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# Appareillage à basse tension

## Première partie: Disjoncteurs

# Low-voltage switchgear and controlgear

## 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 ued as 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 *$I^2t$ 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 *$I^2t$ 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);
Auxiliary switches (see Clause 4.6);
Degrees of protection of enclosures (see IEC Publication 144).

4.2 *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 ($U_e$) 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 ($I_{cn}$) 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) $n \times I_{cn}$ |
|---|---|---|
| $I_{cn} \leq 1\,500$ | 0.95 | $1.41 \times I_{cn}$ |
| $1\,500 < I_{cn} \leq 3\,000$ | 0.9 | $1.42 \times I_{cn}$ |
| $3\,000 < I_{cn} \leq 4\,500$ | 0.8 | $1.47 \times I_{cn}$ |
| $4\,500 < I_{cn} \leq 6\,000$ | 0.7 | $1.53 \times I_{cn}$ |
| $6\,000 < I_{cn} \leq 10\,000$ | 0.5 | $1.7 \times I_{cn}$ |
| $10\,000 < I_{cn} \leq 20\,000$ | 0.3 | $2.0 \times I_{cn}$ |
| $20\,000 < I_{cn} \leq 50\,000$ | 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;<br>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;<br>*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.<br>V | Single-phase a.c.<br>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 °C, and, for releases of the thermal type, the values stated are for an ambient air temperature of + 20 °C or + 40 °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.

These curves shall be given for each extreme value of the current setting and, if the time setting for a given current setting is adjustable, it is recommended that they be given in addition for each extreme value of the time setting.

*Note.* — It is recommended that the current be plotted as abscissae and the time as ordinates, using logarithmic scales. Further, in order to facilitate the study of co-ordination of different types of protection, it is recommended that the current be plotted as multiples of the setting current and the time in seconds on the standard graph sheet detailed in IEC Publication 269-1: Low-voltage Fuses with High Breaking Capacity for Industrial and Similar Purposes. Part 1: General requirements (first edition), Clause 5.6.4.

Unless otherwise specified, it shall be assumed that the opening time of a circuit-breaker with releases other than those of the thermal type is practically independent of the ambient air temperature within the limits of −5 °C to +40 °C, and, for a circuit-breaker with releases of the thermal type, the tables or curves of the opening time correspond to an ambient air temperature of +20 °C or +40 °C as stated by the manufacturer.

Further, the manufacturer shall be prepared to state the influence of variations in the ambient air temperature.

4.6 *Auxiliary switches*

The characteristics of auxiliary switches shall comply with the requirements of IEC Publication 337-1, Control Switches (low-voltage switching devices for control and auxiliary circuits, including contactor relays). Part 1: General requirements.

Unless otherwise stated by the manufacturer, the rated thermal current of the contact elements of the auxiliary switches is 6 A, the rated voltage of the auxiliary switches shall be equal to the corresponding rated voltage of the main circuit of the circuit-breaker, and the rated frequency (if any) shall be equal to that of this main circuit.

## 5. Markings

Each circuit-breaker shall be marked in a durable manner with the following data. The markings shall be on the circuit-breaker itself or on a nameplate or nameplates attached to the circuit-breaker, and shall be located in a place such that they are visible and legible when the circuit-breaker is installed.

*a)* manufacturer's name or trademark;

*b)* type designation or serial number;

*c)* rated operational voltages;

*d)* short-circuit performance category;

*e)* rated thermal or rated uninterrupted current;

*f)* either the indication "d.c." (or the symbol ⎓) or value of the rated frequency, e.g.: ~ 50 Hz;

*g)* rated short-circuit making capacity (if it differs from that specified in Clause 4.3.5.1);

*h)* rated short-circuit breaking capacity;

*i)* rated short-time withstand current (if applicable);

*j)* rated insulation voltage, if higher than the maximum rated operational voltage.

The following information concerning the opening and closing devices of the circuit-breaker shall be placed either on their own nameplates or on the nameplate of the circuit-breaker:

*k)* rated voltage of the closing device (see Clause 7.7.1.3) and rated frequency for a.c.;

*l)* rated voltage of the shunt release (see Clause 7.7.2.2), of the under-voltage release (or of the no-voltage release) (see Clause 7.7.2.4) and rated frequency for a.c.;

*m)* rated current of indirect over-current releases;

*n)* number and type of auxiliary contacts and nature of current, rated frequency (if any) and rated voltages of auxiliary switches, if different from those of the main circuit.

*Notes 1.* — If for small apparatus, the available space is insufficient to carry all the above data, the equipment shall carry at least the information under *a)* and *b)* permitting the complete data to be obtained from the manufacturer.

2\. — It may be necessary to remove the cover of the enclosure to obtain the required information.

## 6. Standard conditions for operation in service

### 6.1 *Standard service conditions*

Circuit-breakers complying with this recommendation shall be capable of operating under the following standard conditions.

For non-standard conditions in service, see Appendix B.

#### 6.1.1 *Ambient air temperature*

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

The lower limit of the ambient air temperature is −5 °C.

*Note.* — Circuit-breakers intended to be used in ambient air temperatures above +40 °C (e.g. in forges, boiler rooms, tropical countries) or below −5 °C shall be designed or used according to an agreement between manufacturer and user. Information given in the manufacturer's catalogue may take the place of such an agreement.

#### 6.1.2 *Altitude*

The altitude of the site of installation does not exceed 2 000 m (6 600 ft).

*Note.* — For installations at higher altitudes, it is necessary to take into account the reduction of the dielectric strength and of the cooling effect of the air. Circuit-breakers intended to be so used shall be designed or used according to an agreement between manufacturer and user. Information given in the manufacturer's catalogue may take the place of such an agreement.

#### 6.1.3 *Atmospheric conditions*

The air is clean and its relative humidity does not exceed 50% at a maximum temperature of + 40 °C. Higher relative humidities may be permitted at lower temperatures, e.g. 90% at + 20 °C. Care should be taken of moderate condensation which may occasionally occur due to variations in temperature.

#### 6.1.4 *Conditions of installation*

The circuit-breaker shall be installed in accordance with the manufacturer's instructions.

## 7. Standard conditions for construction

### 7.1 *Mechanical design*

#### 7.1.1 *General*

Materials shall be suitable for the particular application and capable of passing the appropriate tests.

Special attention shall be called to flame and humidity resisting qualities, and to the necessity to protect certain insulating materials against humidity.

No contact pressure on fixed connections shall be transmitted through insulating material other than ceramic, or other material with characteristics not less suitable, unless there is sufficient resiliency in the metallic parts to compensate for any possible shrinkage of the insulating material.

In the case of oil circuit-breakers, the tank shall be provided with means for indicating the correct oil level.

The circuit-breakers shall be provided with means for indicating their closed and opened positions at the place of operation. If symbols are used, "I" and "O" shall be used to indicate the closed and open positions respectively.

#### 7.1.2 *Clearances and creepage distances*

The clearances and creepage distances shall be as large as practicable and creepage distances shall, wherever practicable, incorporate ridges, in order to break the continuity of conducting deposits which may form.

*Note.* — Recommendations are given in Appendix C.

#### 7.1.3 *Terminals*

Terminal connections shall be such that the conductors may be connected by means of screws or other equivalent means so as to ensure that the necessary contact pressure is maintained permanently.

Terminals shall be so designed that they clamp the conductor between metal surfaces with sufficient contact pressure and without significant damage to the conductor.

Terminals shall not allow the conductors to be displaced, or be displaced themselves in a manner detrimental to the operation or the insulation (by reducing clearances and/or creepage distances).

##### 7.1.3.1 *Arrangement of terminals*

The terminals intended for the connection of external conductors shall be so arranged that they are readily accessible under the intended conditions of use.

##### 7.1.3.2 *Earth terminal* TO BE REPLACED

The chassis, frameworks and the fixed parts of the metal enclosures of circuit-breakers shall be interconnected electrically and connected to a terminal which enables them to be earthed. This requirement can be met by the normal structural parts providing adequate electrical continuity.

The earth terminal shall be readily accessible and so placed that the earth connection of the circuit-breaker is maintained when the cover or any other movable part is removed.

Under no circumstances shall a removable metal part of the enclosure be insulated from the part carrying the earth terminal when the removable part is in place.

Amend. 1

The earth terminal shall be suitably protected against corrosion.

The earth terminal shall be permanently and indelibly marked with the sign ⏚.

7.2 *Enclosures*

7.2.1 *Mechanical details*

The enclosures shall be so arranged that when they are opened, the terminals as well as all parts requiring maintenance, as prescribed by the manufacturer, are readily accessible.

Sufficient space shall be left in the interior of the enclosures for the accommodation of external conductors from their point of entry into the enclosure as far as the terminals.

The movable parts of the protective enclosures shall be firmly secured to the fixed parts by a device such that they cannot be accidentally loosened or detached owing to the effects of operation of the apparatus.

7.2.2 *Insulation*

Metallic enclosures shall be so arranged as to prevent any accidental contact between the enclosure and live parts when the enclosure is in place and during opening and closing of the enclosure. If, for this purpose, the enclosures are partly or completely lined with insulating material, this lining shall be securely fixed to the enclosures.

7.3 *Temperature rise*

7.3.1 *Results to be obtained*

The temperature rises of the several parts of a circuit-breaker, measured during a test carried out under the conditions specified in Clause 8.2.2, shall not exceed the limiting values stated in Tables IV and V.

TABLE IV

*Temperature-rise limits for insulated coils in air and in oil*

| Class of insulating material | Temperature-rise limit (measured by resistance variation) | |
|---|---|---|
| | Coils in air (°C) | Coils in oil (°C) |
| A | 85 | 60 |
| E | 100 | 60 |
| B | 110 | 60 |
| F | 135 | – |
| H | 160 | – |

*Note.* — The classification of insulation is that given in Section II of IEC Publication 85, Recommendations for the Classification of Materials for the Insulation of Electrical Machinery and Apparatus in Relation to their Thermal Stability in Service.

7.3.2 *Ambient air temperature*

The temperature-rise limits given in Tables IV and V are applicable only if the ambient air temperature remains within the limits given in Clause 6.1.1.

TABLE V

*Temperature-rise limits for the various materials and parts*

| Type of material<br>Description of part | Temperature-rise limit (measured by thermocouple) |
|---|---|
| Contact parts in air (main, control and auxiliary contacts):<br>– copper<br>– silver or silver-faced (*)<br>– all other metals or sintered metals<br>Contact parts in oil | <br>45 °C<br>(1)<br>(2)<br>65 °C |
| Bare conductors including non-insulated coils | (1) |
| Metallic parts acting as springs | (3) |
| Metallic parts in contacts with insulating materials | (4) |
| Parts of metal or of insulating material in contact with oil | 65 °C |
| Terminals for external insulated connections | 70 °C (5) |
| Manual operating means:<br>– parts of metal<br>– parts of insulating material | <br>15 °C<br>25 °C |
| Oil in oil-immersed apparatus (measured at the upper part of the oil) | 60 °C (6) |

(*) The expression "silver-faced" includes solid silver inserts as well as electrolytically deposited silver, provided that a continuous layer of silver remains on the contacts after the endurance tests and the short-circuit tests. Contacts faced with other materials, the contact resistance of which is not significantly altered by oxidation, are treated as silver-faced contacts.

(1) Limited solely by the necessity of not causing any damage to adjacent parts.
(2) To be specified according to the properties of the metals used and limited by the necessity of not causing any damage to adjacent parts.
(3) The resulting temperature shall not reach a value such that the elasticity of the material is impaired. For pure copper, this implies a total temperature not exceeding + 75 °C.
(4) Limited solely by the necessity of not causing any damage to insulating materials.
(5) The temperature-rise limit of 70 °C is a value based on the conventional test of Clause 8.2.2.2. A circuit-breaker used or tested under installation conditions may have connections the type, nature and disposition of which will not be the same as those adopted for the test; a different temperature rise of terminals may result and it may be required or accepted.
(6) May be measured by thermometer.

7.3.3 *Main circuit*

The main circuit of a circuit-breaker, including the over-current releases which may be associated with it, shall be capable of carrying the rated thermal current of the apparatus without the temperature rises exceeding the limits specified in Table V.

7.3.4 *Control circuits*

The control circuits, including control devices, used for the closing and opening operations of a circuit-breaker shall permit the rated operating duty, as specified in Clauses 4.3.6 and 8.2.4.3, and also the temperature-rise tests specified in Clause 8.2.2.3 to be made without the temperature rises exceeding the limits specified in Tables IV and V.

7.3.5 *Auxiliary circuits*

Auxiliary circuits, including auxiliary devices, shall be capable of carrying their rated thermal current without the temperature rises exceeding the limits specified in Tables IV and V, when tested in accordance with Clause 8.2.2.4.

7.4 *Dielectric properties*

The circuit-breaker shall be capable of withstanding the dielectric tests specified in Clause 8.2.3.

7.5 *Mechanical and electrical endurances*

The circuit-breaker shall be capable of carrying out a given number of operating cycles:

— for the test of mechanical endurance, without current in the main circuit under the test conditions specified in Clause 8.2.6.3;

— for the test of electrical endurance, with current in the main circuit under the test conditions specified in Clause 8.2.6.4.

Each operating cycle consists of either a closing operation followed by an opening operation (mechanical endurance test) or a making operation followed by a breaking operation (electrical endurance test).

Unless otherwise stated by the manufacturer and depending on whether the circuit-breaker is designed to be maintained or not to be maintained (see Clause 4.2.6), the operating frequency and the number of operating cycles shall be in accordance with the following Table VI:

TABLE VI

*Number of operating cycles*

| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|
| Rated thermal current in amperes | Number of operating cycles per hour (1) | Number of operating cycles | | | | |
| | | All circuit-breakers | Circuit-breakers designed to be maintained (3) | | Circuit-breakers designed not to be maintained | |
| | | With current without maintenance (2) | Without current | Total | Without current | Total |
| | | $n$ | $n'$ | $n + n'$ | $n''$ | $n + n''$ |
| $I_{th} \leq 100$ | 240 | 4 000 | 16 000 | 20 000 | 4 000 | 8 000 |
| $100 < I_{th} \leq 315$ | 120 | 2 000 | 18 000 | 20 000 | 6 000 | 8 000 |
| $315 < I_{th} \leq 630$ | 60 | 1 000 | 9 000 | 10 000 | 4 000 | 5 000 |
| $630 < I_{th} \leq 1250$ | 30 | 500 | 4 500 | 5 000 | 2 500 | 3 000 |
| $1250 < I_{th} \leq 2500$ | 20 | 100 | 1 900 | 2 000 | 900 | 1 000 |
| $2500 < I_{th}$ | 10 | (Subject to agreement between manufacturer and user) | | | | |

(1) If the actual number of operating cycles per hour does not correspond to values in column 2, this shall be stated in the test report.

(2) During each operating cycle, the circuit-breaker shall remain closed for a maximum of 2 seconds.

