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Part 1: Circuit-breakers



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR

Part 1: Circuit-breakers

FOREWORD

- 1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- 2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- 3) In order to promote international unification, the IEC expresses the wish that all National Committees should adopt the text of the IEC recommendation for their national rules in so far as national conditions will permit. Any divergence between the IEC recommendations and the corresponding national rules should, as far as possible, be clearly indicated in the latter.

PREFACE

This Recommendation has been prepared by Sub-Committee 17B, Low-Voltage Switchgear and Controlgear, of IEC Technical Committee No. 17, Switchgear and Controlgear.

During the meeting held in Paris in 1967, it was decided to revise the first edition of this Publication, issued in 1964, and to incorporate the moulded-case circuit-breakers.

Two successive drafts were respectively circulated in January 1970 and, after examination by the Sub-Committee in Washington, in December 1970. During the meeting held in Brussels in 1971, it was decided to circulate, according to the accelerated procedure, a third document which, at a later period, was considered as submitted to the Six Months' Rule from 1st April 1972.

The following countries voted explicitly in favour of publication:

Belgium	Poland
Czechoslovakia	Portugal
France	Romania
Germany	South Africa
Hungary	Spain
Israel	Sweden
Italy *	Switzerland
Japan	Turkey
Netherlands	United Kingdom
Norway	Yugoslavia

The US National Committee has cast a negative vote since it considers too high the value of the temperature-rise limit of 70 °C for the circuit-breaker terminals (Clause 7.3.2, Table V).

This publication is formed by the second edition issued in 1973, Supplement A issued in 1976 and Supplement B issued in 1979.

* With the exception of the caption of category P-1 in Table II of Clause 4.3.6.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR

Part 1: Circuit-breakers

1. General

1.1 Scope

This recommendation applies to circuit-breakers, the main contacts of which are intended to be connected to circuits the rated voltage of which does not exceed 1 000 V a.c. or 1 200 V d.c.; it also contains additional requirements for integrally-fused circuit-breakers.

It applies whatever the rated currents, the method of construction (e.g. conventional circuit-breakers, moulded-case circuit-breakers) or the proposed applications of the circuit-breakers may be.

Supplementary requirements for circuit-breakers used as ~~direct~~ direct-on-line starters are given in IEC Publication 292-1, 'Low-voltage Motor Starters. Part 1: Direct-on-line (full voltage) a.c. starters'.

The requirements for circuit-breakers intended to be accessible to and operated by unskilled people on domestic and similar installations are contained in Publication 157-2 (under consideration).

Particular requirements for circuit-breakers which are also intended to provide earth-leakage protection are under consideration.

Note. — Circuit-breakers which are dealt with in this recommendation may be provided with devices for automatic opening under pre-determined conditions other than those of over-current and under-voltage as, for example, reversal of power or current. This recommendation does not deal with the verification of operation under such pre-determined conditions.

1.2 Object

The object of this recommendation is to state:

- 1) the characteristics of circuit-breakers;
- 2) the conditions with which circuit-breakers must comply with reference to:
 - a) their operation and behaviour in normal service,
 - b) their operation and behaviour in case of overload,
 - c) their operation and behaviour in case of short-circuit,
 - d) their dielectric properties;
- 3) the tests intended for confirming that these conditions have been met and the methods to be adopted for these tests;
- 4) the data to be marked on the apparatus.

2. Definitions

For the purpose of this recommendation, the following definitions shall apply:

2.1 Devices

2.1.1 Switching device

A device designed to make or break the current in one or more electric circuits.

2.1.2 *Mechanical switching device*

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

2.1.3 *Fuse*

A switching device that, by the melting of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted and breaks the current when this exceeds a given value for a sufficient time.

Note. — The fuse comprises all the parts that form the complete switching device.

2.1.4 *Circuit-breaker (mechanical)*

A mechanical switching device, capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and breaking currents under specified abnormal circuit conditions such as those of short-circuit.

Note. — A circuit-breaker is usually intended to operate infrequently, although some types are suitable for frequent operation.

2.1.5 *Integrally-fused circuit-breaker*

A combination, in a single device, of a circuit-breaker and fuses, one fuse being placed in series with each pole of the circuit-breaker intended to be connected to a phase conductor.

2.2 *General terms*

2.2.1 *Over-current*

Any current exceeding the rated current.

2.2.2 *Overload*

Operating conditions in an electrically undamaged circuit, which cause an over-current.

Note. — An overload may cause damage if sustained for a sufficient time.

