value of short-circuit current and the inherent characteristics of the circuit-breakers ; consequently the D.C. component may not reach the required value on some short-circuit tests and may exceed it on others.

DEFINITIONS

4. For the purposes of this British Standard the following definitions shall apply :—

1. Oil circuit-breaker (generally referred to in the text as a circuit-breaker). A device capable of making and breaking a circuit in oil under normal conditions and under abnormal conditions such as those of short-circuit.

2. Remote-controlled circuit-breaker. A circuit-breaker that can be opened and closed from a distance.

3. Auxiliary-switch. A switch working in conjunction with a circuit-breaker to control a circuit for operating auxiliary devices such as trip-coils, indicators or alarms.

4. Main contacts. The fixed and moving contacts in the main current-carrying circuit.

5. Arcing-contacts (or auxiliary-break contacts). Contacts that open after, and close before, the main contacts and are intended to protect the main contacts from injury.

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6. Number of poles. One, two, three, or more, according to whether one, two, three, or more conductors or lines are to be broken.

7. The break. The sum of the gaps introduced in one pole between main contacts, or arcing-contacts (if any) when the circuit-breaker is fully open.

8. Minimum clearance between terminals of one pole. The shortest total distance, in air or oil, between the contacts or any metal parts connected thereto, measured on one pole, with the circuit-breaker fully open.

9. Minimum clearance between poles. The shortest total distance, in air or oil, measured between any live parts of adjacent poles.

10. Minimum clearance to earth. The shortest total distance, in air or oil, measured between any live part and earthed parts.

11. The travel. The distance through which the moving contacts pass between the closed and the fully opened positions.

12. Fixed-trip circuit-breaker. A circuit-breaker that is free to trip only when it is fully closed.

13. Trip-free circuit-breaker. A circuit-breaker that is free to open immediately the tripping power is applied during the closing operation.

14. Opening-time. The time between the instant of application of the tripping-power to the circuit-breaker when closed and the instant of separation of the contacts, with any integral time lag device adjusted to its minimum setting.

15. Loop. That part of an alternating wave that extends from any one zero to the next.

16. Arc-duration (or Arcing-time). The time between the instant of separation of the circuit-breaker contacts and the instant of arc extinction of the short-circuit current, excluding resistor current duration, if any. For the purpose of indicating the number of current zeros after the instant of separation of the contacts up to the instant of arc extinction, arc-duration (or arcing-time) may be referred to as including a stated number of loops.

17. Resistor current duration. The time between the instant of arc-extinction of the short-circuit current and the instant of arc-extinction of the resistor current.

18. Total-break-time. The sum of the opening-time, the arc-duration, and the resistor current duration.

19. Total-short-circuit-break-time. The sum of the opening-time and the arc-duration.

20. Make-time. The time, for a power operated circuit-breaker, between the instant of application of power to the closing device and the instant when the contacts touch or current is established, whichever gives the shorter time.

NOTE. For circuit-breakers whose mechanisms have an integral electrical initiating device, the make-time includes the operating time of this device.

21. Over-current release. A device that causes a circuit-breaker to open the circuit automatically when the current exceeds a predetermined value at which the release has been adjusted to operate.

22. Definite-time-lag over-current release. A device that retards the tripping of a circuit-breaker by a definite time, which may be adjustable, but is independent of the magnitude of the over-current.

23. Inverse-time-lag over-current release. A device that retards the tripping of a circuit-breaker by a time inversely dependent upon the over-current.

24. Inverse-time-lag over-current release with a definite minimum time-lag. A device that retards the tripping of a circuit-breaker by a time inversely dependent upon the over-current, except that the time lag approaches a definite minimum value at large over-currents.

25. Under-voltage release. A device that causes a circuit-breaker to open the circuit if the voltage falls below a predetermined value.

NOTE. The use of the terms 'no-volt release' and 'low-volt release' is deprecated.

26. Making-current release. A device that during a closing operation causes a trip-free circuit-breaker to open automatically and without intentional time lag when the making-current exceeds a predetermined value. The device is rendered inoperative when the circuit-breaker is fully closed.

27. Shunt trip. A device operated from a source of voltage that may be independent of the circuit to which the circuit-breaker is connected.

28. Series trip. An over-current release energized by the main current passing through the circuit-breaker without the interposition of a current transformer.

29. Rating of a circuit-breaker. The set of values assigned by the manufacturer to define the working conditions for which it is built.

30. Performance of a circuit-breaker. The general term used to denote its behaviour on, and the values obtained from, tests made on it under prescribed conditions.

31. Operating-duty. A defined sequence of making and/or breaking operations without any deliberate alterations of the main circuit in which the circuit-breaker is placed.

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32. System-voltage. The r.m.s. voltage between lines for which the system is designed and installed.

33. Service-voltage. The normal r.m.s. voltage between lines of the system at the point where a circuit-breaker may be installed.

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

35. Recovery-voltage. The normal frequency r.m.s. voltage that re-appears between the poles of a circuit-breaker after final arc-extinction.

36. Active-recovery-voltage. The product of the recovery-voltage and the active voltage factor. (See Clauses 2*e* and 57.)

37. Active voltage factor. The factor equal to or less than unity ; its value depends upon the circuit power-factor and the degree of asymmetry of the short-circuit current. (See Clauses 2*e* and 57.)

38. Restriking voltage. The transient voltage that exists at, or in close proximity to, each zero-current pause during the arcing-time : the important characteristics are its amplitude and its rate-of-rise (which is expressed in volts per microsecond) at the time of final arc-extinction.

39. Normal-current. The r.m.s. value of the current that a circuit-breaker is capable of carrying continuously under prescribed conditions.

40. Short-time current. The r.m.s. value of the current that a circuit-breaker is capable of carrying for the stated time under prescribed conditions when fully closed.

41. Breaking-current. The current that exists at the instant of contact-separation.

42. Symmetrical breaking-current. The r.m.s. value of the A.C. component of the breaking-current.

43. Asymmetrical breaking-current. The r.m.s. value of the total breaking-current, which includes both the A.C. and D.C. components of the breaking-current.

44. Prospective current. The current that flows in a circuit due to the applied-voltage when the circuit-breaker under test is replaced by a link of negligible impedance but without any other circuit change.

45. Prospective breaking-current. The r.m.s. value of the A.C. component of the prospective current measured at a specified instant. (See Clause 54.)

46. Breaking-capacity of a circuit-breaker. The current that can be broken at a stated voltage.

NOTE. For all circuit-breakers other than those which operate so rapidly that the current cannot properly be measured and/or which inherently reduce the breaking-current, the breaking-capacity is expressed in terms of the symmetrical and asymmetrical breaking-capacities (see definitions 47 and 48 of Clause 4).

For those circuit-breakers which operate so rapidly that the current cannot properly be measured and/or which inherently reduce the breaking-current, the breaking-capacity is the prospective breaking-current at a stated voltage under prescribed conditions.

47. Symmetrical breaking-capacity. The r.m.s. value of the A.C. component of the current that can be broken at a stated voltage simultaneously in all the poles of a circuit-breaker.

48. Asymmetrical breaking-capacity. The r.m.s. value of the combined A.C. and D.C. components of the current that can be broken at a stated voltage by any one pole of a circuit-breaker.

49. Making-current. The peak value of the maximum current-loop (including the D.C. component) in any pole during the first cycle of current when the circuit is closed by a circuit-breaker.

If the maximum loop is distorted from sine wave form and/or the circuit-breaker inherently reduces the short-circuit current, the making-current may be taken as the prospective making-current.

50. Prospective making-current. The peak-value of the maximum current-loop (including the D.C. component) of the prospective current (see Definition 44 of Clause 4).

51. Making-capacity of a circuit-breaker. The making-current it is capable of making and carrying instantaneously at the rated service-voltage under prescribed conditions.

52. Circuit-breaker closing. A circuit-breaker is closed when it has completed its closing operation and is latched.

53. Trip-free operation. The tripping of a circuit-breaker during the period of closing.

54. Co-ordination of insulation. The process of correlating the insulation strengths of electrical equipment, with anticipated over-voltages and with the characteristics of protective devices (see Appendix D, Section 2*e*). It consists of the steps taken to prevent damage to electrical equipment due to over-voltages and to localize flashovers (when they cannot economically be prevented) to points where they will not cause damage.

55. Insulation level of apparatus. The level that determines the principal dielectric qualities of [illegible]atus, and which is expressed for impulse-tested

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apparatus by a peak impulse value (impulse withstand voltage with full 1/50 μs wave) and for non impulse tested apparatus by a power-frequency r.m.s. voltage value (power-frequency withstand voltage) which the apparatus must withstand under specified test conditions.