(3) The manufacturer shall supply detailed instructions on the adjustments or maintenance required to enable the circuit-breaker to perform the number of operating cycles in column 5.

7.6 *Overload performance*

The circuit-breaker shall be capable of carrying out the number of operating cycles given in Table VII with current exceeding its rated thermal current in the main circuit, under the test conditions laid down in Clause 8.2.7.

Each operating cycle consists of a making operation followed by a breaking operation.

The operating frequency shall be that value specified in column 2 of Table VI. If the circuit-breaker does not latch in at specified operating frequency, this frequency may be reduced sufficiently so that the circuit-breaker will just stay in.

TABLE VII

*Overload performance test*
*Number of operating cycles to be carried out*

| 1 | 2 | 3 | 4 |
|---|---|---|---|
| Rated thermal current (in amperes) | Opening manually (1) | Opening automatically | Total |
| $I_{th} < 100$ | 20 | 5 | 25 |
| $100 < I_{th} < 315$ | 20 | 5 | 25 |
| $315 < I_{th} < 630$ | 20 | 5 | 25 |
| $630 < I_{th} < 1250$ | 22 | 3 | 25 |
| $1250 < I_{th} < 2500$<br>$2500 < I_{th}$ | (Subject to agreement between manufacturer and user) | | |

(1) During each operating cycle, the circuit-breaker shall remain closed for a maximum of 2 seconds.

7.7 *Operating conditions*

7.7.1 *Closing*

7.7.1.1 *Dependent manual closing*

For a circuit-breaker to be closed safely on to the making current corresponding to its rated short-circuit making capacity, it is essential that it should be operated with the same speed and the same firmness as during the type test for proving the short-circuit making capacity.

For a circuit-breaker having a dependent manual closing mechanism, it is not possible to assign an unconditional short-circuit making capacity rating. It is recommended therefore that such a circuit-breaker should not be used in circuits having a prospective peak making current exceeding 10 kA.

However, the paragraph above does not apply in the case of a circuit-breaker having a dependent manual closing mechanism and incorporating an integral fast-acting opening release which causes the circuit-breaker to break safely irrespective of the speed and firmness with which it is closed onto prospective peak currents exceeding 10 kA; in this case, a rated short-circuit making capacity can be assigned.

7.7.1.2 *Independent manual closing*

A circuit-breaker having an independent manual closing mechanism can be assigned an unconditional rated short-circuit making capacity.

7.7.1.3 *Dependent power closing (electrical)*

The power-operated closing mechanism, including intermediate control relays when necessary, shall be capable of securing the closing of the circuit-breaker in any condition between no-load and its rated making capacity, at any supply voltage between 85% and 110% of the rated control supply voltage, and, when a.c., at the rated frequency.

At 110% of the rated control supply voltage, the closing operation performed on no-load shall not cause any damage to the circuit-breaker.

At 85% of the rated control supply voltage, the closing operation shall be performed when the current established by the circuit-breaker is equal to its rated making capacity within the limits allowed by the operation of its relays or releases and, if a maximum time limit is stated for the closing operation, in a time not exceeding this maximum time limit.

7.7.1.4 *Dependent power closing (pneumatic)*

A compressed-air closing mechanism supplied from an external source shall be capable of securing the closing of the circuit-breaker in any condition between no-load and its rated making capacity, when the air pressure measured immediately before the closing operation is between the limiting values $P_{min}$ and $P_{max}$ of the rated supply pressure.

The values $P_{min}$ and $P_{max}$ shall be stated by the manufacturer.

At the pressure $P_{max}$, the closing operation performed on no-load shall not cause any damage to the circuit-breaker.

At the pressure $P_{min}$, the closing operation shall be performed when the current established by the circuit-breaker is equal to its rated making capacity, within the limits allowed by the operation of its relays or releases, and, if a maximum time limit is stated for the closing operation, in a time not exceeding this maximum time limit.

7.7.1.5 *Stored energy closing*

When the energy storing mechanism is manually operated, the direction of operation shall be indicated.

When the energy storing mechanism is power operated, a device which indicates when the mechanism is fully charged shall be provided. Motors for charging mechanism as well as the closing control components shall be capable of operating when the auxiliary supply voltage is between 85% and 110% of the rated control supply voltage value.

*Note.* — It is important to ensure that the initiation of the final closing of the circuit-breaker is not possible until the closing mechanism is sufficiently charged.

7.7.2 *Opening*

7.7.2.1 *General*

Unless otherwise agreed between manufacturer and user, circuit-breakers which open automatically shall be trip-free and have their energy for the opening operation stored prior to the completion of the closing operation.

7.7.2.2 *Opening by shunt release*

A shunt opening release shall operate correctly at all values of supply voltage between 70% and 110% of the rated control supply voltage, under all operating conditions of a circuit-breaker up to the rated short-circuit breaking capacity of this circuit-breaker.

7.7.2.3 *Opening by over-current releases*

7.7.2.3.1 *Opening under short-circuit conditions*

The opening release shall operate with an accuracy of ± 20% for all values of its short-circuit current setting.

7.7.2.3.2 *Opening under overload conditions*

7.7.2.3.2.1 *Instantaneous or definite time-delay operation*

The opening release shall operate with an accuracy of ± 10% for all values of its overload current setting.

7.7.2.3.2.2 *Inverse time-delay operation*

At $A$ times the current setting, i.e. with the conventional non-tripping current (see Clause 2.5.22), the opening release being energized on all its poles, tripping shall not occur in less than time $T$ from the cold state, i.e. with the circuit-breaker at the ambient air temperature. Moreover, when at the end of time $T$ the value of current is immediately raised to $B$ times the current setting, i.e. with the conventional tripping current (see Clause 2.5.23), tripping shall occur less than time $T$ later. The values of $A$, $B$ and $T$ are given in Table VIII below:

TABLE VIII

*Characteristics of the opening operation of inverse time-delay over-current opening releases when energized on all poles*

| Release | Value of current setting $I_r$ (in amperes) | $A$ | $B$ | $T$ (hours) | Reference ambient air temperature |
|---|---|---|---|---|---|
| Not compensated for ambient air temperature | $I_r \leq 63$ | 1.05 | 1.35 | 1 | 20 °C or 40 °C, unless otherwise stated by the manufacturer (see Clause 4.5.4) |
| | $I_r > 63$ | 1.05 | 1.25 | 2 | |
| Compensated for ambient air temperature | $I_r \leq 63$ | 1.05<br>1.05<br>1.00 | 1.30<br>1.40<br>1.30 | 1<br>1<br>1 | + 20 °C<br>− 5 °C<br>+ 40 °C |
| | $I_r > 63$ | 1.05<br>1.05<br>1.00 | 1.25<br>1.35<br>1.25 | 2<br>2<br>2 | + 20 °C<br>− 5 °C<br>+ 40 °C |

*Note.* — When a three-pole over-current opening release operates on two poles only, then the maximum current appearing in column $B$ shall be increased by 10 %.

*Notes 1.* — The requirements of this clause do not apply to circuit-breakers used as starters, which have to comply with Clause 7.5.3.2.1 of IEC Publication 292-1, "Low-voltage Motor Starters. Part 1: Direct-on-line a.c. starters" (First edition).

2\. — If the over-current opening release setting is designated by the value of current at which the release should trip under overload conditions, the requirements of this clause do not apply. Instead, the release shall operate with an accuracy of ± 10% for all values of its setting.

7.7.2.4 *Opening by under-voltage release*

1) *Operating voltage*

An under-voltage opening release shall operate to open the circuit-breaker even on a slowly falling voltage, at rated frequency, at a value between 70% and 35% of its rated voltage.

*Note.* — A no-voltage opening release is a special form of under-voltage opening release in which the operating voltage is between 35% and 10% of the rated supply voltage.

An under-voltage opening release shall prevent the closing of the circuit-breaker when the supply voltage is below 35% of the rated voltage of the release; it shall not prevent closing for a supply voltage equal to or above 85%.

2) *Operating time*

For a time-lag under-voltage opening release, the time-lag must be measured from the instant when the voltage reaches the operating value until the instant when the release actuates the tripping device of the circuit-breaker.

## 8. Tests

8.1 *Verification of the characteristics of circuit-breakers*

The tests to verify the characteristics of circuit-breakers include:

— type tests (see Clause 8.2);
— routine tests (see Clause 8.3).

Type tests include:

*a)* verification of temperature-rise limits (see Clause 8.2.2);
*b)* verification of dielectric properties (see Clause 8.2.3);
*c)* verification of rated short-circuit making and breaking capacities (see Clause 8.2.4);
*d)* verification of the ability to carry rated short-time withstand current (if required) (see Clause 8.2.5);
*e)* verification of mechanical operation and of mechanical and electrical endurances (see Clause 8.2.6);
*f)* verification of overload performance (see Clause 8.2.7);
*g)* verification of tripping characteristics (see Clause 8.2.8);
*h)* verification of additional requirements for integrally-fused circuit-breakers (if applicable) (see Clause 9).

*Note.* — Tests to meet the atmospheric conditions of Clause 6.1.3 are under consideration.

Routine tests include:

*a)* mechanical operation tests (see Clause 8.3.1);
*b)* calibration of releases (see Clause 8.3.2);
*c)* dielectric tests (see Clause 8.3.3).

The tests shall be carried out by the manufacturer at his works, or at any suitable laboratory of his choice.

8.2 *Type tests*

8.2.1 *General*

Each type test shall be made on a sample circuit-breaker which, unless otherwise agreed by the manufacturer, shall be in a clean and new condition.

The circuit-breakers to be tested shall agree in all their essential details with the drawings of the type which they represent.

Unless otherwise specified, tests are to be performed on a circuit-breaker having the maximum rated thermal current furnished in any similar physical size and construction.

Where a tolerance is not specified, type tests shall be made at values not less severe than the specified values; tolerances are subject to the consent of the manufacturer.

8.2.2 *Verification of temperature-rise limits*

*Note.* — When the mutual heating effect between main circuit, control circuits and auxiliary circuits may be of significance, the temperature-rise tests stated in Clauses 8.2.2.2, 8.2.2.3 and 8.2.2.4 shall be made simultaneously.

8.2.2.1 *Ambient air temperature*

The ambient air temperature shall be measured during the last quarter of the test period by means of at least two thermometers or thermocouples equally distributed around the circuit-breaker at about half its height and at a distance of about 1 m from it. The thermometers or thermocouples shall be protected against air currents, heat radiation and indicating errors due to rapid temperature changes.

8.2.2.2 *Temperature-rise tests of the main circuit*

The circuit-breaker shall be mounted approximately as under usual service conditions and shall be protected against undue external heating or cooling.

Circuit-breakers having an integral enclosure and circuit-breakers only intended for use with a special type of enclosure shall be tested in their enclosure for the rated conventional thermal current test. No opening giving false ventilation shall be allowed.

Details of any enclosure, ventilation arrangements, and sizes of test conductors shall be stated in the test report.

For tests with a.c. single-phase or d.c. currents, the test current shall be not less than the rated conventional thermal current. For tests with multi-phase currents, the current shall be balanced in each phase within ±5%, and the average of these currents shall be not less than the rated conventional thermal current.

The temperature-rise test of the main circuit is made at the rated conventional thermal current.

Tests on d.c. rated circuit-breakers may be made with an a.c. supply for convenience of testing, but only with the consent of the manufacturer. Tests on a.c. rated circuit-breakers shall be made at a frequency of between 45 Hz and 62 Hz where the rated frequency of the circuit-breaker is 50 Hz or 60 Hz; for lower or higher rated frequencies, a tolerance of ±20% shall apply.

The test shall be made over a period of time sufficient for the temperature rise to reach a steady-state value, but not exceeding 8 h. In practice, this condition is reached when the variation does not exceed 1 degree Celsius per hour.

*Note.* — In practice, to shorten the test the current may be increased during the first part of the test, it being reduced to the specified test current afterwards.

At the end of the test, the temperature rise of the different parts of the main circuit shall not exceed the values specified in Table V.

Depending on the value of the rated thermal current, one of the following procedures shall be adopted:

*For values of test current up to and including 400 A:*

*a)* The connections shall be single-core, PVC insulated, copper cables or wires with cross-section areas as given Table IX.

*b)* In the case of multi-pole circuit-breakers, tested with a.c., the test may be carried out with single-phase current with all poles connected in series provided magnetic effects can be neglected.

*c)* The connections shall be in free air, and spaced at approximately the distance existing between the terminals.

*d)* For single-phase or multi-phase tests, the minimum length of any temporary connection from a circuit-breaker terminal to another terminal or to the test supply or to a star point shall be:

— 1 m for cross-sections up to and including 35 $mm^2$;

— 2 m for cross-sections larger than 35 $mm^2$ (or AWG 2).

*For values of test current higher than 400 A but not exceeding 800 A:*

*a)* The connections shall be single-core, PVC insulated, copper cables with cross-section areas as given in Table X, or the equivalent copper bars given in Table X as recommended by the manufacturer.

*b)* In the case of multi-pole circuit-breakers, tested with a.c., the test may be carried out with single-phase current with all poles connected in series provided magnetic effects can be neglected.

*c)* Cables or copper bars shall be spaced at approximately the distance between terminals. Copper bars shall be finished matt black. Multiple parallel cables per terminal shall be bunched together and arranged with approximately 10 mm air space between each other. Multiple copper bars per terminal shall be spaced at a distance approximately equal to the bar thickness. If the sizes stated for the bars are not suitable for the terminals, or are not available, it is allowed to use other bars having approximately the same cross-section and approximately the same or smaller cooling surface. Cables or copper bars shall not be interleaved.

*d)* For single-phase or multi-phase tests, the minimum length of any temporary connection from a circuit-breaker terminal to another terminal or to the test supply shall be 2 m. The minimum length to a star point may be reduced to 1.2 m.

*For values of test current higher than 800 A but not exceeding 3 150 A:*

*a)* The connections shall be copper bars of the sizes stated in Table X unless the circuit-breaker is designed only for cable connection. In this case, the size and arrangement of the cables shall be as specified by the manufacturer.

*b)* In the case of multi-pole circuit-breakers, tested with a.c., the test may be carried out with single-phase current with all poles connected in series provided magnetic effects can be neglected.

*c)* Copper bars shall be spaced at approximately the distance between terminals. Copper bars shall be finished matt black. Multiple copper bars per terminal shall be spaced at a distance approximately equal to the bar thickness. If the sizes stated for the bars are not suitable for the terminals, or are not available, it is allowed to use other bars having approximately the same cross-section and approximately the same or smaller cooling surfaces. Copper bars shall not be interleaved.

*d)* For single-phase or multi-phase tests, the minimum length of any temporary connection from a circuit-breaker terminal to another circuit-breaker or to the test supply shall be 3 m, but this can be reduced to 2 m provided that the temperature rise at the supply end of the connection is not more than 5 °C below the temperature rise in the middle of the connection length. The minimum length to a star point shall be 2 m.