2.2.3 *Interlocking device*

A device which makes the operation of a circuit-breaker dependent upon the position or operation of one or more other pieces of equipment.

2.2.4 *Anti-pumping device*

A device which prevents reclosing after a close-open operation as long as the device initiating closing is maintained in the position for closing.

2.2.5 *Main circuit (of a circuit-breaker)*

All the conductive parts of a circuit-breaker included in the circuit which it is designed to close or open.

2.2.6 *Control circuit (of a circuit-breaker)*

All the conductive parts (other than the main circuit) of a circuit-breaker which are included in a circuit used for the closing operation or opening operation, or both, of the circuit-breaker.

2.2.7 *Auxiliary circuit (of a circuit-breaker)*

All the conductive parts of a circuit-breaker which are intended to be included in a circuit other than the main circuit and the control circuits of the circuit-breaker.

Note. — Some auxiliary circuits serve supplementary requirements such as signalling, interlocking, etc., and as such they may be part of the control circuit of another switching device.

2.2.8 *Pole (of a circuit-breaker)*

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

2.2.9 *Closed position*

The position in which the pre-determined continuity of the main circuit of the circuit-breaker is secured.

2.2.10 *Open position*

The position in which the pre-determined clearance between open contacts in the main circuit of the circuit-breaker is secured.

2.2.11 *Ambient air temperature*

The temperature, determined under prescribed conditions, of the air surrounding the complete circuit-breaker (e.g., for enclosed circuit-breakers, it is the air outside the enclosure).

2.2.12 *Operation*

The transfer of the moving contact(s) from one position to an adjacent position.

Notes 1. — This may be a closing operation or an opening operation.

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

2.2.13 *Operating cycle*

A succession of operations from one position to another and back to the first position through all other positions, if any.

Note. — A succession of operations not forming an operating cycle is referred to as an *operating series*.

2.2.14 *Operating sequence*

A succession of specified operations with specified time intervals.

2.2.15 *Short-circuit current*

An over-current resulting from a short-circuit due to a fault or an incorrect connection in an electric circuit.

2.3 *Constructional elements*

2.3.1 *Main contact*

A contact included in the main circuit of a circuit-breaker, intended to carry in the closed position the current of the main circuit.

2.3.2 *Arcing contact*

A contact on which the arc is intended to be established.

Note. — An arcing contact may serve as a main contact. It may be a separate contact so designed that it opens after and closes before another contact which it is intended to protect from injury.

2.3.3 *Control contact*

A contact included in a control circuit of a circuit-breaker and mechanically operated by the circuit-breaker.

2.3.4 *Auxiliary contact*

A contact included in an auxiliary circuit and mechanically operated by the circuit-breaker.

2.3.5 *a-contact (make contact)*

A control or auxiliary contact which is closed when the main contacts of the circuit-breaker are closed and open when they are open.

2.3.6 *b-contact (break contact)*

A control or auxiliary contact which is open when the main contacts of the circuit-breaker are closed and closed when they are open.

2.3.7 *Release*

A device, mechanically connected to a circuit-breaker, which releases the holding means and permits the opening or the closing of the circuit-breaker.

2.3.8 *Instantaneous release*

A release which operates without any intentional time-delay.

2.3.9 *Making-current release*

A release which permits a circuit-breaker to open, without any intentional time-delay, during a closing operation, if the making current exceeds a pre-determined value, and which is rendered inoperative when the circuit-breaker is in the closed position.

2.3.10 *Over-current release*

A release which permits a circuit-breaker to open with or without delay when the current in the release exceeds a pre-determined value.

Note. — This value can in some cases depend upon the rate-of-rise of current.

2.3.11 *Definite time-delay over-current release*

An over-current release which operates with a definite time-delay, which may be adjustable, but is independent of the value of the over-current.

2.3.12 *Inverse time-delay over-current release*

An over-current release which operates after a time-delay inversely dependent upon the value of the over-current.

Note. — Such a release may be designed so that the time-delay approaches a definite minimum value for high values of over-current.

2.3.13 *Direct over-current release*

An over-current release directly energized by the current in the main circuit of a circuit-breaker.

2.3.14 *Indirect over-current release*

An over-current release energized by the current in the main circuit of a circuit-breaker through a current transformer or a shunt.

2.3.15 *Overload release*

An over-current release intended for protection against overloads.

2.3.16 *Thermal overload release*

An inverse time-delay overload release depending for its operation (including its time-delay) on the thermal action of the current flowing in the release.