56. *Electrically exposed installation.* An installation in which the apparatus is subject to over-voltages of atmospheric origin (see Appendix D, Section 2*e*).

NOTE 1. Such installations are usually connected to overhead transmission lines, either directly or through a short length of cable.

NOTE 2. Apparatus may be required for installations which are semi-exposed to over-voltages of atmospheric origin, that is of magnitude less than for an exposed installation. Such installations are usually connected to overhead transmission lines through two-winding transformers, or a longer length of cable, which reduce the amplitude of incoming over-voltages. These cases require special consideration. The apparatus will be chosen from the appropriate exposed or non-exposed insulation class, as a special class of insulation is not proposed for this case.

57. *Electrically non-exposed installation.* An installation in which the apparatus is not subject to over-voltages of atmospheric origin (see Appendix D, Section 2*e*).

NOTE. Such installations are usually connected to cable networks.

58. *Surge-protected installation.* An installation whose external and internal over-voltages are limited by effective protective devices to values less than the insulation level of the apparatus, with a reasonable safety margin.

59. *Insulated neutral system.* A system that has no intentional connection to earth except through indicating, measuring or protective devices of very high impedance (see Clause 20).

60. *Earthed neutral system.* A system that is connected to earth, either solidly, or through a resistor or reactor (see Clause 20).

61. *Over-voltage.* An abnormal voltage in excess of the peak voltage to earth derived from the system voltage (see Appendix D, Section 2*e*).

62. *Arc-suppression coil earthed system.* A system in which the neutral is earthed through a reactor selected to produce resonance with the capacitance to earth of the system during phase-to-earth faults, thus neutralizing the capacitive component of the current passing through the fault.

NOTE. An arc-suppression coil is generally adjusted slightly out of resonance to prevent resonance from causing over-voltages in cases of phase unbalance.

63. *Type-test.* A test of one article intended to show that all articles made to the same specification, and having the same essential details would pass an identical test.

64. *Routine test.* A test of every article made to the same specification.

SYMBOLS

5. The following symbols are used in this specification to define the steps of any operating-duty or test-duty :—

B denoting a breaking-operation.

M denoting a making-operation.

MB denoting a making-operation, followed by a breaking-operation, without the introduction of any intentional time-lag.

t (or a numeral) denoting a time between successive operations of an operating-duty.

SECTION TWO : RATING

RATING

6. A circuit-breaker shall be rated in terms of the following :—

a. Number of poles.

b. Service-voltage.

c. Normal-current.

d. Frequency.

e. Making-capacity.

f. Breaking-capacity.

g. Short-time current.

(i) 1-second or 3-second ; or

(ii) For a circuit-breaker fitted with direct acting trips such as series trip-coils, or other overcurrent devices, 1-second or a time corresponding to the maximum setting of the time-lag device. (See Clause 11*b*.)

h. Operating-duty.

RATED SERVICE-VOLTAGE

7. *a.* The rated service-voltage of a circuit-breaker shall be the r.m.s. voltage of the circuit or system in which it is intended to be used.

b. The rated service-voltage of a three-phase circuit-breaker shall be one of the standard values given in Column 1 of Tables 1 and 2.

c. The rated service-voltage of a circuit-breaker for a single-phase system shall be in accordance with Column 1 of Tables 1 and 2 with the addition of a single-phase rating of 2·2 kilovolts.

d. The rated service-voltage of a neutral-earthing circuit-breaker shall be the voltage to neutral of one of the standard three-phase rated service-voltages given in Column 1 of Tables 1 and 2, i.e. it shall be $V/\sqrt{3}$, where V is the standard three-phase rated service-voltage.

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RATED NORMAL-CURRENT

8. *a.* The rated normal-current of a circuit-breaker shall be the current it can carry continuously with a temperature-rise in accordance with the conditions of Section Six.

b. The rated normal-current of a circuit-breaker shall be one of the standard values given in Column 4 of Tables 1 and 2.

c. When special conditions necessitate higher rated normal currents than those given in Column 4 of Tables 1 and 2 it is recommended that the current shall differ by steps of 1000 amperes from 3000 upwards, e.g. 4000, 5000, and so on.

d. If a circuit-breaker is used at a frequency other than 50 cycles per second, its standard rated normal-current may be increased or decreased, if necessary, in order that it shall comply in all other respects with the requirements of this specification. The larger or smaller current so determined shall then be the rated normal-current at the frequency marked on the nameplate.

RATED MAKING-CAPACITY

9. *a.* The rated making-capacity of a circuit-breaker shall be not less than the rated symmetrical breaking-capacity, in kilo-amperes, multiplied by the product of the factors 1·8 and 1·414, i.e. by 2·55 (see Fig.).

b. A circuit-breaker shall be capable of making the circuit at its rated making-capacity; it shall be required to close and latch (see Definition 52 of Clause 4) or to trip free during the period of closing (see Definition 53 of Clause 4) according to the purchaser's specification (see Appendices A and B).

RATED BREAKING-CAPACITY

10. *a.* The rated symmetrical breaking-capacity of a circuit-breaker shall be one of the standard values given in Column 3 of Tables 1 and 2 for the appropriate standard voltage given in Column 1.

b. For circuit-breakers which operate so rapidly that the current cannot properly be measured and/or those which inherently reduce the breaking-current, the prospective breaking-current shall be deemed to be the rated breaking-current.

c. For practical convenience, the rated symmetrical breaking-capacity may be stated in terms of MVA, as the product of the rated symmetrical breaking-current (in kA), the rated service-voltage (in kV), and the factor $\sqrt{3}$ or 1 for three-phase or single-phase circuit-breakers respectively.

The rated symmetrical breaking-capacity of a three-phase circuit-breaker in MVA, so derived, shall be one of the standard values given in Column 2 of Tables 1 and 2.

d. The rated symmetrical breaking-capacity of a single-phase circuit-breaker in MVA, derived in accordance with Clause 10*c*, shall be $1/\sqrt{3}$

of one of the standard values given in Column 2 of Tables 1 and 2 up to the limit of Group A circuit-breakers; the corresponding symmetrical breaking-currents at the various standard service-voltages are given in Column 3 of Tables 1 and 2, except for 2·2 kV.

e. The rated symmetrical breaking-capacity of a neutral-earthing circuit-breaker in MVA shall be 1/3 of one of the standard values given in Column 2 of Tables 1 and 2. The symmetrical breaking-current shall be one of the values given in Column 3 of Tables 1 and 2 corresponding to a three-phase service-voltage equal to $\sqrt{3}$ times the rated service-voltage of the neutral-earthing circuit-breaker.

RATED SHORT-TIME CURRENT

11. *a.* The rated 1-second or 3-second short-time current of a circuit-breaker not fitted with series trip-coils or over-current release coils shall be not less than the rated symmetrical breaking-current.

The duration of the rated short-time current of such a circuit-breaker shall be :—

(i) 3 seconds, where the ratio of the rated symmetrical breaking-current to the rated normal-current is equal to or less than 40.

(ii) 1 second, where the ratio of the rated symmetrical breaking-current to the rated normal-current is more than 40.

b. A rated short-time current need not be assigned to a circuit-breaker fitted with series trip-coils or over-current release coils provided that, when connected in a circuit the prospective current of which is equal to its rated breaking-current, it shall be capable of carrying the resulting current for the total-break-time required by the circuit-breaker when set for a maximum time-lag and operating in accordance with its rated operating-duty.

RATINGS OF STANDARD 3-PHASE CIRCUIT-BREAKERS

12. Standard circuit-breakers shall where possible be selected having ratings in accordance with Table 1.

A complete list of standard ratings is given in Table 2 but the existence of this extensive list makes the attainment of the economic advantages which should result from standardization very difficult, if not quite impossible. The preferred ratings given in Table 1 have been carefully chosen as the result of experience of many designs over a wide range of applications, in order to assist in the ultimate reduction of the number of standard circuit-breaker ratings.

See also Appendix D, 'Selection of standard oil circuit-breakers'.