*For values of test current higher than 3 150 A:*

Agreement shall be reached between manufacturer and user on all relevant items of the test, such as: type of supply, number of phases and frequency (where applicable), cross-sections of test connections, etc. This information shall form part of the test report.

*Note.* — In all cases, the use of single-phase a.c. current for testing multi-phase circuit-breakers is only permissible if magnetic effects are small enough to be neglected. This requires careful consideration especially for currents above 400 A.

8.2.2.3 *Temperature-rise tests of control circuits*

The temperature-rise tests of control circuits, including control devices, shall be made with the specified kind of supply current and, in the case of a.c., at the rated frequency. Control devices shall be tested at their rated voltage.

Devices intended for continuous operation shall be tested for a sufficient time for the temperature rise to reach a steady-state value, but not exceeding 8 hours. In practice, this condition is reached when the variation does not exceed 1 °C per hour.

For closing and tripping circuits energized only during the closing and opening operations, the tests shall be made under the following conditions:

*a)* When the circuit-breaker is provided with a device which automatically opens the circuit at the end of the operation, the device shall be energized 10 times successively, the time interval between two successive energizings not exceeding 10 seconds.

*b)* When the circuit-breaker has no automatic device for opening the circuit at the end of the operation, the circuit shall be energized 10 times successively, the time interval between two successive energizings not exceeding 10 seconds and the duration of each energizing being 1 second. After complete cooling, the circuit shall be energized once for a duration of 10 seconds.

At the end of these tests, the temperature rise of the different parts of the control circuits shall not exceed the values specified in Tables IV and V.

8.2.2.4 *Temperature-rise tests of auxiliary circuits*

The temperature-rise tests of auxiliary circuits shall be carried out at their rated current and frequency.

### Table IX

*Standard cross-sections of copper conductors corresponding to the test current*

| Range of the test current A (1) | 0<br>7.9 | 7.9<br>15.9 | 15.9<br>22 | 22<br>30 | 30<br>39 | 39<br>54 | 54<br>72 | 72<br>93 | 93<br>117 | 117<br>147 | 147<br>180 | 180<br>216 | 216<br>250 | 250<br>287 | 287<br>334 | 334<br>400 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S ($mm^2$) | 1 | 1.5 | 2.5 | 4 | 6 | 10 | 16 | 25 | 35 | 50 | 70 | 95 | 120 | 150 | 185 | 240 |
| Values of the test current A (2) | ≤ 6 | 8<br>10<br>12 | 16<br>20 | 25 | 32 | 40<br>50 | 63 | 80 | 100 | 125 | 160 | 200 | 250 | – | 315 | 400 |

(1) The value of current shall be greater than the value in the first line and less than or equal to the value in the second line.
(2) These are standard recommended currents and are given for reference purposes only.

Circuits intended for continuous operation shall be tested for a sufficient time for the temperature rise to reach a steady-state value.

At the end of these tests, the temperature rise of the auxiliary circuits shall not exceed the values specified in Tables IV and V.

8.2.2.5 *Measurement of the temperature of parts*

For conductors other than windings, the temperature of the different parts shall be measured by means of thermocouples, at the nearest accessible position to the hottest accessible spot. The temperature of the oil in oil circuit-breakers shall be measured at the upper part of the oil.

Good heat conductivity between the thermocouple and the surface of the part under test shall be ensured.

For shunt connected windings, the method of measuring the temperature by resistance variation shall generally be used. Other methods are permitted only if it is impracticable to use the resistance method.

The temperature of the windings, as measured by a thermocouple before beginning the test, shall not differ from that of the surrounding medium (air, oil, etc.) by more than 3 °C.

For copper conductors, the value of the hot temperature $T_2$ may be obtained from the value of the cold temperature $T_1$ as a function of the ratio of the hot resistance $R_2$ to the cold resistance $R_1$ by the following formula:

$$T_2 = \frac{R_2}{R_1}(T_1 + 234.5) - 234.5$$

where $T_1$ and $T_2$ are expressed in Celsius degrees.

A simpler method, applying also to copper conductors only, giving results only slightly less accurate, may be used for most tests by calculating the temperature rise on the assumption that 0.4% increase in resistance represents a 1 °C increase in temperature.

*Note.* — Strictly speaking, such an assumption is correct only if the cold resistance $R_1$ is measured at approximately +16 °C.

8.2.2.6 *Temperature rise of a part*

The temperature rise of a part is the difference between the temperature of this part, measured in accordance with Clause 8.2.2.5, and the ambient air temperature measured in accordance with Clause 8.2.2.1.

8.2.2.7 *Corrections*

If the ambient air temperature during the test is between + 10 °C and + 40 °C, no corrections are necessary to take account of the ambient air temperature during the test and the values of Tables IV and V are the limiting values of temperature rise. If the ambient air temperature during the test exceeds + 40 °C or is lower than + 10 °C, this recommendation does not apply and the manufacturer and the user shall make a special agreement.

8.2.3 *Verification of dielectric properties*

8.2.3.1 *Condition of the circuit-breaker for tests*

Dielectric tests shall be made on a circuit-breaker mounted as under service conditions, including internal wiring, and in a dry condition.

When the base of the circuit-breaker is of insulating material, metallic parts shall be placed at all the fixing points in accordance with the conditions of normal installation of the circuit-

TABLE X

*Standard test conductors for rated conventional thermal currents higher than 400 A*

| Value of rated conventional thermal current (A) | Range of rated conventional thermal current (A) | Test connection | | | |
|---|---|---|---|---|---|
| | | Cables | | Copper bars | |
| | | Quantity | Cross-sections in $mm^2$ | Quantity | Dimensions in mm |
| 500 | 400 - 500 | 2 | 150 (16) | 2 | 30 × 5 (15) |
| 630 | 500 - 630 | 2 | 185 (18) | 2 | 40 × 5 (15) |
| 800 | 630 - 800 | 2 | 240 (21) | 2 | 50 × 5 (17) |
| 1 000 | 800 - 1 000 | | — | 2 | 60 × 5 (19) |
| 1 250 | 1 000 - 1 250 | | — | 2 | 80 × 5 (20) |
| 1 600 | 1 250 - 1 600 | | — | 2 | 100 × 5 (23) |
| 2 000 | 1 600 - 2 000 | | — | 3 | 100 × 5 (20) |
| 2 500 | 2 000 - 2 500 | | — | 4 | 100 × 5 (21) |
| 3 150 | 2 500 - 3 150 | | — | 3 | 100 × 10 (23) |

*Notes 1.* — Value of current shall be greater than the first value and less than or equal to the second value.

2\. — Bars are assumed to be arranged with their long faces vertical. Arrangements with long faces horizontal may be used if specified by the manufacturer.

3\. — Values in brackets are estimated temperature rises of the test conductors given for reference.

breaker and these parts shall be considered as part of the frame of the circuit-breaker. When the circuit-breaker, whether or not it is made with a moulded case, is mounted in an insulating enclosure, the latter shall be covered by a metal foil connected to the frame. If the operating handle be metallic, it shall be connected to the frame; if it be of insulating material, it shall be covered by a metal foil connected to the frame.

When the dielectric strength of the circuit-breaker is dependent upon the taping of leads or the use of special insulation, such taping or special insulation shall also be used during the tests.

8.2.3.2 *Application of the test voltage*

When the circuits of a circuit-breaker include devices such as motors, instruments, snap switches and solid state devices which, according to their relevant specifications, have been subjected to dielectric test voltages lower than those specified in Clause 8.2.3.3, such devices may, at the discretion of the manufacturer, be disconnected before subjecting the circuit-breaker to the required test.

8.2.3.2.1 *Main circuit*

For these tests, any control and auxiliary circuits, which are not normally connected to the main circuit, shall be connected to the frame. The test voltage shall be applied for 1 min as follows:

*a)* with the main contacts closed:

1) between all live parts of all poles connected together and the frame of the circuit-breaker;
2) between each pole and all the other poles connected to the frame of the circuit-breaker;

*b)* with the main contacts open:

1) between all live parts of all poles connected together and the frame of the circuit-breaker;
2) between the terminals of one side connected together and the terminals of the other side connected together.

8.2.3.2.2 *Control and auxiliary circuits*

For these tests, the main circuit shall be connected to the frame. The test voltage shall be applied for 1 min as follows:

1) between all the control and auxiliary circuits which are not normally connected to the main circuit, connected together, and the frame of the circuit-breaker;
2) where appropriate, between each part of the control and auxiliary circuits which may be isolated from the other parts during normal operation and all the other parts connected together.

8.2.3.3 *Value of the test voltage*

The test voltage shall have a practically sinusoidal waveform, and a frequency between 45 Hz and 62 Hz. The source of the test voltage shall be capable of supplying a short-circuit current of at least 0.5 A.

The value of the dry one-minute test voltage shall be as follows:

*a)* For the main circuit and for the control and auxiliary circuits which are not covered by paragraph *b)* below: in accordance with Table XI.

*b)* For control circuits and auxiliary circuits which are indicated by the manufacturer as unsuitable for connection to the main circuit:

— where the rated insulation voltage $U_i$ does not exceed 60 V: 1 000 V;

— where the rated insulation voltage $U_i$ exceeds 60 V: 2 $U_i$ + 1 000 V, with a minimum of 1 500 V.

TABLE XI

| Rated insulation voltage $U_i$ V | Dielectric test voltage (a.c.) (r.m.s.) V |
|---|---|
| $U_i \leq 60$ | 1 000 |
| $60 < U_i \leq 300$ | 2 000 |
| $300 < U_i \leq 660$ | 2 500 |
| $660 < U_i \leq 800$ | 3 000 |
| $800 < U_i \leq 1000$ | 3 500 |
| $1000 < U_i \leq 1200$* | 3 500 |
| * For d.c. only. | |

8.2.4 *Verification of rated short-circuit making and breaking capacities*

8.2.4.1 *Tolerances on test quantities*

All the tests concerning the verification of rated short-circuit making and breaking capacities shall be performed with values stated by the manufacturer in accordance with the relevant tables of this recommendation. However, the tests will be taken as valid if the values recorded in the test report differ from the values specified only within the following tolerances:

— Current: $^{+5\%}_{\ \ 0\%}$ — Power-factor: $^{\ \ \ 0}_{-0.05}$

— Voltage: ± 5% — Time-constant: $^{+15\%}_{\ \ \ 0\%}$

*Note.* — The value of the tolerance on current may, with the agreement of the manufacturer, be increased to +10% for the prospective peak making current only.

8.2.4.2 *Condition of the circuit-breaker for tests*

The circuit-breaker under test shall be mounted complete on its own support or on an equivalent support. A circuit-breaker intended to be enclosed shall be tested in the same type of enclosure as that in which it will be installed. Its control mechanism shall be operated under the specified conditions. If the mechanism be electrically or pneumatically controlled, it shall be supplied at the minimum voltage or the minimum pressure as specified in Clauses 7.7.1.3 and 7.7.1.4. It shall be verified that the circuit-breaker operates correctly on no-load when it is operated in the above conditions.

A circuit-breaker having a dependent manual closing mechanism, with which the success of a making operation in service does not depend on the speed and firmness with which it is closed on each occasion, shall be closed on test over a range of speeds to verify satisfactory operation throughout this range.

A circuit-breaker having a dependent manual closing mechanism, with which the success of a making operation in service depends on the speed and firmness with which it is closed on each occasion, shall be so closed on test as to simulate service conditions as closely as possible.

If the opening time of a circuit-breaker fitted with adjustable over-current releases is affected significantly over the range of adjustments, two tests shall be made (new circuit-breakers may be used for each of the two series of tests, or maintenance between the test series is permissible):

1) with the release adjusted for the maximum current setting and maximum delay (thus keeping the d.c. component to a minimum);

2) with the release adjusted for the minimum current setting and minimum delay (thus keeping the d.c. component to a maximum).

For circuit-breakers without over-current releases but fitted with another kind of release such as a shunt release, this release shall be energized by the application of a voltage equal to the minimum operating voltage of the release, at a time not earlier than that of the initiation of the short-circuit nor later than 10 ms after the initiation of the short-circuit.

The short-circuit test shall be carried out with metallic screens placed in the neighbourhood of live parts and separated from these parts by distances as stated by the manufacturer. These screens shall be insulated from earth and shall be connected to the frame.

8.2.4.3 *Standard tests*

Standard tests for the verification of the rated short-circuit making and breaking capacities consist of a sequence of making and breaking operations, appropriate to the short-circuit performance category as specified in Clause 4.3.6.

The time interval $t$ shall be 3 minutes or the resetting time of the circuit-breaker, whichever is the longer. The actual value of $t$ shall be stated in the test report.

Tests shall be made at not less than 100% of the rated short-circuit breaking capacity and at not less than 100% of the rated short-circuit making capacity as co-related to the rated short-circuit breaking capacity according to Clause 4.3.5.3 or as assigned as a rated short-circuit making capacity by the manufacturer.

*Notes 1.* — Attention is drawn to the need to ensure that tests on single-pole circuit-breakers are made at the appropriate peak making current.

*2.* — For those circuit-breakers which exhibit critical breaking currents (see Clause 2.5.15) during either breaking operations or make-break operating cycles, an additional test shall be made within such critical breaking current ranges.

*3.* — Attention is drawn to the additional requirements for integrally-fused circuit-breakers detailed in Clause 9.

For all these tests, the live side of the test circuit shall be connected to the corresponding terminals of the circuit-breaker as marked by the manufacturer. In the absence of such markings, the live side of the test circuit shall be connected to that side of the circuit-breaker which gives the more severe conditions. If there is a doubt as to which is the more severe condition, the circuit-breaker shall be tested in both conditions. New circuit-breakers may be used for each of the two series of tests, or maintenance between the test series is permissible.

The maximum value of $I^2t$ (see Clause 2.5.26) noted during these tests shall be recorded on the test report.

*Note.* — The maximum value of $I^2t$ recorded during the tests may not be the maximum possible value for the prescribed conditions. Additional tests are necessary for determining this maximum value.

8.2.4.4 *Frequency of the test circuit for a.c.*

Tests for the verification of short-circuit making and breaking capacities shall be made at the rated frequency of the circuit-breaker. If the rated breaking capacity is essentially dependent on the value of the frequency, the tolerance shall not exceed ± 5%. If the rated breaking capacity is substantially independent of the value of the frequency, the tolerance shall not exceed ± 25%.

8.2.4.5 *Test circuit for the verification of short-circuit making and breaking capacities*

Figures 1, 2 and 3 respectively give the diagrams of the circuits to be used for the tests concerning:

— a three-pole circuit-breaker on three-phase a.c. (Figure 1, page 106);

— a two-pole circuit-breaker on single-phase a.c. or on d.c. (Figure 2, page 107);

— a single-pole circuit-breaker on single-phase a.c. or on d.c. (Figure 3, page 108).

*Note.* — Single-phase tests on a single pole of a multipole circuit-breaker are not dealt with in this recommendation and are subject to an agreement between manufacturer and user.

The supply *S* feeds a circuit including resistors *R*, reactors *L* and the circuit-breaker *A* under test.