2.3.17 *Reverse current release (d.c. only)*

A release which permits a circuit-breaker to open, with or without delay, when the current flows in reverse direction and exceeds a pre-determined value.

2.3.18 *Shunt release*

A release energized by a source of voltage.

Note. — The source of voltage may be independent of the voltage of the main circuit.

2.3.19 *Under-voltage release*

A shunt release which permits a circuit-breaker to open or close, with or without delay, when the voltage across the terminals of the release falls below a pre-determined value.

2.3.20 *Conductive part*

A part which is capable of conducting current although it may not necessarily be used for carrying service current.

2.3.21 *Exposed conductive part*

A conductive part which can be touched readily and which normally is not alive, but which may become alive under fault conditions.

Note. — Typical exposed conductive parts are walls of enclosures, operating handles, etc.

2.4 *Conditions of operation*

2.4.1 *Closing operation*

An operation by which the circuit-breaker is brought from the open position to the closed position.

2.4.2 *Opening operation*

An operation by which the circuit-breaker is brought from the closed position to the open position.

2.4.3 *Dependent manual operation*

An operation solely by means of directly applied manual energy, such that the speed and force of the operation are dependent upon the action of the operator.

2.4.4 *Dependent power operation*

An operation by means of energy other than manual, where the completion of the operation is dependent upon the continuity of the power supply (to solenoids, electric or pneumatic motors, etc.).

2.4.5 *Stored energy operation*

An operation by means of energy stored in the mechanism itself prior to the completion of the operation and sufficient to complete it under pre-determined conditions.

Note. — This kind of operation may be subdivided according to:

- 1) the manner of storing the energy (spring, weight, etc.);
- 2) the origin of the energy (manual, electric, etc.);
- 3) the manner of releasing the energy (manual, electric, etc.).

2.4.6 *Independent manual operation*

A stored energy operation where the energy originates from manual power, stored and released in one continuous operation, such that the speed and force of the operation are independent of the action of the operator.

2.4.7 *Fixed trip circuit-breaker*

A circuit-breaker which cannot be released except when it is in the closed position.

2.4.8 *Trip-free circuit-breaker*

A circuit-breaker the moving contacts of which 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 momentarily reach the closed position.

2.4.9 *Circuit-breaker with lock-out preventing closing*

A circuit-breaker in which each of the moving contacts is prevented from closing sufficiently to be capable of passing current if the closing command is initiated while specified conditions remain established.

2.5 *Characteristic quantities*

2.5.1 *Rated value*

A stated value of any one of the characteristic quantities that serve to define the working conditions for which the circuit-breaker is designed and built.

2.5.2 *Prospective current (of a circuit, and with respect to a circuit-breaker)*

The current that would flow in the circuit, if each pole of the circuit-breaker were replaced by a conductor of negligible impedance.

Note. — The prospective current may be qualified in the same manner as an actual current, e.g.: prospective breaking current, prospective peak current, etc.

2.5.3 *Prospective peak current*

The peak value of a prospective current during the transient period following initiation.

Note. — The definition assumes that the current is made by an ideal circuit-breaker, i.e. with *instantaneous* transition from infinite to zero impedance. For circuits where the current can follow several different paths, e.g. polyphase circuits, it further assumes that the current is made *simultaneously* in all poles, even if only the current in one pole is considered.

2.5.4 *Maximum prospective peak current (of an a.c. circuit)*

The prospective peak current when initiation of the current takes place at the instant which leads to the highest possible value.

Note. — For a multipole circuit-breaker in a polyphase circuit, the maximum prospective peak current refers to a single pole only.

2.5.5 *Making capacity*

A value of prospective peak current that a circuit-breaker is capable of making at a stated voltage under prescribed conditions of use and behaviour.

2.5.6 *Breaking current*

The current in a pole of a circuit-breaker at the instant of initiation of the arc during a breaking operation.

2.5.7 *Breaking capacity*

A value of prospective breaking current that a circuit-breaker is capable of breaking at a stated voltage under prescribed conditions of use and behaviour.

2.5.8 *Short-circuit making (or breaking) capacity*

A making (or breaking) capacity for which the prescribed conditions include a short-circuit at the terminals of the circuit-breaker.

2.5.9 *Short-time withstand current*

The current that a circuit-breaker can carry in the closed position during a specified short time under prescribed conditions of use and behaviour.

Note. — Account has to be taken both of the I^2t let-through and also of the electro-mechanical effects associated with the peak current.

2.5.10 *Peak withstand current*

The value of peak current that a circuit-breaker can withstand in the closed position under prescribed conditions of use and behaviour.