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TABLE 1. STANDARD 3-PHASE OIL CIRCUIT-BREAKERS
PREFERRED RATINGS

1	2	3	4
Service-voltage	Breaking-capacity	Symmetrical breaking-currents corresponding to Col. 2	Normal-currents
kV	MVA	kA	amperes
Excluding pole-mounting and flameproof circuit-breakers.			
0·415*	26	36·0	600 800 1200 1600
3·3	50	8·76	400
	75	13·1	400 800
	150	26·3	800 1200
6·6	150	13·1	400 800
	250	21·9	800 1200
11	150	7·88	400 800
	250	13·1	400 800
	500	26·3	800 1200
33	500	8·76	400 800
	750	13·1	400 800 1200
	1500	26·3	800 1200
66	1500	13·1	800
	2500	21·9	800 1200
132	2500	10·9	600
	3500	15·3	800
Flameproof circuit-breakers.			
0·415*	5·2	7·25	250 400
0·6†	3·75	3·6	150
3·3	25·0	4·38	150 250

NOTE. It is recognized that a rated normal-current less than the minimum standard value given in Column 4 of Table 1 is permissible for circuit-breakers fitted with series trip-coils. All the rated currents (normal and short-circuit) as determined by the trip-coil are then assigned by the manufacturer.

* These circuit-breakers are suitable for use at 0·44 kV and at 0·4 kV with the appropriate adjustments to the breaking-capacity value given in Column 2.

† These circuit-breakers are suitable for use at 0·66 kV with the appropriate adjustment to the breaking-capacity value given in Column 2.

TABLE 2. STANDARD 3-PHASE OIL CIRCUIT-BREAKERS
STANDARD RATINGS

1	2	3	4
Service-voltage	Breaking-capacity	Symmetrical breaking-currents corresponding to Col. 2	Normal-currents
kV	MVA	kA	amperes
Excluding pole-mounting and flameproof circuit-breakers.			
0·415*	15·6	21·6	400 600 800
	26	36·0	400 600 800 1200 1600
	31	43·3	800 1200 1600 2000 2400 3000
0·6†	22·5	21·6	400 600 800
	37·5	36·0	400 600 800 1200 1600
	45	43·3	800 1200 1600 2000 2400 3000
3·3	15	2·63	200 400
	25	4·38	200 400 600
	50	8·76	200 400 600
	75	13·1	400 600 800
	100	17·5	400 600 800
	150	26·3	400 600 800 1200 1600 2000
	250	43·8	800 1200 1600 2000
6·6	75	6·57	400 600
	100	8·76	400 600 800
	150	13·1	400 600 800
	250	21·9	400 800 1200
	350	30·6	400 800 1200 1600
	500	43·8	800 1200 1600 2000
11	75	3·94	400
	100	5·25	400 600 800
	150	7·88	400 600 800
	250	13·1	400 800 1200
	350	18·4	400 800 1200 1600
	500	26·3	400 800 1200 1600 2000
	750	39·4	800 1200 1600 2000
22	250	6·57	400
	350	9·2	400 800
	500	13·1	400 800 1200
	750	19·7	400 800 1200
	1000	26·3	800 1200 1600
	1500	39·4	800 1200 1600

* These circuit-breakers are suitable for use at 0·44 kV and at 0·4 kV with the appropriate adjustments to the breaking-capacity values given in Column 2.

† These circuit-breakers are suitable for use at 0·66 kV with the appropriate adjustments to the breaking-capacity values given in Column 2.

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TABLE 2 (continued)

1	2	3	4
Service-voltage	Breaking-capacity	Symmetrical breaking-currents corresponding to Col. 2	Normal-currents
kV	MVA	kA	amperes
33	250	4·38	400
	350	6·13	400
	500	8·76	400 800
	750	13·1	400 800 1200
	1000	17·5	400 800 1200
	1500	26·3	400 800 1200 1600
44	500	6·57	400 800
	750	9·85	400 800 1200
	1000	13·1	400 800 1200
	1500	19·7	400 800 1200
66	500	4·38	400
	750	6·57	400 800
	1000	8·76	400 800
	1500	13·1	800 1200
	2500	21·9	800 1200
88	1000	6·57	600
	1500	9·85	600
	2500	16·4	600
110	1000	5·25	600
	1500	7·88	600
	2500	13·1	600
132	1500	6·57	600
	2500	10·9	600
	3500	15·3	800 1200
165	1500	5·25	600
	2500	8·76	600
	3500	12·2	600
220	1500	3·94	600
	2500	6·57	600
	3500	9·2	600
275	3500	7·38	600
	5000	10·6	600
	7500	15·8	800 1200

TABLE 2 (continued)

1	2	3	4
Service-voltage	Breaking-capacity	Symmetrical breaking-currents corresponding to Col. 2	Normal-currents
kV	MVA	kA	amperes
Pole mounting circuit-breakers.			
6·6	50	4·38	200
11	75	3·94	200
33	250	4·38	400
Flameproof circuit-breakers.			
0·415*	2·6	3·60	150 250 800
	5·2	7·25	150 250 400 800
	10·4	14·5	250 400
0·6†	3·75	3·60	150 250
	7·5	7·25	150 250 400
	15	14·5	250 400
3·3	10	1·75	150 200 250
	25	4·38	150 200 250 400 600
	50	8·76	250 400 600
6·6	25	2·19	200
	50	4·38	200

NOTE. It is recognized that a rated normal-current less than the minimum standard value in Column 4 of Table 2 is permissible for circuit-breakers fitted with series trip-coils. All the rated currents (normal and short-circuit) as determined by the trip-coil are then assigned by the manufacturer.

* These circuit-breakers are suitable for use at 0·44 kV and at 0·4 kV with the appropriate adjustments to the breaking-capacity values given in Column 2.

† These circuit-breakers are suitable for use at 0·66 kV with the appropriate adjustments to the breaking-capacity values given in Column 2.

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STANDARD RATED AUXILIARY SUPPLY VOLTAGES

13. The standard rated voltage of auxiliary circuits shall be 30 volts, 110 volts or 240 volts, A.C. or D.C. except that 30 volts shall not be used for energizing main closing solenoids.

POWER CLOSING DEVICES

14. *a.* All circuit-breakers shall be capable of operating satisfactorily when the voltage at the terminals of the closing device is any value from 80 per cent to 100 per cent of the rated auxiliary supply voltage. Where spring or compressed air operation of the closing device is employed, the terminals referred to are those of the initiating coil.

b. Where, for large circuit-breakers or for exceptional conditions of voltage drop in the auxiliary supply connections, the designed normal voltage at the terminals of the operating device is less than the rated normal voltage of the auxiliary supply, the percentage range prescribed in Clause 14*a* shall relate to the designed normal voltage.

NOTE. Where circuit-breakers of different sizes are operated from a common source of auxiliary power, the auxiliary supply arrangements shall be so designed as to limit the voltage at each closing device to the designed normal voltage.

c. A compressed air operated circuit-breaker shall be capable of operating satisfactorily when the air pressure at the closing device is not more than that of the prescribed safety valve setting of the air system directly associated with it, nor less than the lockout pressure. The lockout pressure shall be not more than 90 per cent of the normal working pressure.

SHUNT TRIP-COILS

15. *a.* A circuit-breaker shall be capable of operating satisfactorily when the voltage at the terminals of the shunt trip-coil is any value from 80 per cent to 120 per cent of the rated voltage of the auxiliary supply.

b. A circuit-breaker, when not carrying current, shall be capable of operating satisfactorily when the voltage at the terminals of the shunt trip-coil is not more than 50 per cent of the rated auxiliary supply voltage.

NOTE. For the purpose of assessment of the total break-time on any of the test-duties 1 to 5 of Clause 47 it is permissible to use the opening-time obtained from a no-load test with the trip-coil energized at 100 per cent of the rated voltage of the auxiliary circuit, together with the arc-duration obtained on the appropriate test-duty. This is particularly important for high-voltage circuit-breakers intended for high-speed operation.

SERIES TRIP-COILS, CURRENT-TRANSFORMERS AND OVER-CURRENT RELEASES

16. *a.* The series trip-coils or primary windings of current-transformers which form part of a circuit-breaker for any purpose (e.g. over-current protection) shall carry without thermal or electromagnetic damage the rated making-current and rated short-time current of the circuit-breaker

for times corresponding to their own time lags and to the operating-duty of the circuit-breaker. The rated normal-current of series trip-coils shall be one of the standard values given in Table 3.

TABLE 3. STANDARD RATED NORMAL-CURRENT OF SERIES TRIP-COILS

Amperes	Amperes
5	100
10	150
15	200
20	300
30	400
40	500
50	600
60	800
75	1000

For currents above 1000 amperes, series trip-coils are likely to have single-turn windings and the rated normal-current of the trip-coil will be that of the circuit-breaker (see Column 4 of Tables 1 and 2).

b. The value of the lowest setting of an over-current release shall not exceed the rated normal-current, except that circuit-breakers having direct-acting over-current trip-coils with time lags may have a lowest setting not exceeding 33 per cent above the rated normal-current.

c. The current corresponding to the maximum calibration-mark on the scale shall be not less than three times the rated normal-current for instantaneous release, and not less than twice the rated normal-current for the time lag release.

d. The over-current release shall operate with currents differing not more than 10 per cent from the marked settings.