In all cases the supply shall have sufficient power to permit the verification of the characteristics given on the nameplate (see Clause 8.2.4.8.3).

The resistance and reactance of the test circuit shall be adjustable to satisfy the specified test conditions. The reactors *L* must be air-cored. They shall always be connected in series with the resistors *R*, and their value shall be obtained by series coupling of individual reactors; parallel connecting of reactors is permitted when these reactors have practically the same time-constant.

Since the transient recovery voltage characteristics of test circuits including large air-cored reactors are not representative of usual service conditions, the air-cored reactor in any phase shall be shunted by a resistor taking approximately 0.6% of the current through the reactor, unless otherwise agreed between manufacturer and user.

*Note.* — Further particulars for specifying the test circuit, with particular reference to the transient recovery voltage characteristic, are under consideration.

In each test circuit (Figures 1, 2 and 3), the resistors and reactors are inserted between the supply source *S* and the circuit-breaker *A* under test.

When tests are made with current less than the rated short-circuit breaking capacity, the additional impedance required may, however, be inserted on the load side of the circuit-breaker between it and the short-circuit. In any case, the diagram of the test circuit shall appear in the test report.

Unless a special agreement has been drawn up between manufacturer and user and details noted in the test report, the diagram of the test circuit shall be in accordance with the figures.

There shall be one and only one point of the test circuit which is directly earthed; this may be the short-circuit link of the test circuit or the neutral point of the supply or any other convenient point, but the method of earthing shall be stated in the test report.

All parts of the circuit-breaker normally earthed in service, including its enclosure, shall be insulated from earth and connected to a point as indicated on Figures 1, 2 or 3. This connection shall include a reliable device D (such as a fuse consisting of a copper wire of 0.1 mm diameter and not less than 50 mm in length) for the detection of the fault current and, if necessary, a resistor limiting the value of the prospective fault current to about 100 A. Any artificial neutral should be substantially inductive, and permit a prospective fault current of at least 100 A.

Units $0_1$ of the oscillograph are connected on the short-circuited side in series with each pole of the circuit-breaker.

Another unit $0_2$ of the oscillograph may be connected between the terminals of the supply side of the circuit-breaker under test. Other units $0_3$ of the oscillograph are connected across the terminals of each pole. The values of the resistances of the measuring circuits shall be at least 100 ohms per volt of the power-frequency recovery voltage. The values of the resistances shall be stated in the test report.

8.2.4.6 *Power-factor or time-constant of the test circuit*

8.2.4.6.1 *Power-factor of the test circuit*

For a.c., the power-factor of each phase of the test circuit may be determined according to one of the methods indicated in Appendix A *a)*.

The power-factor of a polyphase circuit is considered as the mean value of the power-factors of each phase.

The power-factor shall be as given in Table I of Clause 4.3.5.3 for the appropriate rated short-circuit breaking capacity.

The mean value of the power-factor of the test circuit shall be given in the test report.

The difference between the mean value and the maximum and minimum values of the power-factors in the different phases shall not exceed 25% of the mean value.

8.2.4.6.2 *Time-constant of the test circuit*

For d.c., the time-constant of the test circuit may be determined according to the method given in Appendix A *b)*.

The value of the time-constant shall be 15 milliseconds, unless otherwise agreed between manufacturer and user.

8.2.4.7 *Power-frequency recovery voltage*

For breaking-capacity tests, the average value of the power-frequency recovery voltage shall be equal to a value corresponding to 110% of the rated operational voltage of the circuit-breaker under test.

*Note.* — This may require that the applied voltage be increased, but the tolerance on the prospective peak making current shall not be exceeded without consent of the manufacturer.

8.2.4.8 *Test procedure*

8.2.4.8.1 *Calibration of the test circuit* (see Figures 1, 2, 3 and 6, pages 106, 107, 108 and 111)

The circuit-breaker *A* under test is replaced by temporary connections *B* having a negligible impedance compared with that of the test circuit.

For a.c., resistors *R* and reactors *L* are adjusted so as to obtain, at the test voltage, a current equal to the rated short-circuit breaking capacity at the instant of separation of the arcing contacts as well as the power-factor as indicated in Clause 8.2.4.6.1.

For d.c., resistors $R$ and reactors $L$ are adjusted so as to obtain, at the test voltage, a current the maximum value of which is equal to the rated short-circuit breaking capacity as well as the time-constant as indicated in Clause 8.2.4.6.2.

The test circuit is energized simultaneously in all poles and the current curve is recorded with oscillograph $0_1$ for a duration of at least 0.1 second.

*Note.* — For d.c. circuit-breakers parting their contacts before the peak value of the calibration curve is reached, it is sufficient to make a calibration oscillogram with additional pure resistance in the circuit to demonstrate that the rate-of-rise of the current expressed in amperes/second is the same as for the test current and the time-constant specified. This additional resistance shall be such that the peak value of the calibration current curve is at least equal to the peak value of the breaking current. This resistance shall be removed for the actual test (see note of Clause 8.2.4.8.3 *b)*).

8.2.4.8.2 *Performance of the test*

The temporary connections $B$ are replaced by the circuit-breaker under test.

The test sequence shall be in accordance with Clauses 4.3.6 and 8.2.4.3.

After arc extinction, the recovery voltage shall be maintained for a period not less than 0.1 second.

8.2.4.8.3 *Interpretation of oscillograms*

*a) Determination of the applied and power-frequency recovery voltages*

The applied and power-frequency recovery voltages are determined from the oscillogram corresponding to the break test made with the apparatus under test and estimated as indicated in Figures 4 *b)* and 4 *c)*, page 109, for a.c. and in Figures 5 *b)* and 5 *c)*, page 110, for d.c.

The difference between the average value of the power-frequency recovery voltages on all phases and the value of the power-frequency recovery voltage on each phase shall not exceed 5% of the average value.

*Note.* — The value of 5% can in certain cases, due to the influence of short time variations in the insulation resistance of the circuit-breaker arc gaps and/or to the influence of the resistance in the measuring circuits, be exceeded without affecting the validity of the test.

*b) Determination of the prospective breaking current*

This determination is made by comparing the current curves, recorded with the oscillograph during initial calibration of the circuit, with those recorded during the break test of the circuit-breaker.

For a.c., the a.c. component of the prospective breaking current is taken as being equal to the r.m.s. value of the a.c. component of the calibration current at the instant of separation of the arcing contacts (values corresponding to $A_1$ or $A_2$ of Figure 4 *a)*). The prospective breaking current shall be the average of the prospective currents in all the phases and the prospective current in any phase shall not vary from the average by more than 10% of the average.

For d.c., the value of the prospective breaking current is taken as being equal to the maximum value $A_2$ as determined from the calibration curve for circuit-breakers breaking before the current has reached its maximum value, and to the value $A$ for circuit-breakers breaking after the current has passed its maximum value (see Figures 5 *a)* and 5 *b)* ).

*Note.* — For d.c. circuit-breakers tested according to the requirements of the note of Clause 8.2.4.8.1, when the calibration of the test circuit has been made at a current $I_1$ lower than the rated breaking capacity, the test is considered void if the actual breaking current $I_2$ is higher than $I_1$ and it shall be carried out again after a calibration at a current $I_3$ of a higher value than $I_2$ (see Figure 6, page 111).

The prospective breaking current $A_2 = \dfrac{U}{R}$ shall be determined by calculating the resistance $R$ of the test circuit from the resistances $R_1$ and $R_2$ of the corresponding calibration circuits. The time-constant of the test circuit is given by: $T = \dfrac{A_2}{\mathrm{d}i/\mathrm{d}t}$ .

*c) Determination of the prospective peak making current*

The prospective peak making current is determined from the calibration oscillogram and its value shall be taken as being equal to $A_3$ for a.c. and to $A_2$ for d.c. In the case of a three-phase test, it shall be taken as the highest of the three $A_3$ values obtained from the oscillogram.

*Note.* — For tests on single-pole circuit-breakers, attention is drawn to the fact that the prospective peak making current determined from the calibration oscillogram may differ from the value of the prospective peak making current corresponding to the test, depending on the instant of making.

8.2.4.9 *Behaviour of the circuit-breaker during making and breaking tests*

During tests within the limits of specified making and breaking capacities and according to the operating sequence specified in Clauses 4.3.6, 8.2.4.3 and 8.2.4.8.2, the circuit-breaker shall show no excessive signs of distress nor shall it endanger the operator. Furthermore, there shall be no permanent arcing, no flashover between poles or between poles and frame, no melting of the fuse in the earth circuit (see Clause 8.2.4.5).

In the case of oil-immersed circuit-breakers, there shall be no external emission of flame and the gas produced, together with any oil expelled by this gas, shall be channelled and directed towards the exterior of the circuit-breaker in a direction away from the operator and from any live part.

For the other types of circuit-breakers, any emission of arc products capable of diminishing the insulation level of the circuit-breaker shall not be projected beyond the limits laid down by the manufacturer.

8.2.4.10 *Condition of the circuit-breaker after making and breaking tests*

After the test operating sequence carried out in accordance with Clauses 4.3.6, 8.2.4.3 and 8.2.4.8.2, the circuit-breaker shall be capable, without maintenance, of withstanding a voltage equal to twice its rated insulation voltage, and of making and breaking its rated thermal current at its rated operational voltage.

The mechanical parts and the insulators of the circuit-breaker shall be substantially in the same condition as before the test.

The operation of over-current releases intended to provide overload protection shall be verified at 2.5 times the value of their current setting. This test may be made at a reduced voltage.

8.2.4.10.1 *Circuit-breakers of short-circuit performance category P-1*

*a)* A temperature-rise test shall be made at the rated thermal current, or at the maximum value of current that the circuit-breaker will carry continuously if the circuit-breaker trips with its rated thermal current, to check that the contacts are capable of carrying this current without excessive temperature rise. The temperature rise shall not cause any damage to adjacent insulating materials.

*Notes 1.* — If the test is not made at the rated thermal current, this fact shall be noted in the test report.

2\. — This test is not intended to evaluate the current permitted for further service, but is solely intended to ensure that excessive temperature rises will not occur in continued service.

*b)* When testing over-current releases at 2.5 times the value of their current setting, the operating time shall not exceed the maximum value stated by the manufacturer for twice the value of the current setting.

8.2.4.10.2 *Circuit-breakers of short-circuit performance category P-2*

*a)* The circuit-breaker shall, without maintenance, be capable of carrying its rated thermal current. Where doubt exists as to the ability of the contacts to meet this requirement, a temperature-rise test at the rated thermal current shall be made. In this case, the temperature rise shall not cause any damage to adjacent insulating materials.

*b)* When testing over-current releases at 2.5 times their current setting, the operating time shall fall within the tolerances stated by the manufacturer.

8.2.5 *Verification of the ability to carry rated short-time withstand current*

*Note.* — This test may be made before or after the short-circuit test. It can also be made on a separate sample at the option of the manufacturer; if so, the fact shall be stated in the test report.

The tests shall be made, with the circuit-breaker in the closed position, at any convenient test voltage and starting from cold state with the circuit-breaker at the ambient air temperature.

*a) For a.c.*

The tests shall be made at the rated frequency of the circuit-breaker with a tolerance of ± 25%.

The current shall be applied for the specified time and its r.m.s. value shall be equal to or higher than the specified value in at least one pole.

The highest peak value of the current during its first cycle shall be not less than *n* times the rated short-circuit breaking capacity, the value of *n* being that appearing in the third column of Table I in Clause 4.3.5.3.

When, however, the characteristics of the testing station are such that the above requirements cannot be obtained, the following alternatives are permitted provided that the integral of the product of the square of the current and the duration, obtained during the test, shall be not less than the product of the square of the rated short-time withstand current and the rated duration of short-circuit:

1) If the decrement of the short-circuit current of the testing station be such that the rated short-time withstand current cannot be obtained for the rated time without applying initially an excessively high current, the r.m.s. value of the current may be permitted to fall during the test below the specified value, the duration being increased appropriately, provided that the value of the highest peak current is not less than that specified.

2) If, in order to obtain the required peak value, the r.m.s. value of the current has to be increased above the specified current, the duration of the test shall be reduced accordingly.

After this test, the circuit-breaker shall comply with the requirements specified in Clause 8.2.4.10.

*b) For d.c.*

The current shall be applied for the specified time and its r.m.s. value determined from the oscillogram shall be at least equal to the specified value.

When the characteristics of the testing station are such that the above requirements cannot be obtained for the rated time without applying initially an excessively high current, the value of the current may be permitted to fall during the test below the specified value, the duration being increased appropriately, provided that the maximum value of the current is not less than that specified.

Finally, if the testing station is unable to make these tests on d.c., they may, if agreed between manufacturer and user, be made on a.c., provided suitable precautions are taken; for instance, the peak value of current shall not exceed the permissible current.

After this test, the circuit-breaker shall comply with the requirements specified in Clause 8.2.4.10.

8.2.6 *Verification of mechanical operation and of mechanical and electrical endurances*

8.2.6.1 *General test conditions*

The tests shall be made at the ambient temperature of the test room. For circuit-breakers designed to be maintained (see Clause 4.2.6), adjustment or maintenance laid down in the manufacturer's instructions shall be carried out in accordance with those instructions.

The control supply voltage of each control circuit shall be measured at its terminals at the rated current.

All resistors or impedances forming part of the control device shall be in circuit. However, no supplementary impedances shall be inserted between the current source and the terminals of the device.

The tests of Clauses 8.2.6.2, 8.2.6.3 and 8.2.6.4 shall be made on the same circuit-breaker, but the order in which these tests are carried out is optional.

8.2.6.2 *Mechanical operation tests*

The operating tests shall be carried out to demonstrate that the circuit-breaker meets the operating conditions specified at the upper and lower limits of supply voltage and pressure specified for the control device during closing and opening.

Tests shall be made as specified in Clause 8.2.6.1 for the following purposes:

— to prove satisfactory tripping of the circuit-breaker with the closing device energized;

— to prove satisfactory behaviour of the circuit-breaker when the closing operation is initiated with the tripping device actuated;

— to prove that the operation of a power-operated device when the circuit-breaker is already closed shall neither cause damage to the circuit-breaker nor endanger the operator.

If the closing and opening times have been stated, they shall be checked by means of appropriate tests.

8.2.6.3 *Mechanical endurance tests*

These tests shall be made under the conditions specified in Clause 8.2.6.1. The number of operating cycles to be carried out on the circuit-breaker is given in column 4 or 6 of Table VI in Clause 7.5; the number of operating cycles per hour is given in column 2 of this table.

The tests may be carried out without current in the main circuit of the circuit-breaker. Ten per cent of the total number of tests shall be close-open operations, i.e. with the tripping mechanism energized by the closing of the main contacts.

The tests shall be made on a circuit-breaker with its own closing mechanism. In the case of circuit-breakers fitted with electrical or pneumatic closing devices, these devices shall be supplied at their rated control supply voltage or at their rated pressure and the tests shall be so carried out that the temperature rises of the electrical components do not exceed the values indicated in Tables IV and V.