2.5.11 *Applied voltage*

The voltage which exists across the terminals of a pole of a circuit-breaker just before the making of the current.

2.5.12 *Recovery voltage*

The voltage which appears across the terminals of a pole of a circuit-breaker after the breaking of the current.

Note. — This voltage may be considered in two successive intervals of time, one during which a transient voltage exists, followed by a second one during which power-frequency voltage alone exists.

2.5.12.1 *Transient recovery voltage (abbreviation: TRV)*

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

Notes 1. — The transient voltage may be oscillatory or non-oscillatory or a combination of these depending on the characteristics of the circuit and the circuit-breaker. It includes the voltage shift of the neutral of a polyphase circuit.

2. — The transient recovery voltage in three-phase circuits is, unless otherwise stated, that across the first pole to clear because this voltage is generally higher than that which appears across each of the other two poles.

2.5.12.2 *Power-frequency recovery voltage*

The recovery voltage after the transient voltage phenomena have subsided.

Note. — This definition applies also to the case of d.c., the frequency then being considered as zero.

2.5.13 *Opening time (until separation of the arcing contacts)*

The opening time until separation of the arcing contacts of a circuit-breaker is defined according to the type of its opening release as stated below and with any time-delay device forming an integral part of the circuit-breaker adjusted to its minimum setting or, if possible, cut out entirely:

- a) For a circuit-breaker tripped by any form of auxiliary power, the opening time is measured from the instant of application of the auxiliary power to the opening release of the circuit-breaker, when in the closed position, to the instant when the arcing contacts have separated in all poles.
- b) For a circuit-breaker tripped by a current in the main circuit without the aid of any form of auxiliary power, the opening time is measured from the instant at which, the circuit-breaker being in the closed position, the current in the main circuit reaches the operating value of the over-current release to the instant when the arcing contacts have separated in all poles.

2.5.14 *Arcing time*

2.5.14.1 *Arcing time of a pole*

The interval of time between the instant of the initiation of the arc and the instant of final arc extinction in *that* pole.

2.5.14.2 *Arcing time of a multipole circuit-breaker*

The interval of time between the instant of the first initiation of an arc and the instant of final arc extinction in *all* poles.

2.5.15 *Critical breaking current*

A value of breaking current, less than the rated short-circuit breaking capacity, at which the arcing time is significantly longer or the arc energy is significantly higher than at the rated short-circuit breaking capacity.

2.5.16 *Break-time*

The interval of time between the beginning of the opening time of a circuit-breaker and the end of the arcing time.

2.5.17 *Make-time*

The interval of time between the initiation of the closing operation and the instant when the current begins to flow in the main circuit.

Note. — The make-time includes the operating time of any auxiliary equipment necessary to close the circuit-breaker and forming an integral part of the circuit-breaker.

2.5.18 *Make-break time*

The interval of time between the instant when the current begins to flow in a pole and the instant of final arc extinction in all poles, with the opening release energized at the instant when current begins to flow in the main circuit.

2.5.19 *Current setting (of an over-current release)*

The value of the operating current for which the release is adjusted and in accordance with which its operating conditions are defined.

2.5.20 *Current setting range (of an over-current release)*

The range between the minimum and maximum values over which the current setting of the release can be adjusted.

2.5.21 *Take-over current*

The value of current corresponding to the intersection of the characteristics of operation of two over-current protecting devices (either I^2t or homogeneous time-current characteristic curves).

Note. — When a circuit-breaker is associated with a back-up device (fuse or another circuit-breaker) generally intended for protecting it from short-circuits exceeding its breaking capacity, one must distinguish:

a) the take-over current I_B : the maximum over-current value beyond which the back-up device will necessarily operate;

Note. — The take-over current may also be defined as the back-up limit of current.

b) the selectivity limit of current I_S : the maximum over-current value at which the circuit-breaker will operate alone (see Figures 7 and 8, page 113).

2.5.22 *Conventional non-tripping current (of an overload release)*

A specified value of current which the release is capable of carrying for a specified time (conventional time) without operating.

2.5.23 *Conventional tripping current (of an overload release)*

A specified value of current which causes the release to operate within a specified time (conventional time).

2.5.24 *Clearance*

The distance between two conductive parts along a string stretched the shortest way between these conductive parts.

2.5.24.1 *Clearance between poles*

The clearance between any conductive parts of adjacent poles.

2.5.24.2 *Clearance to earth*

The clearance between any conductive parts and any parts which are earthed or intended to be earthed.