INVERSE TIME LAG ATTACHMENTS TO OVER-CURRENT RELEASES

17. *a.* A mechanical or electromagnetic inverse time lag attachment supplied with a circuit-breaker shall comply with the following requirements when the temperature of the attachment is 25°C.

(i) *Time rating.* The time-rating shall be expressed as the nominal tripping-delay in seconds at 125 per cent of the current setting.

(ii) *Nominal time-rating.* When the time-rating is affected by adjusting the current-setting, the nominal time-rating shall be that of the mean current-setting, namely the mean of the minimum and maximum current-settings. When the time lag attachment has several time-settings, the nominal time-rating of the device shall be that at

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the middle graduation-mark. The relation between time-setting graduation-marks, and nominal time-rating shall be stated.

(iii) *Temperature-correction.* When the time lag is dependent on temperature, as it is with dashpots, data shall be provided showing the variation of nominal time-rating with the temperature of the fluid between the limits of 10°C. and 50°C.

b. Shunt-fuses. When the inverse time lag attachment is a fuse in parallel with the trip-coil, the rated current of the fuse shall be the current that will melt it in two minutes.

NOTE. It is recognized that the attachments referred to under Sub-clauses 17*a* and 17*b* are not capable of giving consistently accurate timing. For consistent timing, relays should be used.

UNDER-VOLTAGE RELEASES

18. *a.* An under-voltage release, with or without a time lag attachment shall operate on a slowly falling voltage, at normal frequency, between 65 per cent and 25 per cent of the rated service-voltage. At half of the normal frequency the lower limit of operating-voltage shall be not less than 15 per cent of the rated service-voltage.

b. If the under-voltage release is self-resetting, it shall require not more than 90 per cent of the rated service-voltage to reset it.

SECTION THREE : MARKING

MARKING THE NAMEPLATE

19. All circuit-breakers shall be provided with nameplates which shall be indelibly marked with the following rating data :—

a. The number of this British Standard, i.e. B.S. 116 : 1952.

b. Service-voltage.

c. Normal-current.

d. Frequency.

e. Making-capacity		peak	kA
f. Breaking-capacity :	Symmetrical		kA
	equivalent to		MVA
	Asymmetrical		kA
g. Short-time current	1-second		kA
or	3-second		kA

It shall also be marked with the following information, when applicable :—

h. The operating-duty of the circuit-breaker if it is more severe than that specified in Clause 25*b*.

j. The maximum and minimum operating voltage at the terminals of the closing device corresponding to the operating range, as defined in Clauses 14*a* and 14*b*.

k. The rated operating-voltage of the trip-coil, (see Clause 15).

l. Normal-current of series trip-coils or transformer-operated trip-coils, (see Clause 16*a*).

m. Rated making-current and rated short-time current of series trip-coils, or current-transformers, when the rated over-current of the series trip-coils or current-transformers is less than the rated making-current and rated short-time currents of the circuit-breaker as defined in this specification.

SECTION FOUR : SERVICE CONDITIONS

SYSTEM EARTHING

20. Standard circuit-breakers complying with this specification shall be suitable for use on systems earthed as given in *conditions a*, *b*(i), *b*(ii) and *d* below. Where the system is effectively earthed in accordance with *condition a*, and adequate surge protection is provided, standard circuit-breakers having insulation suitable for the test-voltages specified for effective earthing in Clauses 41, 42 and 62 may be used.

Circuit-breakers for use on systems having other earthing *conditions* (e.g. *b*(iii) and *c*) require special consideration (see Appendix D, Section 2*a*. Selection of rated service-voltage).

The following system earthing *conditions* are recognized :—

a. At least one of the neutral points of a three-phase system permanently earthed, either solidly or through a resistor or reactor of low impedance.

A three-phase system is considered to be effectively earthed if, during phase-earth faults, the voltage to earth of the sound phases does not exceed 80 per cent of the voltage between lines of the system. Generally this involves solid earthing of all transformer neutrals.

b. At least one of the neutral points of a three-phase system earthed normally through an arc suppression coil.

On such a system it is the intention that the majority of phase-earth faults will be self-clearing without interruption of the supply. When phase-earth faults occur which are not self-clearing three methods of system operation are recognized :

(i) The fault is automatically disconnected from the system after a short delay.

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(ii) When non-automatic disconnection is used the faults are generally cleared quickly although they may be allowed to persist for several hours provided that the total duration does not exceed 125 hours per annum, with a maximum of 8 hours in any 24.

(iii) Faults are allowed to remain for a longer duration than in (ii) but not approaching continuous operation with one phase earthed.

c. All the neutral points of a three-phase system insulated from earth.

d. A single-phase system having one line earthed.

AMBIENT TEMPERATURE

21. The performance of standard circuit-breakers shall be based on the following limits of ambient temperature :—

A peak value not exceeding 40°C. and an average value not exceeding 35°C. when measured over a 24-hour period (see Clause 27).

ALTITUDE

22. Standard circuit-breakers in accordance with this specification shall be suitable for use at an altitude not exceeding 3300 ft. above sea level (see Clauses 30 and 32).

ATMOSPHERIC CONDITIONS

23. Standard circuit-breakers in accordance with this specification shall be suitable for use in an atmosphere not subject to excessive pollution by smoke, chemical fumes, salt-laden spray, etc., such as may occur in some areas and coastal districts.

OPERATION

24. Standard circuit-breakers in accordance with this specification shall be suitable for the following short-circuit operating duty.

B—3′—MB—3′—MB

SECTION FIVE : OPERATION IN SERVICE

OPERATION IN SERVICE

25. *a.* The maintenance and the opening and closing operations shall be in conformity with the manufacturer's instructions for the manipulation and use of the circuit-breaker and its auxiliary apparatus.

b. A circuit-breaker shall be capable of operating at any current up to its rated making and rated breaking-capacity in accordance with the following duty and the requirements of Clause 44.

B—3′—MB—3′—MB

c. When operating conditions are more severe than those specified in Clause 25*b* above, a circuit-breaker shall be capable of operating in accordance with the number and kind of operations and the intervals for which it is rated.

d. The behaviour of a circuit-breaker shall be satisfactory irrespective of the proportions of D.C. and A.C. components of breaking-current, provided that the A.C. component does not exceed the rated symmetrical breaking-capacity and the asymmetrical breaking-current does not exceed the rated asymmetrical breaking-capacity.

e. During the operations referred to above, a circuit-breaker shall neither endanger the operator nor show undue distress. For example, there shall be no outward emission of flame or ignition of escaping gases. The gases produced, together with the oil displaced by the gases, shall be conducted from the circuit-breaker, and directed away from it so as not to cause electrical breakdown. The amount of oil lost during any of the opening and/or closing operations referred to in Sub-clauses 25*b* or 25*c* shall be such as not to affect the satisfactory subsequent behaviour of the circuit-breaker.

f. A circuit-breaker shall be capable of withstanding its rated service-voltage without dielectric failure after the operations described in Sub-clauses 25*b* or 25*c*. In addition, the mechanical parts and insulators of a circuit-breaker shall be essentially in the same condition as before the operations, and it shall be capable of making and breaking its normal-current, and of carrying it with a temperature-rise not greater than 10 Centigrade degrees in excess of the temperature-rise allowable under Section Six. The making-capacity and breaking-capacity may, however, be materially reduced.

g. After the operations described in Sub-clauses 25*b* or 25*c* and to restore the making-capacity and breaking-capacity to the original rated values, maintenance shall be undertaken. The following are typical adjustments :—

(i) Renewal of arcing-contacts and other parts that assist in extinguishing the arc.

(ii) Filtration or renewal of the oil, or the addition of oil necessary to restore its normal level.

(iii) Removal from the insulation of carbon or other deposit caused by decomposition of the oil.

OIL

26. Oil for normal use shall comply with B.S. 148, 'Insulating oils for electrical purposes'. When circuit-breakers are installed in places subject to freezing temperatures, an appropriate low-freezing oil, as specified in B.S. 148, shall be used, or alternatively, suitable steps shall be taken to prevent the oil from freezing, e.g. by the use of electrical heaters.

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SECTION SIX : LIMITS OF TEMPERATURE-RISE

REFERENCE AMBIENT TEMPERATURE

27. The temperature-rise of a circuit-breaker shall not exceed the appropriate value given in Clause 28 when based on an ambient temperature having a peak value not exceeding 40°C. and an average value not exceeding 35°C. measured over a 24-hour period.