In the case of manually operated circuit-breakers, they shall be operated as in normal use.

8.2.6.4 *Electrical endurance tests*

The circuit-breaker condition and method of installation shall be as specified in Clauses 8.2.2.2 and 8.2.6.1.

The number and frequency of the operating cycles to be carried out are given in columns 3 and 2 of Table VI in Clause 7.5.

The circuit-breaker shall be operated so as to make or to break its rated thermal current at its rated operational voltage and with the following circuit characteristics:

| Characteristics of the circuit | a.c. | d.c. |
|---|---|---|
| Power-factor cos $\varphi$ | 0.8 ± 0.1 | – |
| Time-constant $L/R$ (ms) | – | from 1 to 3 |

Tests on a.c. rated circuit-breakers shall be made at a frequency of between 45 Hz and 62 Hz.

The tests shall be made on a circuit-breaker with its own closing mechanism. In the case of circuit-breakers fitted with electrical or pneumatic closing devices, these devices shall be supplied at their rated control supply voltage or at their rated pressure and the tests shall be so carried out that the temperature rises of the electrical components do not exceed the values indicated in Tables IV and V.

In the case of manually operated circuit-breakers, they shall be operated as in normal use.

8.2.6.5 *Condition of the circuit-breaker after tests*

After the tests made in accordance with Clauses 8.2.6.2, 8.2.6.3 and 8.2.6.4, the circuit-breaker shall be capable, without maintenance, of withstanding a voltage equal to twice its rated insulation voltage, and of making and breaking its rated thermal current at its rated operational voltage.

Circuit-breakers of short-circuit performance category P-1, if fitted with direct over-current releases, shall comply with the specified maximum tripping time requirements of Clause 7.7.2.3, the values of the test current being increased by 10% for the purpose of this check test.

Circuit-breakers of short-circuit performance category P-2, if fitted with direct over-current releases, shall comply with the over-current calibration requirements of Clause 7.7.2.3.

8.2.7 *Verification of overload performance*

The circuit-breaker condition and method of installation shall be as specified in Clause 8.2.2.2.

The circuit-breaker shall be capable of carrying out the required number of operating cycles laid down in Clause 7.6.

If test conditions at the testing station do not permit testing at the specified operating frequency, a slower frequency may be used, but details shall be stated in the test report.

The values of the electrical quantities and the characteristics of the circuit shall be as follows:

| | a.c. | d.c. |
|---|---|---|
| Current | 6 $I_{th}$ | 2.5 $I_{th}$ |
| Voltage | 1.1 $U_{em}$ | 1.1 $U_{cm}$ |
| Power-factor cos $\varphi$ | 0.5 ± 0.05 | – |
| Time-constant $L/R$ (ms) | – | 2.5 ± 15 % |
| $I_{th}$ Rated thermal current of the circuit-breaker; $U_{em}$ Maximum rated operational voltage of the circuit-breaker. | | |

Tests on a.c. rated circuit-breakers shall be made at a frequency of between 45 and 62 Hz.

The prospective short-circuit current at the point of connection to the supply terminals of the circuit-breaker shall be at least ten times the value of the test current, or at least 50 kA, whichever is the lower.

The resistance and reactance of the test circuit shall be adjustable to satisfy the specified test conditions. The reactors shall be air-cored. They shall always be connected in series with the resistors, and their value shall be obtained by series coupling of individual reactors; parallel connecting of reactors is permitted when these reactors have practically the same time-constant.

The air-cored reactor in any phase shall be shunted by a resistor taking approximately 0.6% of the current through the reactor, unless otherwise agreed between manufacturer and user.

*Note.* — The influence of the transient recovery voltage is under consideration.

There shall be one and only one point of the test circuit which is directly earthed; this may be the neutral point on the load side or of the supply or any other convenient point, but the method of earthing shall be stated in the test report.

In the case of circuit-breakers fitted with electrical or pneumatic devices, these devices shall be supplied at their rated control supply voltage or at their rated pressure.

Following the tests, all the components, including the contacts, shall be in satisfactory condition and shall not show signs of excessive wear. The different mechanical parts shall not be permanently deformed. Irrespective of its short-circuit performance category, the circuit-breaker shall comply with the requirements of Clause 8.2.4.10.2.

8.2.8 *Verification of operating limits and characteristics of over-current opening releases*

The ambient air temperature shall be measured as for the temperature-rise tests (see Clause 8.2.2.1).

When the over-current opening release is normally a built-in part of the circuit-breaker, it shall be verified inside the corresponding circuit-breaker.

The separate release, if appropriate, or the complete circuit-breaker shall be mounted approximately as under usual service conditions, and shall be protected against undue external heating or cooling.

The connections of the separate release, if appropriate, or of the complete circuit-breaker shall be made as for the usual service, with conductors the cross-sections of which are chosen as a function of the release current setting according to the co-relation given in Tables IX and X between the cross-sections and the values of rated thermal current.

The test currents shall be applied as follows:

*a) Verification of non-tripping*

This verification is made under the conditions laid down in Clause 8.2.8.1 or in Clause 8.2.8.2.1 according to the releases; the current is maintained:

— for 0.2 s in the case of instantaneous releases;

— for an interval of time equal to twice the time delay stated by the manufacturer, in the case of definite time-delay releases.

*b) Verification of tripping*

This verification is made under the conditions laid down in Clause 8.2.8.1 or in Clause 8.2.8.2.1 according to the releases, but with a current value equal to 1.2 $I_r$ or 1.1 $I_r$, depending on the type of the releases; the current may be maintained:

— for 0.2 s in the case of instantaneous releases;

— for an interval of time equal to twice the time delay stated by the manufacturer, in the case of definite time-delay releases.

8.2.8.1 *Opening under short-circuit conditions*

The operation of opening releases intended for protection against short-circuits shall be verified at 80% and 120% of the short-circuit current setting of the release. The test current shall have no asymmetry. At a test current having a value equal to 80% of the short-circuit current setting, the release shall not operate; at a test current having a value equal to 120% of the short-circuit current setting, the release shall operate.

The operation of multipole opening releases shall be verified by loading two poles in series with the test current.

8.2.8.2 *Opening under overload conditions*

8.2.8.2.1 *Instantaneous or definite time-delay operation*

The operation of instantaneous or definite time-delay over-current opening releases intended for protection against overloads shall be verified at 90% and 110% of the overload current setting of the release. The test current shall have no asymmetry. At a test current having a value equal to 90% of the overload current setting, the release shall not operate; at a test current having a value equal to 110% of the overload current setting, the tripping time shall be less than or equal to the maximum value stated by the manufacturer.

The operation of multipole opening releases shall be verified with all poles loaded simultaneously with the test current.

8.2.8.2.2 *Inverse time-delay operation*

The operating characteristics of inverse time-delay over-current releases shall be verified in accordance with the performance requirements of Clause 7.7.2.3.2.2.

An additional test, at a current value to be agreed between manufacturer and user, shall be made to verify that the time-current characteristics of the over-current opening release conform (within stated tolerances) to the curves provided by the manufacturer. During this test, the release shall be loaded on all its poles. If a test is made at an ambient air temperature different from the one stated (see Clause 7.7.2.3.2.2), a correction shall be made.

The influence of ambient air temperature on the operating characteristics shall be verified at + 20 °C and + 40 °C for releases which are not compensated for ambient air temperature (see Clauses 4.5.3 and 7.7.2.3.2.2).

8.2.8.3 *Verification of operation of definite time-delay releases*

8.2.8.3.1 *Verification of time delay*

This verification is made for a current value equal to 1.5 times the current setting:

— with all the poles loaded, in the case of releases intended for protection against overloads;

— with two poles in series carrying the test current, in the case of releases intended for protection against short-circuits.

The value measured shall be between the limits stated by the manufacturer.

8.2.8.3.2 *Verification of non-tripping duration*

This verification is made under the same conditions as for the verification of the time delay (see Clause 8.2.8.3.1).

Firstly, the current is maintained for a time interval equal to the non-tripping duration stated by the manufacturer; then, the current is reduced to the rated thermal current and maintained at this value for twice the time delay stated by the manufacturer. The circuit-breaker shall not trip.

8.3 *Routine tests*

8.3.1 *Mechanical operation tests*

The following tests shall be applied to P-2 circuit-breakers and, where applicable, to P-1 circuit-breakers:

A. At the maximum control supply voltage and/or pressure specified:

5 closing operations and 5 opening operations.

B. At the minimum control supply voltage and/or pressure specified:

5 closing operations and 5 opening operations.

C. At the rated control supply voltage and/or pressure specified:

1) 5 trip-free operations,
2) for automatic reclosing circuit-breakers, 5 automatic reclosing operations.

D. Manually operated circuit-breakers:

5 closing operations and 5 opening operations.

The tests shall be carried out without current in the main circuit, except when necessary for the operation of releases.

During the routine tests, no adjustment shall be made and the operation shall be satisfactory.

Following these tests, the circuit-breaker shall be examined to ascertain whether any of its components have been damaged and that all parts are in satisfactory operating condition.

8.3.2 *Calibration of releases*

If applicable, tests for the verification of the calibration of releases shall be carried out on:

— over-current releases;
— under-voltage releases;
— any other releases.

In the case of over-current releases, the test may be a single test at a multiple of the current setting, to check that the tripping time conforms (within tolerances) to the curves provided by the manufacturer.

8.3.3 *Dielectric tests*

The tests shall be performed on clean and dry circuit-breakers.

The value of the test voltage shall be in accordance with Clause 8.2.3.3.

The duration of each test may be reduced to one second.

The test voltage shall be applied as follows:

*a)* between poles with the circuit-breaker closed;
*b)* between poles and frame with the circuit-breaker closed;
*c)* across the terminals of each pole with the circuit-breaker open;
*d)* to the control and auxiliary circuits, as mentioned in Clause 8.2.3.2.2.

The use of metal foil, as specified in Clause 8.2.3.1, is unnecessary.

## 9. Additional requirements for integrally-fused circuit-breakers

This clause deals with additional requirements for integrally-fused circuit-breakers (see Clause 2.1.5) to be used in locations where the breaking capacity of the circuit-breaker itself is not sufficient.

9.1 *Object*

The object of this clause is to specify:

— the general requirements for the co-ordination of the circuit-breaker with its fuses;

— the types and the characteristics of the co-ordinated devices forming an integrally-fused circuit-breaker;
— the tests intended to verify that the conditions for co-ordination have been met.

9.2 *General requirements for co-ordination of the circuit-breaker with its fuses*

9.2.1 *Behaviour of circuit-breaker alone*

Any circuit-breaker incorporated into a composite unit, so forming an integrally-fused circuit-breaker, shall itself comply with this publication in all respects up to the rated breaking capacity assigned to it when operating alone.

The circuit-breaker shall operate alone, without causing fuses to operate, at the occurrence of over-currents not exceeding a limiting value stated by the manufacturer.

9.2.2 *Behaviour of the composite unit*

For all over-currents up to and including the breaking capacity assigned to the composite unit:

*a)* The making operation as well as the breaking operation of the unit shall not give rise to external manifestations (such as projection of flames) extended beyond the safety perimeter stated by the manufacturer (see Clause 8.2.4.9).

*b)* There shall be no flashover between poles or between poles and frame, nor welding of contacts.

*c)* When one or more fuses operate, the circuit-breaker shall open (in order to prevent single-phasing). If the circuit-breaker is stated by the manufacturer to be with lock-out preventing closing (see Clause 2.4.9), it shall not be possible to reclose the circuit-breaker until either the melted fuse-links or any missing fuse-links have been replaced.

9.3 *Type and characteristics of the co-ordinated fuses*

The manufacturer of integrally-fused circuit-breakers shall state the precise type and the characteristics of the fuses to be used within the unit, and the maximum prospective short-circuit current for which the unit is suitable, at the stated rated operational voltage (or voltages, as the case may be).

It is recommended that, as far as the short-circuit performances are concerned, the fuses comply with the relevant IEC publications such as: Publications 269-1, 269-2 and 269-3: Low-voltage Fuses with High Breaking Capacity for Industrial and Similar Purposes. Part 1: General requirements. Part 2: Supplementary recommendation for industrial fuses. Part 3: Supplementary recommendation for fuses for domestic and similar applications with rated currents not exceeding 100 A a.c.

9.4 *Characteristics of integrally-fused circuit-breakers*

This type of composite unit shall be considered as a device different from the circuit-breaker it incorporates, with a set of characteristics which may differ from the characteristics of the circuit-breaker itself. The whole of this publication applies to that new device (i.e. the integrally-fused circuit-breaker), except for the short-circuit tests.

9.5 *Verification of the requirements for co-ordination*

9.5.1 *Verification of the take-over current*

Compliance with the requirements of Clause 9.2.1 shall be verified by considering the characteristics of the circuit-breaker and of the fuses (see Figures 7 and 8, page 113).

If the circuit-breaker is fitted with adjustable over-current releases, the total break-time shall be considered at the minimum setting current.

For fuses, the over-current curve of back-up type fuses, or the over-current ability of fuses for general purposes calculated from the pre-arcing curve, shall be considered (see IEC Publication 269-1, Low-voltage Fuses with High Breaking Capacity for Industrial and Similar Purposes. Part 1: General requirements).

$I_B$ is the take-over current corresponding to the maximum break-time (operating time) of the fuse and to the minimum break-time of the circuit-breaker alone for the conditions of its minimum opening time. $I_B$ is the lowest current value for which the fuses will certainly interrupt the current before the circuit-breaker; $I_B$ shall be less than the breaking capacity of the circuit-breaker alone.

*Note.* — Strictly speaking, the superposition of the time-current characteristic of one device, having the prospective current as abscissa, with the time-current characteristic of another device, having also the prospective current as abscissa, is not correct when reference has to be made to the behaviour of these two devices operating in series, since the impedance of the devices is not always negligible.

It is recommended that this should be taken into account.
For high over-currents, it is recommended that reference should be made to Joule integrals instead of times.

9.5.2 *Verification of the behaviour of the composite unit*

Compliance with the requirements of Clause 9.2.2 shall be verified by short-circuit tests at different test currents, all the test conditions being as specified in Clause 8.2 of this publication, the adjustable resistors and inductors being:

— on the supply side of the integrally-fused circuit-breaker, only for the part corresponding to the rated short-circuit breaking capacity assigned to the unit under test;

— on either side for the remaining part, corresponding to reduced test currents.

*Note.* — It is assumed that the short-circuit breaking capacity of the circuit-breaker alone has already been tested.

9.5.3 *Test currents*

The following test currents are considered, in connexion with a stated operational voltage:

*a)* $I_A$: short-circuit breaking capacity assigned to the integrally-fused circuit-breaker.

*b)* The rated short-circuit breaking capacity of the circuit-breaker alone.