2.5.24.3 *Clearance between open contacts (gap)*

The total clearance between the contacts, or any conductive parts connected thereto, of a pole of a circuit-breaker in the open position.

2.5.25 *Creepage distance*

The shortest distance along the surface of an insulating material between two conductive parts.

Note. — A joint between two pieces of insulating material is considered part of the surface.

2.5.26 *Joule integral (I^2t)*

The integral of the square of the current over a given time interval:

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

Note. — This definition is that of the International Electrotechnical Vocabulary (I.E.V.) (441-07-14) without the notes.

2.5.26.1 *I²t characteristic of a circuit-breaker*

A curve giving the values of I^2t related to break times (generally minimum or maximum values of I^2t) as a function of the prospective current under stated conditions of operation.

Note. — Normally it is sufficient to quote maximum and minimum values of I^2t at rated breaking capacity.

2.5.26.2 *I²t zone of a circuit-breaker*

The zone contained between the minimum I^2t and the maximum I^2t characteristics.

3. Classification

3.1 According to the method of control of the closing operation, circuit-breakers are designated as having:

- dependent manual closing,
- independent manual closing,
- dependent power closing,
- stored energy closing.

3.2 According to the interrupting medium, circuit-breakers are divided into different groups, e.g.:

- air-break,
- oil-immersed break.

3.3 According to the degree of protection provided by the enclosure, distinction is made in accordance with IEC Publication 144, Degrees of Protection of Enclosures for Low-voltage Switchgear and Controlgear.

4. Characteristics of circuit-breakers

4.1 *Summary of characteristics*

The characteristics of a circuit-breaker shall be stated in the following terms, where such terms are applicable:

Type of circuit-breaker (see Clause 4.2);

Rated values (see Clause 4.3);

Control circuits and air-supply systems (see Clause 4.4);

Types and characteristics of releases (see Clause 4.5);

4.3.2 Auxiliary switches (see Clause 4.6);

Degrees of protection of enclosures (see IEC Publication 144).

4.2.1 *Type of circuit-breaker*

The following shall be stated:

4.2.1 *Number of poles*

4.2.2 *Kind of current*

Kind of current (a.c. or d.c.) and, in the case of a.c., number of phases and rated frequency.

4.2.3 *Interrupting medium (air, oil, etc.)*

4.2.4 *Method of closing*

Method of closing, for example: direct manual closing, manual remote closing, electrical

closing by motor or solenoid, electro-pneumatic closing, etc. In the case of hand-operated circuit-breakers, the type of closing device shall be stated: handle, lever, wheel, etc.

4.2.5 *Method of opening*

Method of opening, for example: direct manual opening, manual remote opening, electrical opening by motor or solenoid, over-current opening, under-voltage opening, reverse power (or current) opening, etc.

4.2.6 *Provision for maintenance*

According to whether or not provision has been made for maintenance, circuit-breakers are designated as:

- designed to be maintained;
- designed not to be maintained.

4.3 *Rated values*

The rated values established for a circuit-breaker shall be stated in accordance with Clauses 4.3.1 to 4.3.6, but it is not necessary to establish all the rated values listed.

4.3.1 *Rated voltages*

A circuit-breaker is defined by the following rated voltages:

4.3.1.1 *Rated operational voltages*

A rated operational voltage (U_o) of a circuit-breaker is a value of voltage to which the making and breaking capacities and the short-circuit performance categories are referred.

For polyphase circuits, it is stated as the voltage between phases.

Notes 1. — The same circuit-breaker may be assigned a number of rated operational voltages and associated making and breaking capacities for different duties and short-circuit performance categories.

2. — For rated voltages of control circuits, see Clause 4.4.1.

4.3.1.2 *Rated insulation voltage*

The rated insulation voltage (U_i) of a circuit-breaker is the value of voltage which designates it and to which dielectric tests, clearances and creepage distances are referred.

Unless otherwise stated, the rated insulation voltage is the value of the maximum rated operational voltage of the circuit-breaker. In no case shall the maximum rated operational voltage exceed the rated insulation voltage.

4.3.2 *Rated currents*

A circuit-breaker is defined by the following rated currents:

4.3.2.1 *Rated conventional thermal current*

The rated conventional thermal current (I_{th}) of a circuit-breaker is the maximum current stated by the manufacturer that the unenclosed circuit-breaker can carry in 8 hour duty (see Clause 4.3.4.1) when tested in free air, without the temperature rise of its several parts exceeding the limits specified in Clause 7.3 (Tables IV and V) when tested according to Clause 8.2.2.