NOTE. Under normal conditions of service the available cooling air is subjected to natural atmospheric variations of temperature, and hence the peak 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 Centigrade degrees below peak temperatures will occur within the same 24-hour period, and that the average temperature taken over any 24-hour period that includes the peak temperature will be at least [illegible] Centigrade degrees below the peak value. When 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 to an average value not exceeding 35°C.

If the ambient temperature exceeds that specified above, the permissible temperature-rise shall be reduced by an amount equal to the excess ambient temperature.

NOTE. Temperature-rises may be measured at normal room temperatures, since they are not materially affected by moderate changes in ambient temperature.

TEMPERATURE RISE OF PARTS OTHER THAN COILS

28. The maximum temperature-rises of parts other than coils shall not exceed the following values when the circuit-breaker is in clean new condition and is carrying its rated normal-current continuously.

a. For current carrying parts in oil or air (including contacts).

(i) For normal-current ratings of 800 amperes or less
40 Centigrade degrees.

(ii) For normal-current ratings above 800 amperes
50 Centigrade degrees.

(iii) When the main and isolating contacts have an adequate and durable silver facing, the temperature-rise for normal-current ratings of 800 amperes or less may be increased to
50 Centigrade degrees.

b. For all other parts in direct contact with insulation other than oil
50 Centigrade degrees.

The type-test record of millivolt-drop across contacts and/or terminals, or the equivalent resistance-measurement, shall be taken as a datum for all subsequent tests to indicate compliance with this clause.

NOTE. For notes on temperature-measurement see Appendix K.

TEMPERATURE-RISE OF COILS

29. *a.* Depending upon the material with which a coil is insulated, the temperature-rise of continuously-rated coils measured by thermometer or thermocouple on the surface (in accordance with Paragraph 1*a* or 1*b* of Appendix K), or by the self-resistance method (in accordance with Paragraph 1*c* of Appendix K), shall not exceed the appropriate value given in Table 4, Columns 2 and 3, and that of intermittently-rated coils shall not exceed the appropriate values in Columns 4 and 5.

TABLE 4. TEMPERATURE-RISE OF COILS

1	2	3	4	5
Insulating material	Maximum temperature-rise (Centigrade degrees)			
	Continuously-rated coils		Intermittently-rated coils	
	Thermometer or thermocouple	Self resistance method	Thermometer or thermocouple	Self resistance method
Class 0 (coils in air): cotton, silk, paper, and similar materials non-impregnated	40	60	45	65
Class A (coils in air): cotton, silk, paper, and similar materials impregnated; enamel associated with such fibrous material.	50	70	55	75
Enamelled wire not associated with such fibrous material.	65	80	75	90
Class B (coils in air): built-up asbestos, mica, and similar materials, and bare coils.	85	100	95	110
Class D (coils in air): synthetic-resin impregnated	65	80	75	90
All classes (coils in oil)	40	60	50	70

b. The requirements of Sub-clause 29*a* above shall apply to intermittently rated tripping-coils and closing-coils after operation at the rated normal voltage or current under one of the following conditions :—

(i) When the time of operation is dependent upon the operator, the current shall be maintained for 30 seconds.

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(ii) When the time of operation is independent of the operator, the operation shall be repeated ten times in rapid succession.

c. The temperature-rises stated in Clause 29*a* shall apply after continuous operation at the rated voltage and frequency for under-voltage releases, and at the rated current and frequency for over-current releases when set to trip at 133 per cent of the rated current.

TEMPERATURE-RISE CORRECTION FOR ALTITUDE

30. Circuit-breakers intended for service at altitudes not exceeding 3300 feet shall comply with the requirements of Clauses 28 and 29. When a circuit-breaker, intended for service at an altitude exceeding 3300 feet, is tested near sea-level, the limits of temperature-rise specified in Clauses 28 and 29 shall be reduced one per cent for each 1000 feet above sea-level at which the circuit-breaker is intended to work in service.

SECTION SEVEN : CONSTRUCTION

CLEARANCES AND INSULATOR LENGTHS

31. *a.* The clearances and lengths of insulators for indoor-type circuit-breakers Group A shall be not less than those given in Table 5. Class A clearances are the minimum values for use under standard conditions of service. Class B clearances shall be used only where special or more onerous conditions of service apply.

The clearances and lengths of insulators for indoor-type circuit-breakers Group B shall be not less than those given for Class B in Table 5.

The specified clearances are required only between bare conductors. They shall not be reduced except under the following conditions:—

(i) When solid insulation is interposed and the clearance distances, as measured by a taut string between conductors or to earth, are not less than the values specified in Table 5. Such insulation shall be capable of withstanding the full power-frequency high-voltage test value specified in Clause 62, for the appropriate rated service-voltage; the test being made in accordance with the relevant British Standard for the material.

(ii) When appropriate conductors are covered with insulation capable of withstanding the full power-frequency high-voltage test value specified in Clause 62 for the appropriate rated service-voltage.

(iii) When the space between the conductors is completely filled with insulating-material other than air at atmospheric pressure, as in oil-filled, compound-filled, or compressed-gas-filled switchgear, capable of withstanding the full power-frequency high-voltage test value specified in Clause 62 for the appropriate rated service-voltage.

b. The clearances for outdoor-type circuit-breakers having a rated service-voltage of 22 kV and above shall be sufficient to meet the requirements of the impulse-voltage tests specified in Clause 41. The clearances for outdoor-type circuit-breakers having rated service-voltages of 6·6 kV and 11 kV shall be in accordance with Table 7.

c. The clearances specified in Tables 5 and 7 shall apply to three-phase circuit-breakers for use on systems earthed in accordance with the provisions of Clause 20 *conditions a, b* (i) and *b* (ii).

d. For single-phase systems conforming to Clause 20, *condition d,* the lengths of insulators and clearances for indoor-type circuit-breakers shall be not less than those given in Columns 2, 3, 6 and 7 of Table 5, but the minimum clearance to earth, instead of being in accordance with Columns 4 and 5, shall be not less than the value of the minimum length of insulators given in Columns 2 and 3.

e. For indoor and outdoor neutral-earthing circuit-breakers the clearances in Tables 5 and 7 shall apply, with the proviso that values appropriate to the standard three-phase rated service-voltage nearest to the rated service-voltage of the neutral-earthing circuit-breaker shall be taken in accordance with Tables 6 and 8 respectively.

TABLE 5. CLEARANCES FOR INDOOR-TYPE OIL CIRCUIT-BREAKERS

1	2	3	4	5	6	7
Rated service-voltage	Minimum length of insulator in air		Minimum clearance to earth in air		Minimum clearance between poles or between terminals of one pole in air	
	Class A	Class B	Class A	Class B	Class A	Class B
kV	in.	in.	in.	in.	in.	in.
Up to 0·6	¾	1	¾	1	¾	1
3·3	2	3½	2	2½	2	3½
6·6	3½	5	2½	3	3½	5
11	5	7	3	4½	5	7
22	8	8	5½	5½	9½	9½
33	12	12	8¾	8¾	14	14
Above 33	Values subject to agreement between the manufacturer and the purchaser.					

NOTE 1. The clearances specified for voltages up to 0·6 kV are suitable for 0·66 kV.
NOTE 2. The length of insulator given is the direct length from the live metal to earth, regardless of the shape, i.e. a taut string measurement.

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TABLE 6. BASIS OF CLEARANCES FOR INDOOR-TYPE NEUTRAL-EARTHING OIL CIRCUIT-BREAKERS

1	2	3
Three-phase rated service-voltage	Rated service-voltage of neutral-earthing circuit-breaker	Standard three-phase rated service-voltage on which clearances to Table 5 are to be based
kV	kV	kV
3·3	1·91	3·3
6·6	3·81	3·3
11	6·35	6·6
22	12·7	11
33	19·1	22
44	25·4	33
66	38·1	Clearances subject to agreement between the manufacturer and purchaser.

TABLE 7. CLEARANCES FOR OUTDOOR-TYPE OIL CIRCUIT-BREAKERS

1	2	3
Rated service-voltage	Minimum clearance to earth in air	Minimum clearances between poles or terminals of one pole in air
kV	in.	in.
Up to 6·6	5½	7
11	7	9
Above 11	See Sub-clause 31*b*.	

NOTE 1. The lengths of insulators required are not specified since these will depend upon conditions of service such as altitude and degree of atmospheric pollution.

NOTE 2. The above clearances are to be regarded as the minimum values which may be used in any circumstances. Where the method of mounting bushings or insulators is not such as to prevent lodgement of birds or vermin, it may be necessary to employ larger clearances.