9.5.4 *Test procedure*

*a)* The following order of tests shall apply:

| Order of tests | Test clauses applicable to circuit-breakers of short-circuit performance categories | |
|---|---|---|
| | P-1 | P-2 |
| Short-circuit test at current $I_A$ (note 1) | O - $t$ (*) - CO<br>8.2.4 | O - $t$ (*) - CO - $t$ (*) - CO<br>8.2.4 |
| Calibration test (note 2) | 8.2.8 | 8.2.8 |
| Reduced voltage dielectric test (note 3) | 8.2.3 | 8.2.3 |
| Temperature-rise test | 8.2.4.10.1 *a)* | 8.2.4.10.2 *a)* |

1) After each test, all the fuse-links shall be replaced.
2) With new fuse-links.
3) The test is limited to the main circuit, the test-voltage value being twice the rated insulation voltage value.

*) The time interval $t$ may be greater than the limit specified in Clause 8.2.4.3 in order to permit replacement of the fuse-links. The actual time interval shall be recorded in the test report.

*b)* A test shall be made on the composite unit at the rated short-circuit breaking capacity of the circuit-breaker alone; it shall be made with a circuit-breaker in a new condition, unless otherwise agreed by the manufacturer. It consists of a single CO operating cycle; during the test, at least one fuse shall operate.

9.5.5 *Results to be obtained*

See Clause 8.2.4.9.

After each short-circuit test, it shall be verified that the circuit-breaker has been tripped open and remains in the open position.

10. **Additional requirements for four-pole circuit-breakers**

10.1 The fourth pole shall only be intended for connecting the neutral, and shall be clearly marked to that effect by the letter N.

10.2 The fourth pole shall operate together with the other poles.

10.3 The fourth pole may be fitted with an over-current release.

10.4 For a circuit-breaker having a value of rated thermal current not exceeding 200 A, the thermal rating of all four poles shall be identical.

For higher thermal current ratings, the fourth pole may have a rating not less than 50% of that of each of the other poles but not less than 200 A.

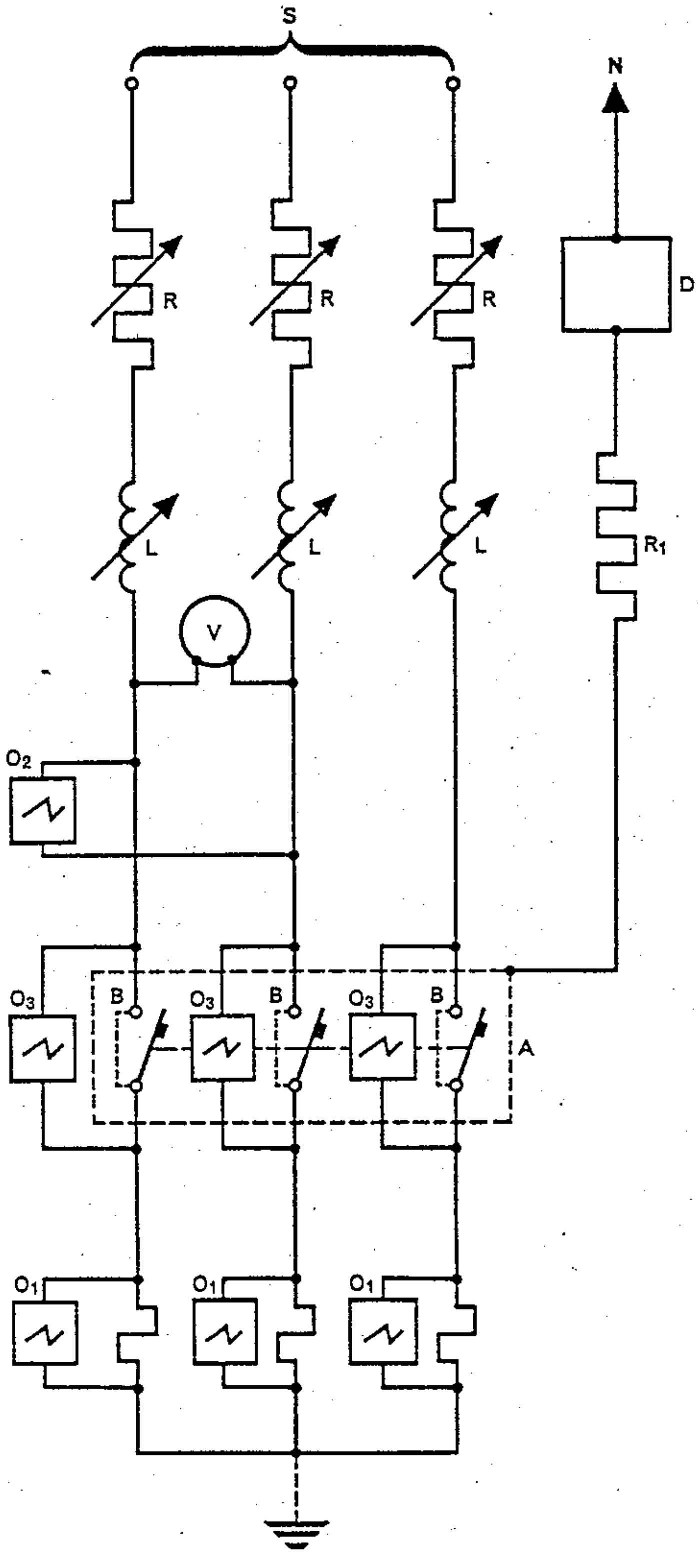
10.5 A temperature rise test in accordance with Clause 8.2.2 shall first be made on the three poles which incorporate over-current releases.

For a circuit-breaker having a value of rated thermal current not exceeding 200 A, a separate and additional test shall be made by passing the test current through the fourth pole and its adjacent pole.

For higher thermal current ratings, the method of testing shall be the subject of a separate agreement between manufacturer and user.

10.6 For short-circuit tests in accordance with Clause 8.2.4, the neutral point on the load side of the circuit-breaker on test shall be bonded back to the neutral of the supply (or to its artificial neutral) (see Figure 1, page 106).

10.7 An additional short-circuit test in accordance with Clause 8.2.4 shall be made on the fourth pole and its adjacent pole at rated breaking capacity, using the circuit shown in Figure 2, page 107.




S — Source de courant / Supply

R — Résistances réglables / Adjustable resistances

L — Inductances réglables / Adjustable reactors

A — Disjoncteur en essai / Circuit-breaker under test

B — Connexions provisoires pour l'étalonnage / Temporary connections for calibration

V — Voltmètre / Voltmeter

$O_1$ — Oscillographes enregistrant le courant / Recording current elements

$O_2$ et/and $O_3$ — Oscillographes enregistrant la tension / Recording voltage elements

D — Dispositif destiné à déceler un courant de défaut / Device for the detection of a fault current

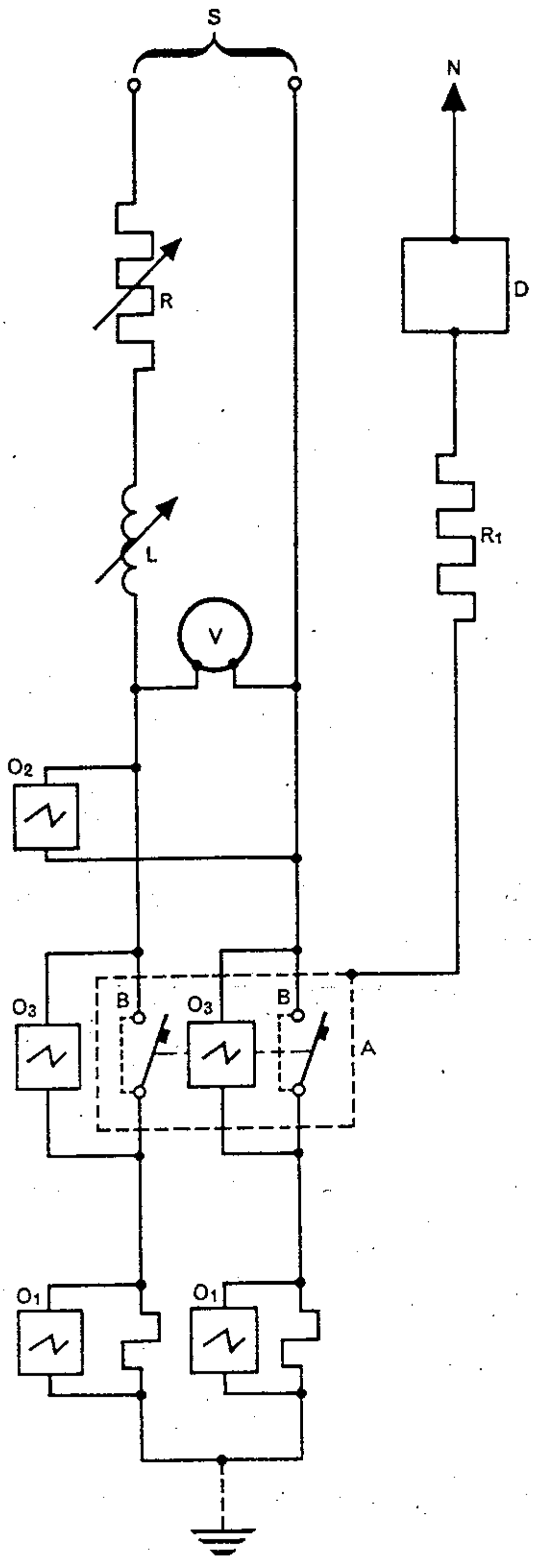
$R_1$ — Résistance limitant le courant dans le dispositif D / Resistance limiting the current in the device D

N — au neutre de la source ou à son neutre artificiel / to the neutral of the supply or to its artificial neutral

*Note.* — $O_2$ est facultatif (voir article 8.2.4.5).
$O_2$ is optional (see Clause 8.2.4.5).

FIG. 1. — Schéma de circuit d'essai pour la vérification des pouvoirs de fermeture et de coupure en court-circuit d'un disjoncteur tripolaire en courant triphasé.

Diagram of the test circuit for the verification of short-circuit making and breaking capacities of a three-pole circuit-breaker on three-phase a.c.




S Source de courant
Supply

R Résistances réglables
Adjustable resistances

L Inductances réglables
Adjustable reactors

A Disjoncteur en essai
Circuit-breaker under test

B Connexions provisoires pour l'étalonnage
Temporary connections for calibration

V Voltmètre
Voltmeter

$O_1$ Oscillographes enregistrant le courant
Recording current elements

$O_2$ et / and $O_3$ Oscillographes enregistrant la tension
Recording voltage elements

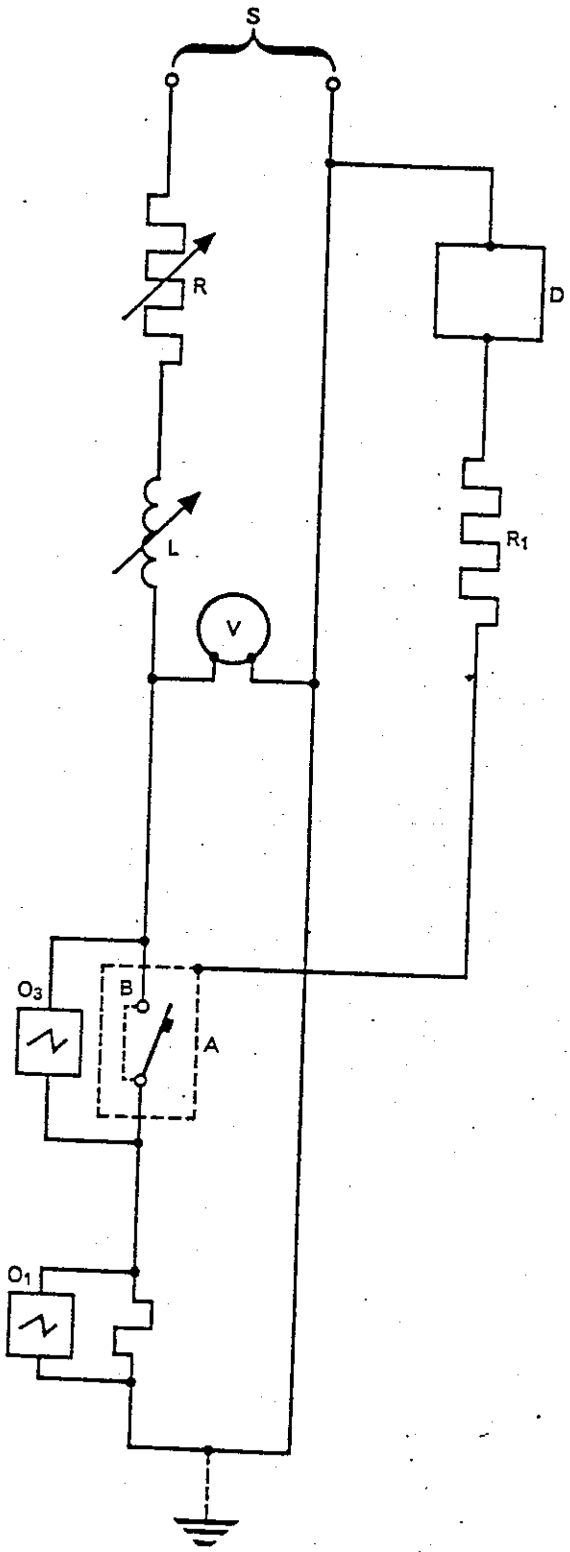
D Dispositif destiné à déceler un courant de défaut
Device for the detection of a fault current

$R_1$ Résistance limitant le courant dans le dispositif D
Resistance limiting the current in the device D

N au point milieu de la source ou à son point milieu artificiel
to the midpoint of the supply or to its artificial midpoint

*Note.* — $O_2$ est facultatif (voir article 8.2.4.5).
$O_2$ is optional (see Clause 8.2.4.5).

FIG. 2. — Schéma de circuit d'essai pour la vérification des pouvoirs de fermeture et de coupure en court-circuit d'un disjoncteur bipolaire en courant monophasé ou en courant continu.
Diagram of the test circuit for the verification of short-circuit making and breaking capacities of a two-pole circuit-breaker on single-phase a.c. or on d.c.