Notes 1. — Free air is understood to be that obtained under normal indoor conditions reasonably free from draughts and external radiation.

2. — An unenclosed circuit-breaker is a circuit-breaker supplied by the manufacturer without an enclosure or a circuit-breaker supplied by the manufacturer with an enclosure forming an integral part of the circuit-breaker.

4.3.2.2 *Rated enclosed thermal current*

The rated enclosed thermal current (I_{the}) of a circuit-breaker is the maximum current stated by the manufacturer that the circuit-breaker can carry in the stated duty (see Clause 4.3.4) when mounted in a specified enclosure. Tests for this rating shall be in accordance with Clause 8.2.2, but are not mandatory if the test for "rated conventional thermal current" has been made, and the manufacturer is prepared to state an enclosed thermal current rating.

The rating may be an unventilated rating, in which case the enclosure shall be of the size stated by the manufacturer to be the smallest enclosure that is applicable in service. Alternatively, the rating may be a ventilated rating with the ventilation in accordance with the manufacturer's data.

Note. — It is not possible to usefully define a rated service thermal current as the installation and service conditions can vary greatly. (The "rated current" Sub-clause 4.2 of IEC Publication 439 is in effect the "rated service thermal current".)

4.3.2.3 *Rated uninterrupted current*

The rated uninterrupted current (I_u) of a circuit-breaker is a value of current, stated by the manufacturer, which the circuit-breaker can carry in uninterrupted duty (see Clause 4.3.4.2).

4.3.3 *Rated frequency*

The rated frequency of a circuit-breaker is the service frequency for which the circuit-breaker is designed and to which the values of the other characteristics correspond.

4.3.4 *Rated duty*

The rated duties considered as normal are as follows:

4.3.4.1 *Eight-hour duty*

Duty in which the main contacts of a circuit-breaker remain closed whilst carrying a steady current long enough to reach thermal equilibrium but not for more than eight hours without interruption.

Notes 1. — This is the basic duty on which the rated thermal current of the apparatus is determined.

2. — Interruption means breaking of the current by operation of the circuit-breaker.

4.3.4.2 *Uninterrupted duty*

Duty in which the main contacts of a circuit-breaker remain closed whilst carrying a steady current without interruption for periods of more than eight hours (weeks, months, or even years).

Note. — This kind of service is set apart from the eight-hour duty because oxides and dirt can accumulate on the contacts and lead to progressive heating. Uninterrupted duty can be taken account of either by a de-rating factor, or by special design considerations (e.g. silver or silver-faced contacts) (see Table V).

4.3.5 *Rated short-circuit making and breaking capacities and rated short-time withstand current*

4.3.5.1 *Rated short-circuit making capacity*

The rated short-circuit making capacity of a circuit-breaker is the value of short-circuit making capacity assigned to that circuit-breaker by the manufacturer for the rated operational voltage, at rated frequency, and at a specified power-factor (or time-constant). It is expressed as the maximum prospective peak current.

For a.c., the rated short-circuit making capacity of a circuit-breaker shall be not less than its rated short-circuit breaking capacity, multiplied by the factor n of Table I (see Clause 4.3.5.3).

For d.c., the rated short-circuit making capacity of a circuit-breaker shall be not less than its rated short-circuit breaking capacity, on the assumption that the steady-state short-circuit current is constant.

A rated short-circuit making capacity implies that the circuit-breaker shall be able to make the current corresponding to that rated capacity at an applied voltage up to and including that corresponding to 110% of the rated operational voltage.

4.3.5.2 *Rated short-circuit breaking capacity*

The rated short-circuit breaking capacity (I_{en}) of a circuit-breaker is the value of short-circuit breaking capacity assigned to that circuit-breaker by the manufacturer for the rated operational voltage, at rated frequency and at a specified power-factor (or time-constant). It is expressed as the value of the prospective breaking current (r.m.s. value of the a.c. component in the case of a.c.).

For a.c., the circuit-breaker shall be capable of breaking a prospective current corresponding to its rated short-circuit breaking capacity, irrespective of the value of the inherent d.c. component, on the assumption that the a.c. component is constant.

A rated short-circuit breaking capacity requires that the circuit-breaker shall be able to break any value of current up to and including the value corresponding to that rated capacity at a power-frequency recovery voltage equal to 110% of the rated operational voltage, and:

- for a.c., at any power-factor not less than that of Table I (see Clause 4.3.5.3);
- for d.c., unless otherwise stated by the manufacturer, with any time-constant not exceeding that given in Clause 4.3.5.4.