TABLE 8. BASIS OF CLEARANCES FOR OUTDOOR-TYPE NEUTRAL-EARTHING OIL CIRCUIT-BREAKERS

1	2	3
Three-phase rated service-voltage	Rated service-voltage of neutral-earthing circuit-breaker	Standard three-phase rated service-voltage on which clearances to Table 7 are to be based
kV	kV	kV
Up to 11	Up to 6·35	6·6
22	12·7	11
33	19·1	22 } See Clause 31*b*.
44	25·4	33 } See Clause 31*b*.
66	38·1	44 } See Clause 31*b*.

EFFECT OF ALTITUDE ON CLEARANCES AND INSULATION

32. Circuit-breakers shall have clearances in accordance with Tables 5 and 7 for service at altitudes not exceeding 3300 ft. above sea level. For higher altitudes clearances and insulation shall be suitable for the lower air density at the altitude in question.

The effect of high altitude is to lower the air flashover voltage compared with the flashover voltage at sea level, the puncture strength and oil flashover being unaffected.

The clearances specified in Tables 5 and 7 shall be increased by 3.5 per cent for each 1000 ft. in excess of 3300 ft. above sea level for indoor circuit-breakers up to 33 kV, and outdoor circuit-breakers up to 11 kV.

For outdoor circuit-breakers of 22 kV and above for altitudes exceeding 3300 ft. above sea level the insulation level of parts in air shall be selected by increasing the standard impulse withstand voltage and the standard wet withstand voltage by 3·5 per cent for each 1000 ft. in excess of 3300 ft. above sea level, and by choosing a circuit-breaker the air insulation of which is designed to withstand, at sea level, voltages corresponding to these adjusted values (see Clause 38).

CREEPAGE DISTANCES FOR OUTDOOR INSULATORS

33. It is recognized that for outdoor applications it is necessary to relate the creepage distance provided on the outdoor end of the insulator with the atmospheric conditions likely to be met in service. The recommendation of Appendix D, Section 2*d* should be considered in conjunction with Table 9 below, which gives the minimum creepage distances for insulators for:—

a. Normally polluted atmospheres.

b. Heavily polluted atmospheres.

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Insulators having a creepage distance in accordance with Column 2 are suitable for general use in most atmospheres (see Appendix D, Section 2*d*).

Insulators having creepage distances in accordance with Column 3 are suitable for more onerous service conditions where the atmosphere is heavily polluted (see Appendix D, Section 2*d*).

TABLE 9. CREEPAGE DISTANCES FOR OUTDOOR INSULATORS

1	2	3
Rated service-voltage	Minimum creepage distance for normally polluted atmospheres	Minimum creepage distance for heavily polluted atmospheres
kV	in.	in.
11	9	15
22	15	22
33	23	33
44	29	44
66	44	66
88	59	88
110	73	110
132	88	132
165	110	165
220	147	220
275	184	275
Insulators for neutral-earthing circuit-breakers only		
Up to		
6.35	5	9
12·7	9	15
19·1	15	22
25·4	23	33
38·1	29	44

The protected creepage distance for outdoor insulators having rated service-voltages of 33 kV and above in heavily polluted atmospheres shall be not less than half the creepage distance specified in Column 3. The protected creepage distance refers to that part of the insulator which is protected against rain at right angles to the axis of the insulator and which is assessed from lines at right angles to the axis touching the lowest edges of the skirts. A protected creepage distance for outdoor insulators in normally polluted atmospheres is not specified.

Methods of achieving satisfactory performance, other than the specification of creepage distance, for instance the use of designs improved by special measures, are permissible subject to agreement between manufacturer and purchaser.

BUSHING INSULATORS

34. Bushing insulators for both indoor and outdoor type circuit-breakers shall comply with B.S. 223, 'Electrical performance of high-voltage bushing-insulators'.

OUTDOOR CONSTRUCTION

35. Circuit-breakers intended for outdoor use shall be weatherproof.

OPERATING-MECHANISM

36. *a.* Circuit-breakers of Group A shall be provided with suitable closing mechanism for actuating them under all conditions within their ratings without endangering the operator (see Appendix D, Section 3*c*, Selection of operating-mechanisms for circuit-breakers).

b. Circuit-breakers of Group B shall be provided with suitable power closing mechanisms for operation from a distance. Auxiliary manual operating-mechanisms, where provided, shall be used only for maintenance and for emergency operation on a dead circuit.

c. When a circuit-breaker is provided with a spring-operated closing mechanism, the state of the spring shall be described as 'charged' when it is in a condition to close the circuit-breaker and 'free' when it is not in condition to close the circuit-breaker.

d. Operation of a power-operated closing device when a circuit-breaker is already closed shall neither cause damage to the circuit-breaker nor endanger the operator.

VENTILATING-OUTLETS

37. *a.* Ventilating-outlets from circuit-breakers shall be so situated that a discharge of oil or gases or both will not cause electrical breakdown and shall be directed away from any place where an operator may have to be in the course of his ordinary duties.

b. The construction shall be such that gas cannot collect at any point where ignition can be caused, during or after operation, by sparks arising from normal working of the circuit-breaker or its ancillary equipment.

SECTION EIGHT : TYPE-TESTS

GENERAL

38. All tests in accordance with this specification shall be type-tests except those specified in Section Nine which shall be routine tests. The

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circuit-breakers used for the type-tests shall be identical with those to be used in service in all details likely to affect their performance during individual type-tests and, for the purpose of the tests, shall be mounted in a manner representative of service conditions. For example, in breaking-capacity type-tests the test circuit-breakers shall be identical with those to be used in service in those features which affect breaking-capacity. Certificates of type-tests shall be considered as evidence of the compliance of circuit-breakers with the requirements of the relevant clauses of the specification and the manufacturer shall hold available such certificates together with detail drawings of the circuit-breakers and a record of any alterations that have been made in them subsequent to the type-test.

Type-tests in accordance with the following clauses shall be made and certified by a recognized authority, who may be the manufacturer :—

Mechanical endurance test—Clause 39.

Test of temperature-rise—Clause 40.

Impulse voltage test (Outdoor-type gear rated at 22 kV and above only)—Clause 41.

Wet test (Outdoor-type gear only)—Clause 42.

Making-capacity, breaking-capacity and short-time current tests—Clause 43.

Normally during type-testing at altitudes of less than 3300 ft. above sea-level it is not possible to demonstrate that the increased air insulation for circuit-breakers for service at altitudes exceeding 3300 ft. above sea-level has been obtained, since the puncture or oil flashover values may limit the increased impulse and wet test voltages which can be applied. In such cases the tests to be applied shall be subject to agreement between manufacturer and purchaser (see Clause 32).

MECHANICAL-ENDURANCE TEST

39. A mechanical-endurance test shall be made by closing and opening the circuit-breaker 500 times, of which one-tenth shall be MB operations (e.g. trip energized through main contacts), without normal current through the main current carrying contacts, after which all parts shall be in good order and shall not show permanent distortion or undue wear. The operating mechanism shall be used during this test, and if it is power-operated the auxiliary supply shall be controlled to give the force corresponding with the rated normal value (see Clause 14).

No mechanical adjustment shall be made during the test.

TESTS OF TEMPERATURE-RISE (*See Section Six*)

40. *a.* Tests of temperature-rise shall be made with alternating current at an average frequency not below 95 per cent of the rated frequency. For tripping-coils and closing-coils intended for operation with direct

current, the temperature-rise tests shall be made with direct current. Any temporary connections used for tests shall be such that their temperature-rise is not less than 80 per cent of the temperature-rise allowed in Clause 28, or not less than the actual temperature-rise of the adjacent current-carrying parts of the apparatus under test if this should be below 80 per cent of the specified maximum temperature-rise.

b. Type-tests for temperature-rise of circuit-breakers as a whole shall include also, for comparison with the results of routine tests, millivolt-drop tests or equivalent resistance measurements across the main contacts and across the circuit-breaker terminals (see Clause 61).

c. The temperature-rise during the type-tests shall be measured in accordance with Appendix K.

IMPULSE-VOLTAGE TESTS FOR OUTDOOR-TYPE CIRCUIT-BREAKERS

41. *a.* Circuit-breakers, having rated service-voltages of 22 kV and above, and constructed for outdoor service (see Appendix D, Section 2*e*, Insulation co-ordination) shall be subjected to impulse-voltage tests.

b. For these tests the circuit-breakers shall be in clean, new condition, and arcing horns or rings may be removed, or their spacing increased.

c. The test-voltage shall be a full impulse-voltage wave having a wave-front of 1 microsecond and a time to half-value of wave-tail of 50 microseconds, measurement of the wave-shape being made in accordance with B.S. 923, 'Impulse-voltage testing'.