S Source de courant
Supply

R Résistance réglable
Adjustable resistance

L Inductance réglable
Adjustable reactor

A Disjoncteur en essai
Circuit-breaker under test

B Connexion provisoire pour l'étalonnage
Temporary connection for calibration

V Voltmètre
Voltmeter

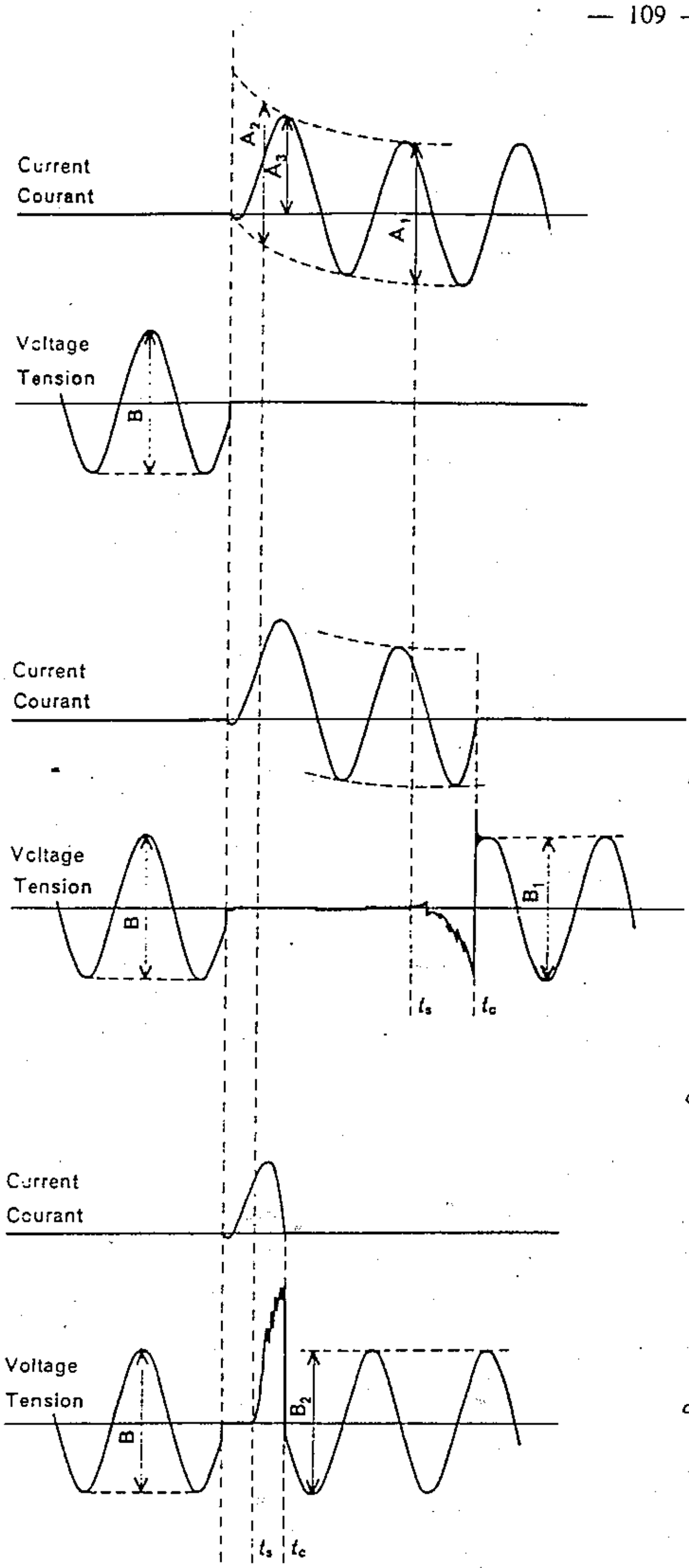
$O_1$ Oscillographe enregistrant le courant
Recording current element

$O_3$ Oscillographe enregistrant la tension
Recording voltage element

D Dispositif destiné à déceler un courant de défaut
Device for the detection of a fault current

$R_1$ Résistance limitant le courant dans le dispositif D
Resistance limiting the current in the device D

FIG. 3. — Schéma de circuit d'essai pour la vérification des pouvoirs de fermeture et de coupure en court-circuit d'un disjoncteur unipolaire en courant monophasé ou en courant continu.
Diagram of the test circuit for the verification of short-circuit making and breaking capacities of a single-pole circuit-breaker on single-phase a.c. or on d.c.




$t_s$ = instant de séparation des contacts
$t_s$ = separation of contacts

$t_c$ = instant d'extinction des arcs
$t_c$ = arc extinction

*a)* Etalonnage du circuit.

Courant présumé établi (valeur de crête) = $A_3$

Courant présumé coupé symétrique

$$= \frac{A_2}{2\sqrt{2}} \text{ ou } \frac{A_1}{2\sqrt{2}}$$

*a)* Calibration of the circuit.

Prospective peak making current = $A_3$

Prospective symmetrical breaking current

$$= \frac{A_2}{2\sqrt{2}} \text{ or } \frac{A_1}{2\sqrt{2}}$$

*b)* Oscillogramme correspondant à une coupure intervenant après que le courant a atteint sa valeur de crête.

Pouvoir de fermeture en court-circuit:

Courant $I_{crête} = A_3$ sous tension $U_{eff} = \frac{B}{2\sqrt{2}}$

Pouvoir de coupure en court-circuit:

Courant $I_{eff} = \frac{A_1}{2\sqrt{2}}$ sous tension $U_{eff} = \frac{B_1}{2\sqrt{2}}$

*b)* Oscillogram corresponding to a break after the current has reached its peak value.

Short-circuit making capacity:

Current $I_{peak} = A_3$ at voltage $U_{r.m.s.} = \frac{B}{2\sqrt{2}}$

Short-circuit breaking capacity:

Current $I_{r.m.s.} = \frac{A_1}{2\sqrt{2}}$ at voltage $U_{r.m.s.} = \frac{B_1}{2\sqrt{2}}$

*c)* Oscillogramme correspondant à une coupure intervenant avant que le courant ait atteint sa valeur de crête.

Pouvoir de fermeture en court-circuit:

Courant $I_{crête} = A_3$ sous tension $U_{eff} = \frac{B}{2\sqrt{2}}$

Pouvoir de coupure en court-circuit:

Courant $I_{eff} = \frac{A_2}{2\sqrt{2}}$ sous tension $U_{eff} = \frac{B_2}{2\sqrt{2}}$

*c)* Oscillogram corresponding to a break before the current has reached its peak value.

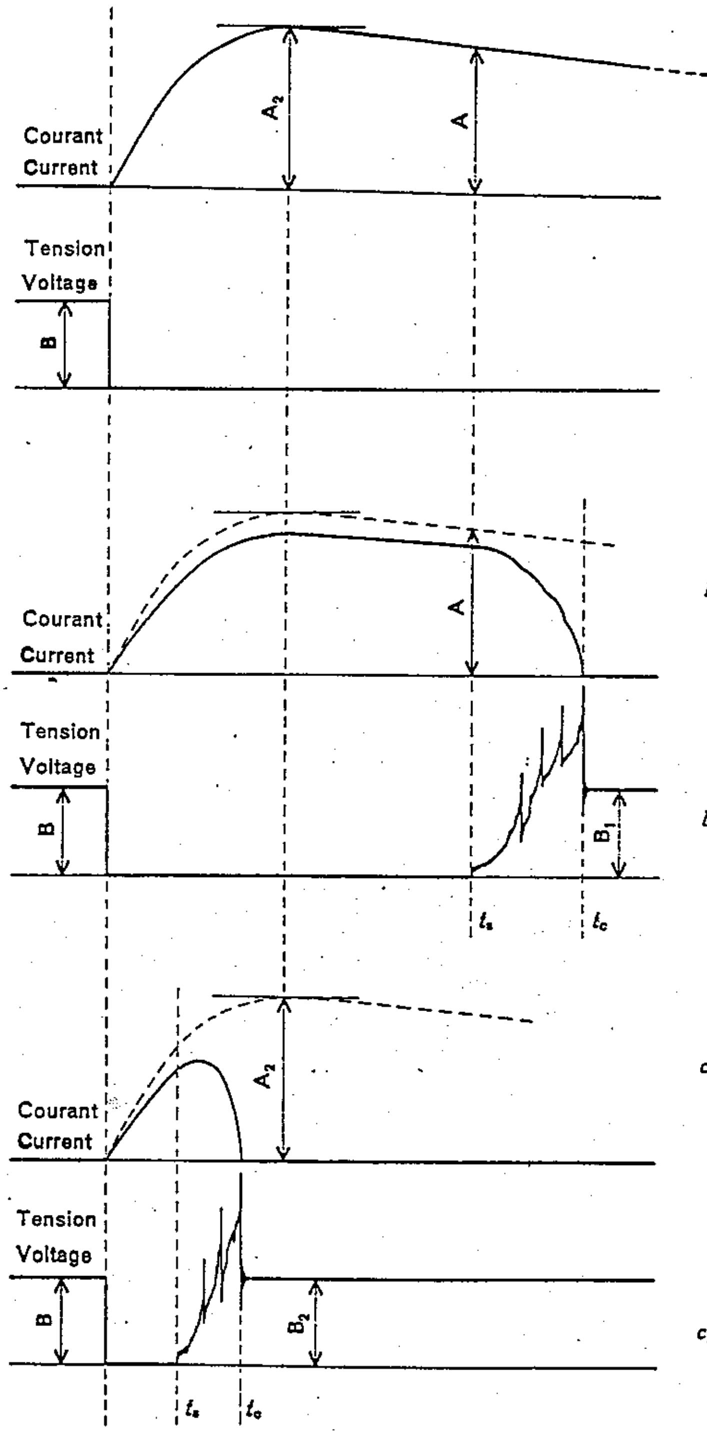
Short-circuit making capacity:

Current $I_{peak} = A_3$ at voltage $U_{r.m.s.} = \frac{B}{2\sqrt{2}}$

Short-circuit breaking capacity:

Current $I_{r.m.s.} = \frac{A_2}{2\sqrt{2}}$ at voltage $U_{r.m.s.} = \frac{B_2}{2\sqrt{2}}$

FIG. 4. — Vérification des pouvoirs de fermeture et de coupure en court-circuit en courant alternatif.
Verification of short-circuit making and breaking capacities on a.c.




*a)* Etalonnage du circuit.

Courant présumé établi (valeur de crête) = $A_2$

*a)* Calibration of the circuit.

Prospective peak making current = $A_2$

*b)* Oscillogramme correspondant à une coupure intervenant après que le courant a dépassé sa valeur maximale.

Pouvoir de coupure en court-circuit:
Courant $I = A$ sous tension $U = B_1$

Pouvoir de fermeture en court-circuit:
Courant $I = A_2$ sous tension $U = B$

*b)* Oscillogram corresponding to a break after the current has passed its maximum value.

Short-circuit breaking capacity:
Current $I = A$ at voltage $U = B_1$

Short-circuit making capacity:
Current $I = A_2$ at voltage $U = B$

*c)* Oscillogramme correspondant à une coupure intervenant avant que le courant ait atteint sa valeur maximale.

Pouvoir de coupure en court-circuit:
Courant $I = A_2$ sous tension $U = B_2$

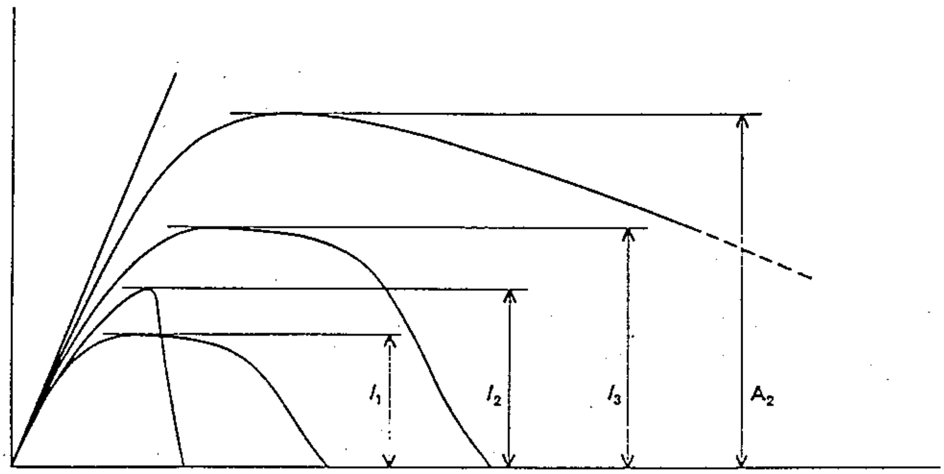
Pouvoir de fermeture en court-circuit:
Courant $I = A_2$ sous tension $U = B$

*c)* Oscillogram corresponding to a break before the current has reached its maximum value.

Short-circuit breaking capacity:
Current $I = A_2$ at voltage $U = B_2$

Short-circuit making capacity:
Current $I = A_2$ at voltage $U = B$

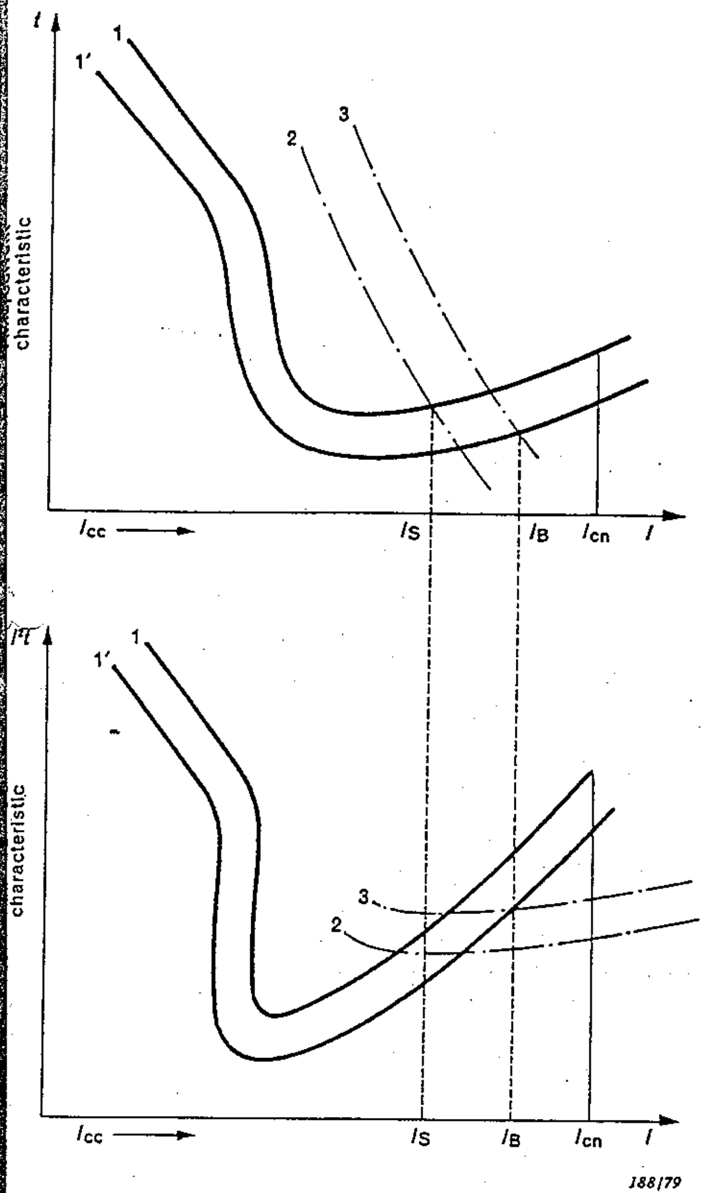
FIG. 5. — Vérification des pouvoirs de fermeture et de coupure en court-circuit en courant continu.
Verification of short-circuit making and breaking capacities on d.c.