For power-frequency recovery voltages in excess of 110% of the rated operational voltage, no short-circuit breaking capacity is guaranteed.

4.3.5.3 *Relationship between rated short-circuit making and breaking capacities and power-factor*

The standard relationship between rated short-circuit breaking capacity, power-factor and minimum required rated short-circuit making capacity is given in the following Table I:

TABLE I

Ratio n between minimum required rated short-circuit making capacity and rated short-circuit breaking capacity

Rated short-circuit breaking capacity I_{cn} (amperes)	Standard power-factor	Minimum required rated short-circuit making capacity (n times rated short-circuit breaking capacity) $n \times I_{cn}$
$I_{cn} < 1\,500$	0.95	$1.41 \times I_{cn}$
$1\,500 < I_{cn} < 3\,000$	0.9	$1.42 \times I_{cn}$
$3\,000 < I_{cn} < 4\,500$	0.8	$1.47 \times I_{cn}$
$4\,500 < I_{cn} < 6\,000$	0.7	$1.53 \times I_{cn}$
$6\,000 < I_{cn} < 10\,000$	0.5	$1.7 \times I_{cn}$
$10\,000 < I_{cn} < 20\,000$	0.3	$2.0 \times I_{cn}$
$20\,000 < I_{cn} < 50\,000$	0.25	$2.1 \times I_{cn}$
$50\,000 < I_{cn}$	0.2	$2.2 \times I_{cn}$

Note. — For power-frequency recovery voltages in excess of 110% of the rated operational voltage, for power-factors less than (or time-constants exceeding) the specified ones and for power frequencies other than the rated frequency, no making and breaking capacities are guaranteed.

The rated short-circuit making and breaking capacities are only valid when the circuit-breaker is operated in accordance with the requirements of Clauses 7.7.1 and 7.7.2.

For special requirements, the manufacturer may assign a value of rated short-circuit making capacity higher than that required by the above table. Tests to verify these rated values shall be the subject of agreement between manufacturer and user.

Note. — For the sake of simplicity and, in particular, for circuit-breakers having rated short-circuit breaking capacities of 10 000 A and less, a circuit-breaker may be specified by the single value of its rated short-circuit breaking capacity and, where applicable, a rated short-time withstand current complying with the co-related values given in Clauses 4.3.5.3 and 4.3.5.5.

4.3.5.4 Rated time-constant

For d.c., the rated time-constant shall be 15 milliseconds, unless otherwise agreed between manufacturer and user.

4.3.5.5 Rated short-time withstand current

The rated short-time withstand current of a circuit-breaker is the value of short-time withstand current assigned to that circuit-breaker by the manufacturer under the test conditions specified in Clause 8.2.5.

For a.c., the value of this current is the r.m.s. value of the a.c. component of the prospective short-circuit current.

The duration of the rated short-time withstand current is one second. If this current is less than that corresponding to the rated short-circuit breaking capacity, the manufacturer shall also indicate the time during which the latter current can be carried.

A circuit-breaker fitted with over-current releases need not have a rated short-time withstand current assigned to it because it is sufficient that such a circuit-breaker can carry the current corresponding to its rated short-circuit breaking capacity for its total break-time with the over-current releases set at their maximum time-lag (see Clause 8.2.4.2); if, however, a circuit-breaker normally fitted with over-current releases may also be used without these releases, a rated short-time withstand current shall be assigned. Similarly, an integrally-fused circuit-breaker need not have a rated short-time withstand current assigned to it because it is sufficient that the combination can carry the current for the operating time of the fuses; however, if a circuit-breaker normally used as part of an integrally-fused circuit-breaker may also be used without fuses and without over-current releases, then a rated short-time withstand current shall be assigned.

4.3.6 Short-circuit performance categories

The performance category shall be stated in terms of the rated operating sequence and the condition of the circuit-breaker after performing this sequence at rated short-circuit making and breaking capacities. In this recommendation, the following short-circuit performance categories are considered standard.

Note. — For the same circuit-breaker, the values of the rated short-circuit breaking and corresponding making capacities may be different for the two short-circuit performance categories.