The peak value of the test-voltages shall be not less than the value specified in the appropriate column of Table 10 for the appropriate rated service-voltage. These test-voltages may require correction for atmospheric conditions when they are applied to external insulation (see Appendix L).

d. The test-voltage shall be applied to the circuit-breakers as follows:—

(i) between each pole or phase and earth in turn, with the circuit-breaker closed and with the remaining poles or phases earthed.

(ii) between all the terminals on one side of the circuit-breaker and all the other terminals earthed, with the circuit-breaker open.

During the test one terminal of the output of the impulse-voltage generator shall be connected to earth and to the frame of the circuit-breaker.

Where the physical arrangement of one side of the break or breaks of a circuit-breaker differs from that of the other side, test (ii) shall be made with each side of the circuit-breaker alive in turn.

Five consecutive impulse-voltage waves shall be applied. If a flashover or puncture does not occur the circuit-breaker shall have passed the test. If puncture occurs or if two of the applied test waves cause flashover through air the circuit-breaker shall have failed. If one of the applied test

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waves causes flashover through air, five additional test waves shall be applied. Only if flashover through air or puncture does not occur on any of these last five waves shall the circuit-breaker be considered to have passed the test.

The circuit-breaker shall be capable of passing the specified test with voltages of both positive and negative polarity, but where there is evidence as to which polarity will give the lower breakdown voltage it is sufficient to test with that polarity.

The peak value, and the wave-shape of the test-voltage, shall be recorded by means of a cathode ray oscillogram of the voltage wave for the first and last wave applied in each group of five tests.

TABLE 10. IMPULSE-VOLTAGE TEST VALUES FOR OUTDOOR-TYPE OIL CIRCUIT-BREAKERS

1	2	3	4
Rated service-voltage	Peak value of impulse test-voltage (withstand)		
	All circuit-breakers for systems up to 88 kV	Circuit-breakers for non-effectively earthed systems of 110 kV and above	Circuit-breakers for effectively earthed systems of 110 kV and above
kV	kV	kV	kV
22	150	—	—
33	190	—	—
44	260	—	—
66	330	—	—
88	450	—	—
110	—	550	450
132	—	630	550
165	—	730	630
220	—	1050	890
275	—	—*	1050

NOTE. These values are provisional pending I.E.C. agreement on impulse-voltage test values. When this agreement has been obtained the above values will be subject to review.

* All 275 kV systems are considered for this specification to be effectively earthed (see Clause 41*g*).

e. For three-phase circuit-breakers for a rated service-voltage above 66 kV, comprising three single pole units, the tests specified in Clauses 41*d* (i) and 41*d* (ii) may be made on a single pole only, provided that the clearance between poles in the final assembly is agreed between manufacturer and purchaser.

f. The impulse test-voltages specified in Table 10, Columns 2 and 3, apply to three-phase circuit-breakers for use on systems earthed in accordance with the provisions of Clause 20, *conditions a* (except as qualified by Clause 41*g*), *b* (i) and *b* (ii) and to circuit-breakers for single-phase systems conforming with Clause 20 *condition d*.

g. For three-phase circuit-breakers for systems of 110 kV and above, and effectively earthed in accordance with Clause 20, *condition a* and provided with adequate surge protection, the impulse test-voltages shall be those corresponding to Column 4 of Table 10.

POWER-FREQUENCY VOLTAGE WET TEST FOR EXTERNAL INSULATION OF OUTDOOR-TYPE CIRCUIT-BREAKERS

42. *a.* Bushings shall comply with the wet test specified in B.S. 223, 'Electrical performance of high-voltage bushing insulators', and evidence of compliance with that British Standard shall be accepted as satisfying the requirements of this Clause.

b. Where the external insulation of the circuit-breaker is not included in the scope of B.S. 223, a test shall be made as follows:—

The external insulation of the circuit-breaker shall be subjected to artificial rain sprayed at an angle of 45 degrees to the vertical at the rate of approximately 0·12 in. (3·05 mm.) per minute. The volume resistivity of the water, measured at the temperature (between 15°C. and 25°C.) at which it is sprayed, shall be between 9000 and 11 000 ohm-centimetres. The artificial rain shall be a finely divided and reasonably uniform spray.

The external insulation of the circuit-breaker shall be sprayed for two minutes with rated service-voltage applied to it before the test-voltage is applied.

The test-voltage shall be as given in the appropriate column of Table 11 for the appropriate rated service-voltage and for standard air density (i.e. air density correction factor unity) and shall be applied for 30 seconds without flashover occurring.

For other than standard air density the test-voltage shall be corrected as given in Appendix L.

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TABLE 11. POWER-FREQUENCY VOLTAGE VALUES FOR WET TESTS ON THE EXTERNAL INSULATION OF OUTDOOR-TYPE OIL CIRCUIT-BREAKERS

1	2	3	4
	Test-voltage (withstand)		
Rated service-voltage	All circuit-breakers for systems up to 88 kV	Circuit-breakers for non-effectively earthed systems of 110 kV and above	Circuit-breakers for effectively earthed systems of 110 kV and above
kV	kV	kV	kV
3·3	16	—	—
6·6	22	—	—
11	30	—	—
22	55	—	—
33	80	—	—
44	100	—	—
66	150	—	—
88	195	—	—
110	—	240	195
132	—	285	240
165	—	350	285
220	—	460	385
275	—	—*	460

* All 275 kV systems are considered for this specification to be effectively earthed (see Clause 42*d*).

c. The test-voltages specified in Table 11, Columns 2 and 3, apply to three-phase circuit-breakers for use on systems earthed in accordance with the provisions of Clause 20, *conditions a* (except as qualified by Clause 42*d*), *b* (i) and *b* (ii) and to circuit-breakers for single-phase systems conforming with Clause 20, *condition d*.

d. For three-phase circuit-breakers for systems of 110 kV and above, and effectively earthed in accordance with Clause 20, *condition a*, and provided with adequate surge protection the test-voltages shall be those corresponding to Column 4 of Table 11.

MAKING-CAPACITY, BREAKING-CAPACITY, AND SHORT-TIME CURRENT TESTS OF CIRCUIT-BREAKERS: GENERAL

43. *a.* Type-tests of circuit-breakers shall comply with the requirements of Clauses 44 to 58.

b. When type-tests of circuit-breakers have been made, a certificate issued by the testing-authority shall show the performance-values obtained for each operating-duty specified, and shall state whether the circuit-breaker closed or tripped free (see Definitions 52 and 53 of Clause 4).

Type-test certificates of rating shall be issued only when the circuit-breaker has satisfactorily performed the series of test-duties in accordance with this standard, and shall state any departures from strict compliance, including the deviations permitted by Sub-clause 47*f*, whether or not these are considered immaterial by the testing authority.

Appendix F states the information which shall be included in certificates of rating and other reports of type-tests for making-capacity and breaking-capacity ratings and for short-time current ratings in accordance with this specification.

CONDITION OF CIRCUIT-BREAKER FOR TESTS

44. *a.* All circuit-breakers subjected to short-circuit test shall be complete with their own operating mechanisms and shall truly represent their own type in all details of construction as recorded in certified drawings. Hand-operated circuit-breakers shall be so closed on test as to simulate service conditions as closely as possible.

A circuit-breaker supplied as an integral part of a complete draw-out type metal-clad unit shall be assembled in its own supporting structure, complete with isolating features, with vent-outlets forming part of the unit, and where practicable with main connections and busbars. For the purpose of the test, current transformers may be replaced by copper links. All other circuit-breakers shall be mounted for short-circuit tests on their own supporting structure, or its equivalent where use of their own structure is impracticable.

Appropriate electrical connections shall be made to the trip circuit auxiliary switches, and such auxiliary switches shall be operative.

b. Circuit-breakers of Group A, and those of Group B which have their arcing-contacts supported within a common or single tank, shall be tested as complete circuit-breakers. Multi-tank circuit-breakers of Group B, which have their arcing-contacts of each phase supported within a separate tank, shall be tested preferably as complete circuit-breakers, but for convenience, or owing to the limitation of testing-plant capacity, one phase alone may be tested provided that it is equivalent over the range of tests to the complete circuit-breaker in respect of :

(i) Speed of make.
(ii) Speed of break.
(iii) Availability of arc-extinguishing medium.
(iv) Power and strength of closing and tripping mechanism.
(v) Rigidity of structure.

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Test-duty 4*a*, however, of Clause 47*f* shall preferably be performed on a three-phase unit.