TABLE II
Short-circuit performance categories

Short-circuit performance category	Rated operating sequence for short-circuit making and breaking capacity tests	Condition after short-circuit tests
P-1	O - t - CO	Required to be capable of performing reduced service (see Clauses 8.2.4.10 and 8.2.4.10.1)
P-2	O - t - CO - t - CO	Required to be capable of performing normal service (see Clauses 8.2.4.10 and 8.2.4.10.2)
O represents a breaking operation; CO represents a making operation followed, after the appropriate opening time (or immediately, that is without any intentional time delay, in the case of a circuit-breaker not fitted with integral over-current releases), by a breaking operation; t represents a specified time interval (see Clause 8.2.4.3).		

4.4 Control circuits and air-supply systems

The characteristics of control circuits and air-supply systems are:

4.4.1 For control circuits

- rated control supply voltage U_s ;
- kind of current;
- rated frequency, if a.c.

The rated control supply voltage and the rated frequency of a control circuit are the values upon which the operating, temperature-rise and insulation characteristics of that circuit are based.

The control supply voltage is understood to be the voltage measured at the terminals of the control circuit with operating current flowing, including, if any, auxiliary resistors or any accessories (for example, rectifiers), supplied or specified by the manufacturer as being essential for the correct operation of the circuit-breaker.

Unless otherwise specified, the rated control supply voltage U_s of a circuit-breaker is that of its main circuit and the permissible limits for the voltage in fact applied to the control circuit are 85% and 110% of the rated value U_s .

If the rated control supply voltage is different from that of the main circuit, it is recommended that its value be chosen from Table III.

TABLE III
*Standard values of the rated control supply voltage,
if different from that of the main circuit*

D.C. V	Single-phase a.c. V
24, 48, 110, 125, 220, 250	24, 48, 110, 127, 220

Note. — The manufacturer shall be prepared to state the value or values of the current taken by the control circuits at the rated control supply voltage.

4.4.2 *For air-supply systems*

- rated pressure and its limits;
- volumes of air, at atmospheric pressure, required for each closing and each opening operation.

The rated supply pressure of a pneumatically or electro-pneumatically controlled circuit-breaker is the air pressure upon which the operating characteristics of the pneumatic control system are based.

4.5 *Types and characteristics of releases*

4.5.1 *Types*

- 1) Shunt release.
- 2) Over-current release:
 - a) instantaneous;
 - b) definite time delay;
 - c) inverse time delay:
 - independent of previous load;
 - dependent on previous load (e.g. thermal type release).
- 3) Under-voltage opening release.
- 4) Other releases.

4.5.2 *Characteristics*

1) Shunt release and under-voltage release:

- rated voltage;
- kind of current;
- rated frequency, if a.c.

2) Over-current release:

- rated thermal current;
- kind of current;
- rated frequency, if a.c.;
- current setting (or range of settings);
- time setting (or range of settings).

The rated thermal current of an over-current release is the value of current (r.m.s., if a.c.) which it shall be capable of carrying under the test conditions specified in Clause 8.2.2 without the temperature rise of its several parts exceeding the values specified in Tables IV and V.

4.5.3 *Current setting of over-current releases*

For circuit-breakers fitted with interchangeable or adjustable releases, the current setting (or range of current settings, if adjustable) shall be marked on the release or on its scale. The marking may be either directly in amperes, or as a multiple of the current value marked on the release.

For circuit-breakers fitted with non-interchangeable and non-adjustable releases, the marking may be on the circuit-breaker. If the operating characteristics of the release comply with the requirements of Table VIII, it shall be sufficient to mark the circuit-breaker with its rated thermal current.

In the case of indirect releases operated by current transformers, the marking may refer either to the primary current of the current transformer through which they are supplied, or to the current setting of the overload release. In either case, the ratio of the current transformer shall be stated.

Unless otherwise specified, the operating value of over-current releases other than those of the thermal type is independent of the ambient air temperature within the limits of -5°C to $+40^{\circ}\text{C}$, and, for releases of the thermal type, the values stated are for an ambient air temperature of $+20^{\circ}\text{C}$ or $+40^{\circ}\text{C}$. The manufacturer shall be prepared to state the influence of variations in the ambient air temperature (see Clause 7.7.2.3.2).

4.5.4 *Time setting of over-current releases*

1) *Releases, the time delay of which is independent of the over-current*

The time setting shall be stated as the duration in seconds of the opening time of the circuit-breaker, if the time delay is not adjustable, or the extreme values of the opening time, if the time delay is adjustable.

2) *Releases, the time delay of which is dependent on the over-current*

The time-current characteristics shall be given in the form of curves supplied by the manufacturer. These shall indicate how the opening time, starting from the cold state, varies with current up to a value of at least 10 times the current setting. The manufacturer shall indicate, by suitable means, the tolerances applicable to these curves.