Power-closing and tripping devices shall be energized in accordance with Clauses 14 and 15, at 80 per cent of the rated auxiliary supply voltage (or 80 per cent of the designed normal voltage of the closing device—see Clause 14*b*). The air supply for compressed air closing devices shall be, in accordance with Clause 14*c*, at minimum (lockout) pressure.

c. Circuit-breakers with series trip-coils or over-current release coils shall be fitted for test in accordance with Clauses 47 and 58 as specified below, and such series trip-coils or over-current release coils shall be connected to the live side of the test-circuit.

(i) *For Clause* 47 *: Standard type-test duties*. With the coil of the maximum current-rating set to operate at the maximum current and maximum time-lag settings for test-duties 1 to 4 (thus keeping the D.C. component to a minimum) and at the minimum current and minimum time-lag settings for test-duty 5 (thus making the D.C. component a maximum).

NOTE. When the time-lag is too great for convenient oscillographic recording it is permissible to use a setting less than the maximum time-lag setting or to make the time-lag device inoperative for test-duties 1 and 2 only.

(ii) *For Clause* 58 *: Short-time current tests*. With the coil of the minimum current-rating set to operate at the maximum current and maximum time-lag (thus subjecting the circuit-breaker fitted with the coil of the minimum current rating to a short-circuit current of maximum duration).

d. Where the physical arrangement of one side of the break or breaks of a circuit-breaker differs from that of the other side, the live side of the test-circuit shall be connected for test to that side of the circuit-breaker, connection with which gives the more onerous condition.

POWER-FACTOR OF THE TEST-CIRCUIT

45. *a*. The power-factor of the circuit shall not exceed 0·15 lagging for circuit-breakers in Group A, and 0·3 lagging for circuit-breakers in Group B, when determined by methods given in Appendix G, and shall be the power-factor before contact-separation.

b. The power-factor of a polyphase circuit shall be deemed to be the average of the cosines of the angles of lag in all the phases.

c. The power-factor of any phase shall not vary from the average by more than 25 per cent of the average.

EARTHING THE TEST-CIRCUIT

46. *a*. *General*. The test-circuit in which a circuit-breaker is connected shall produce a voltage distribution between poles, and between poles and earthed metal, as nearly as possible the same as that existing under service conditions.

b. *For three-phase tests*. Whenever possible the neutral point of a supply to a test-circuit shall be insulated and the short-circuit point shall be earthed, the circuit-breaker having its structure earthed as in service (see Fig. 4*a*).

When the above connections cannot be made, the neutral point of the testing supply may be earthed and the short-circuit point insulated (see Fig. 4*b*).

In either case the connections used shall be shown in the test report.

c. *For single-phase tests*. When testing single-phase circuit-breakers of Group A, or single-pole units of three-phase circuit-breakers of Group B, it may be difficult owing to limitations of the testing plant, to obtain the required voltage value between pole and earthed metal simultaneously with the necessary voltage between terminals. In such cases the value of voltage between pole and earthed metal shall be as nearly as convenient in accordance with the appropriate value shown below; in all cases the connections used shall be shown in the test report.

(i) Circuit-breakers for single-phase systems—100 per cent rated service-voltage.

Typical test-circuits are shown in Figs. 4*c* and 4*d*.

(ii) Circuit-breakers for three-phase insulated systems and three-phase systems not effectively earthed, or in which unearthed neutrals may occur—87 per cent rated service-voltage.

Typical test-circuits are shown in Figs. 4*e* and 4*f*.

(iii) Circuit-breakers for three-phase effectively earthed systems where all neutral points adjacent to the circuit-breaker are effectively earthed—58 per cent rated service-voltage.

Typical test-circuits are shown in Figs. 4*e* and 4*f*.

STANDARD TYPE-TEST DUTIES

47. *a*. The standard type-tests shall consist of the following series of test-duties:—

Test-duty (1) B—3′—B—3′—B at 10 per cent of the rated symmetrical breaking-capacity.

Test-duty (2) B—3′—B—3′—B at 30 per cent of the rated symmetrical breaking-capacity.

Test-duty (3) B—3′—B—3′—B at 60 per cent of the rated symmetrical breaking-capacity.

Test-duty (4) B—3′—MB—3′—MB at not less than 100 per cent of the rated symmetrical breaking-capacity, and not less than 100 per cent of the rated making-capacity.

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Test-duty (5) B—3′—B—3′—B at not less than 100 per cent of the rated asymmetrical breaking-capacity and with a D.C. component at the moment of contact-separation not less than 50 per cent of the A.C. component in one phase in each breaking operation.

For test-duties 1, 2, 3 and 4 the breaking-current in any phase shall not include a D.C. component greater than 20 per cent of the A.C. component at the instant of contact-separation (see Fig. 2).

b. When the rated operating-duty as marked on the nameplate differs from the standard operating-duty specified in Clause 24, the test-duties specified above shall be modified appropriately.

c. For circuit-breakers in Group A the recovery-voltage (Clause 56) for the breaking operations of all test-duties shall be not less than 95 per cent of the rated service-voltage.

For circuit-breakers in Group B the recovery-voltage for the breaking-operation of all test-duties shall be as near to 100 per cent of the rated service-voltage as is practicable for the testing-plant, and in any case for ratings up to and including 1500 MVA it shall be not less than the minimum recovery-voltage shown in Fig. 8. For circuit-breakers rated above 1500 MVA the method of test and values of recovery-voltage shall be the subject of agreement between the manufacturer and the purchaser.

For circuit-breakers in Group A and Group B, the recovery-voltage for the breaking operations of all test duties shall be maintained for at least 5 cycles after interruption of the short-circuit current.

d. For all circuit-breakers in Group A the value of the applied voltage when performing test-duty 4*a* as permitted by Clause 47*f*, shall be not less than 100 per cent of the rated service-voltage. For circuit-breakers in Group B, this applied voltage shall be as near to 100 per cent of the rated service-voltage as is practicable for the testing plant.

e. For circuit-breakers which operate so rapidly that the current cannot properly be measured, or which distort from sine wave form the first major loop of current made or broken, or which inherently reduce the making- and breaking-current, the prospective making-current and prospective breaking-current shall be measured from oscillograms obtained by means of prospective current tests.

f. Permissible deviations. The following deviations from the specified requirements are permitted :—

(i) *Test-duties.* If on test-duty 4 it is impossible to keep the D.C. component within the prescribed limit, or if the current-decrement is such that to obtain the specified breaking-current and recovery-voltage it is necessary to have a making-current more than 110 per cent of the rated making-capacity, or to reduce the applied voltage

below 100 per cent of the rated service-voltage, the making-tests and breaking-tests may be made separately as follows :—

4*a* Make-tests M—3′—M

4*b* Break-tests B—3′—B—3′—B.

For convenience in testing, it is permissible to introduce, in test-duty 4*a*, breaking-operations immediately following the making-operations. The breaking-current and the recovery-voltage may then be less than the specified values, but shall never exceed them without the manufacturer's agreement. When such breaking-operations follow the making-operations in test duty 4*a*, it is then permissible between test-duties 4*a* and 4*b* to restore the circuit-breaker to its initial conditions, as indicated in Clause 49.

If it is possible to prove 100 per cent making-capacity in a test-duty other than test-duty 4, it is permissible to perform test-duty 4*b* only in place of test-duty 4.

(ii) *Breaking-currents.* For test-duties 1, 2 and 3 the breaking-currents may depart from the specified values by ± 20 per cent of the specified value.

(iii) *D.C. component.*

A. If the testing authority so require, the breaking-currents of test-duties 3 and 4 of circuit-breakers in Group B may include a D.C. component at contact-separation in excess of 20 per cent of the A.C. component, provided that the value of active recovery-voltage ascribed to the test is reduced according to the actual D.C. component. The active recovery-voltage shall be determined in accordance with Clause 57 and shall be as near to 100 per cent as is practicable, and in any case it shall be not less than the minimum recovery-voltage specified by Fig. 8 .

B. Circuit-breakers, with the exception of those which operate in times preventing the control of the D.C. component, shall be considered to have satisfied test-duty 5, if during test, the highest D.C. component in one break operation is less than 50 per cent of the A.C. component, provided that the average of the D.C. components in the most asymmetrical phase of each of the three break operations exceeds 50 per cent of the A.C. component.

C. For circuit-breakers which operate in times preventing the control of the D.C. component, when in a condition for test as set out in Clause 44*c*, the D.C. component may be greater than that specified for test-duties 1 to 4 and less than that specified for test-duty 5.

D. If when testing single-phase circuit-breakers, or single-pole units of three-phase circuit-breakers, it is impracticable to obtain the D.C. component specified for test-duty 5, it is permissible to have

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