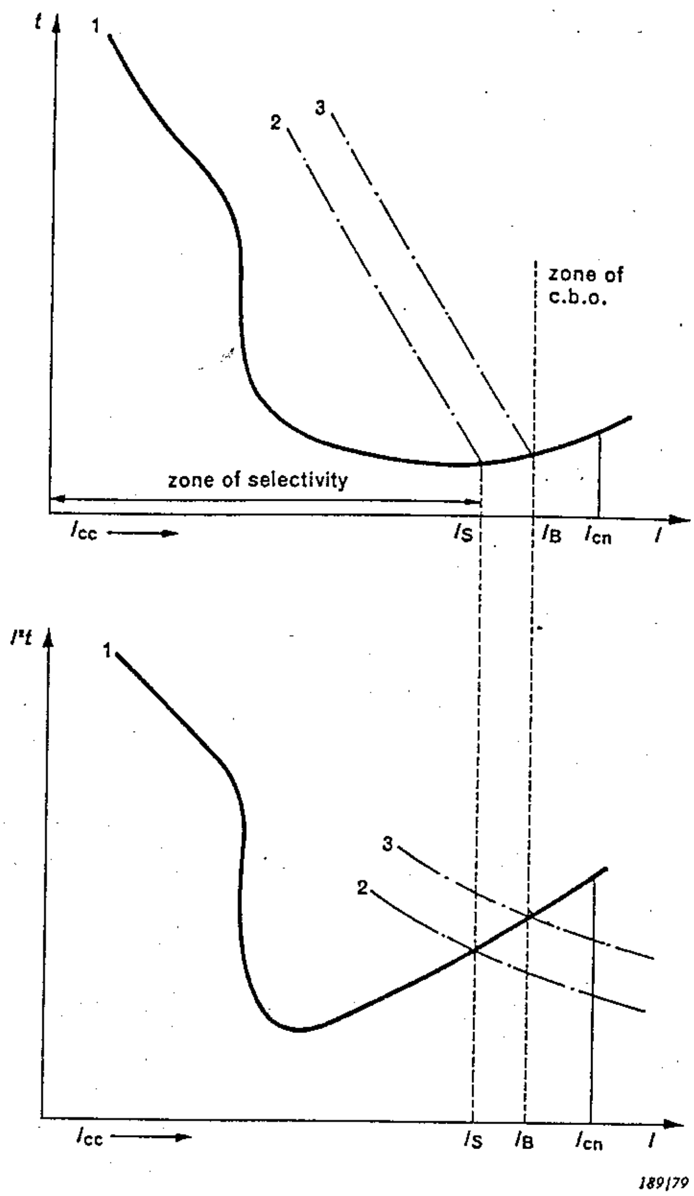



| | |
|---|---|
| $I_1$ Premier étalonnage | $I_1$ First calibration |
| $I_2$ Courant réellement coupé | $I_2$ Actual breaking current |
| $I_3$ Second étalonnage | $I_3$ Second calibration |
| $A_2$ Pouvoir de coupure | $A_2$ Breaking capacity |

FIG. 6. — Détermination du courant présumé coupé dans le cas où le premier étalonnage du circuit d'essai a été effectué à un courant inférieur au pouvoir de coupure assigné (note de l'article 8.2.4.8.3 *b*).

Determination of the prospective breaking current when the first calibration of the test circuit has been made at a current lower than the rated breaking capacity (note of Clause 8.2.4.8.3 *b*).




$I_{cc}$ = Prospective short-circuit current;
$I_{cn}$ = Rated short-circuit breaking capacity (see Clause 4.3.5.2);
$I_S$ = Selectivity limit of current (see new Clause 2.5.21*b*));
$I_B$ = Take-over current (see new Clause 2.5.21*a*));
$I^2t$ = The integral of the square of the current extended over the break-time;
1 = Upper limit of the operating range of the circuit-breaker;
1′ = Lower limit of the operating range of the circuit-breaker;
2 = Pre-arcing characteristic of the fuse;
3 = Operating characteristic of the fuse;
Zone of c.b.o. = zone of certain back-up operation.

FIG. 7. — General case of circuit-breakers with break-time exceeding 40 ms or 50 ms (in particular circuit-breakers fitted with time-lag release independent from overcurrent).

FIG. 8. — General case of circuit-breakers with break-time less than 20 ms (in particular current-limiting circuit-breakers).

# APPENDIX A

## DETERMINATION OF SHORT-CIRCUIT POWER-FACTOR OR TIME-CONSTANT

There is no method by which the short-circuit power-factor or time-constant can be determined with precision, but for the purpose of the present recommendation, the determination of the power-factor or the time-constant of the test circuit may be made by the following methods:

### *a)* DETERMINATION OF SHORT-CIRCUIT POWER-FACTOR

**Method I. Determination from d.c. component**

The angle $\varphi$ may be determined from the curve of the d.c. component of the asymmetrical current wave between the instant of the short-circuit and the instant of contact separation as follows:

1. The formula for the d.c. component is:

$$i_d = I_{do}\, e^{-Rt/L}$$

where

$i_d$ is the value of the d.c. component at the instant $t$,
$I_{do}$ is the value of the d.c. component at the instant taken as time origin,
$L/R$ is the time-constant of the circuit, in seconds,
$t$ is the time, in seconds, taken from the initial instant,
e is the base of Napierian logarithms.

The time-constant $L/R$ can be ascertained from the above formula as follows:

*a)* Measure the value of $I_{do}$ at the instant of short-circuit and the value of $i_d$ at an other instant $t$ before contact separation,
*b)* determine the value of $e^{-Rt/L}$ by dividing $i_d$ by $I_{do}$,
*c)* from a table of values of $e^{-x}$ determine the value of $-x$ corresponding to the ratio $i_d/I_{do}$,
*d)* the value $x$ then represents $Rt/L$, from which $L/R$ is obtained.

2. Determine the angle $\varphi$ from:

$$\varphi = \arctan \omega L/R$$

where $\omega$ is $2\pi$ times the actual frequency.

This method should not be used when the currents are measured by current transformers, except if suitable precautions are taken to eliminate errors due to:

— the time-constant of the transformer and its burden in relation to that of the primary circuit;
— magnetic saturation which can result from the transient flux conditions combined with possible remanence.

**Method II. Determination with pilot generator**

When a pilot generator is used on the same shaft as the test generator, the voltage of the pilot generator on the oscillogram may be compared in phase first with the voltage of the test generator and then with the current of the test generator.

The difference between the phase angles between pilot generator voltage and main generator voltage on the one hand and pilot generator voltage and test generator current on the other hand gives the phase angle between the voltage and current of the test generator, from which the power-factor can be determined.

### *b)* DETERMINATION OF SHORT-CIRCUIT TIME-CONSTANT (OSCILLOGRAPHIC METHOD)

The value of the time-constant is given by the abscissa corresponding to the ordinate 0.632 $I$ of the ascending part of the curve of the oscillogram of calibration of the circuit (Figure 5, page 110).

# APPENDIX B

## INFORMATION TO BE GIVEN BY THE USER WHEN CONDITIONS FOR OPERATION IN SERVICE DIFFER FROM THE STANDARD

**B1. Ambient air temperature**

The user shall state to the manufacturer the expected range of ambient air temperature if this temperature can be lower than −5 °C or higher than +40 °C.

**B2. Altitude**

The user shall state to the manufacturer the altitude of the place of installation if it is more than 2 000 metres (6 600 feet).

**B3. Atmospheric conditions**

The user shall call the manufacturer's attention in case the atmosphere in which the circuit-breaker is to be installed may have a relative humidity greater than the values specified in Clause 6.1.3 or contain an abnormal amount of dust, acids, corrosive gases, etc. The same applies if the circuit-breaker is to be installed near the sea.

**B4. Conditions of installation**

The user shall call the manufacturer's attention in case the circuit-breaker may be fitted to a moving device, if its support may be capable of assuming a sloping position either permanently or temporarily (circuit-breakers fitted aboard ships), or if it may be exposed in service to abnormal shocks or vibrations.

**B5. Connections with other apparatus**

The user shall inform the manufacturer of the type and dimensions of electrical connections with other apparatus in order to enable him to provide enclosures and terminals meeting the conditions of installation and temperature rise prescribed by this recommendation, and also to enable him to provide space where necessary to spread out conductors within the enclosure.

**B6. Auxiliary switches**

The user shall specify the number and type of auxiliary switches to be supplied to satisfy requirements such as signalling, interlocking, etc.

# APPENDIX C

## CLEARANCES AND CREEPAGE DISTANCES FOR CIRCUIT-BREAKERS

### C1. Introduction

It is not possible to lay down a simple set of rules relating to clearances and creepage distances which can be applied to circuit-breakers as so much depends on variable factors such as atmospheric conditions, the type of insulation employed, the disposition of the creepage paths and the conditions of the system in which the circuit-breaker is to be used. For these reasons, the selection of the proper values for clearances and creepage distances remains the responsibility of the manufacturer.

### C2. Definitions

(Vacant.)

### C3. General

C3.1 It is recommended that the surface of the insulating parts should be designed with ridges so arranged as to break the continuity of conducting deposits which may form.

C3.2 Conducting parts covered only with varnish or enamel, or protected only by oxidation or a similar process, should not be considered as being insulated from the point of view of clearances and creepage distances.

C3.3 Clearances and creepage distances shall be maintained under the following circumstances:

*a)* On the one hand, without external electrical connections, and, on the other hand, when conductors either insulated or bare, of the type and of any dimensions specified for the circuit-breaker, are installed according to the manufacturer's instructions, if any.

*b)* After interchangeable parts have been changed, taking into account maximum permissible manufacturing tolerances.

*c)* Taking into consideration possible deformations either due to the effect of temperature, ageing, shock, vibration, or due to short-circuit conditions which the circuit-breaker is intended to endure.

# APPENDIX D

## CO-ORDINATION OF CIRCUIT-BREAKERS WITH SEPARATE FUSES ASSOCIATED IN THE SAME CIRCUIT

**Introduction**

With integrally-fused circuit-breakers, the circuit-breaker manufacturer is responsible for ensuring the correct co-ordination of the circuit-breaker with its fuses. But circuit-breakers are frequently connected in series with separate fuses, for reasons such as the method of power distribution adopted for the installation, or because the breaking capacity of the circuit-breaker alone may be insufficient for the proposed application. In such instances, the fuses may be mounted in locations remote from the circuit-breaker. Moreover, the fuse or fuses may be protecting a main feeder supplying a number of circuit-breakers or just an individual circuit-breaker.

*Note.* — Generally, fuses are located on the supply side of the circuit-breaker in such an association. However, specific installation rules may authorize to locate them on the load side of the circuit-breaker. As regards co-ordination, problems are the same in both cases.

For such applications, the user or specifying authority may have to decide, on the basis of a desk study alone, how best the optimum level of co-ordination may be achieved. This appendix is therefore intended to give guidance on this decision, and also to give guidance on the type of information the circuit-breaker manufacturer should make available to the prospective user.

*Note.* — The term "co-ordination" includes consideration of discrimination (i.e. selective operation) as well as consideration of back-up protection (see new Clause 2.5.21).

Guidance is also given on test requirements, should such tests be deemed essential for the proposed application. But for the vast majority of applications, expensive and complicated testing may not be considered necessary. This may be for a variety of practical considerations, such as the prospective short-circuit current being less than or only marginally in excess of the breaking capacity of the circuit-breaker alone.

### D1. Scope

This appendix deals with requirements for the co-ordination of circuit-breakers with separate fuses associated in the same circuit.

### D2. Object

The object of this appendix is to state:

— the general requirements for the co-ordination of a circuit-breaker with its associated fuse or fuses;

— the methods and the tests (if deemed necessary) intended to verify that the conditions for co-ordination have been met.

### D3. General requirements for co-ordination of a circuit-breaker with its associated fuse or fuses

D3.1 *General considerations*

Ideally, the co-ordination should be such that the circuit-breaker alone will operate at all values of over-current up to the limit of its rated breaking capacity.

In practice, the following considerations apply:

*a)* If the value of the prospective fault current at the point of installation is less than the rated breaking capacity of the circuit-breaker, it may be assumed that the fuse or fuses are only in the circuit for considerations other than those of back-up protection. If the value of the take-over current $I_B$ (see definition 2.5.21) is too low, there is a risk of unnecessary loss of selectivity (i.e. selective operation).

*b)* If the value of the prospective fault current at the point of installation exceeds the rated breaking capacity of the circuit-breaker, the fuse or fuses shall be so selected as to ensure compliance with the requirements of Clauses D3.2 and D3.3.

D3.2 *Take-over current*

The take-over current $I_B$ (see definition 2.5.21) shall be not greater than the breaking capacity of the circuit-breaker alone.

D3.3 *Behaviour of the circuit-breaker in association with its fuses*

For all values of over-current up to and including the breaking capacity assigned to the combination:

*a)* The making operation of the circuit-breaker as well as the breaking operation of the combination shall not give rise to external manifestations (such as emission of flames) projected beyond the limits stated by the manufacturer, see Clause 9.2.2*a)*.

*b)* There shall be no flashover between poles or between poles and frame, nor welding of contacts see Clause 9.2.2*b)*.

*Note.* — See also Clauses D5.2 and D5.3.

## D4. Type and characteristics of the associated fuses

On request, the manufacturer of the circuit-breaker shall state, in accordance with the relevant IEC publications (Publications 269-1 and 269-2 or 269-3), the type and the characteristics of the fuses to be used with the circuit-breaker, and the maximum prospective short-circuit current for which the combination is suitable at the stated rated operational voltage.

Whenever possible, the fuses shall be located on the supply side of the circuit-breaker. If the fuses are located on the load side, it is essential that the connections between the circuit-breaker and the fuses be so designed as to minimize any risk of short circuit.

## D5. Methods for verification of the co-ordination

D5.1 *Determination of the take-over current*

Compliance with the requirements of Clause D3.2 shall be verified by comparing the operating characteristics of the circuit-breaker and of the fuse.

If the circuit-breaker is fitted with adjustable over-current opening releases, the operating characteristics to be used shall be those corresponding to the minimum current setting. If the circuit-breaker can be fitted with instantaneous over-current opening releases, the operating characteristics to be used shall be those corresponding to the circuit-breaker fitted with such releases.

D5.2 *Verification of the behaviour of the circuit-breaker/fuse combination under short-circuit conditions*

*a)* Full compliance with the requirements of Clause D3.3 can be verified only by tests in accordance with Clause D5.3. In this case, all the conditions for the test shall be as specified in Clause 8.2

of this standard, with the adjustable resistors and inductors for the short-circuit test on the supply side of the association.

*b)* If the circuit-breaker is of the non-current-limiting type, then in some practical cases it may be sufficient to compare the operating characteristics of the circuit-breaker and the fuse, special attention being paid to the following:

*1)* The Joule-integral values of the circuit-breaker and of the fuse during the total clearing time;

*2)* The effects on the circuit-breaker (e.g. by arc energy, by maximum peak current, etc.) at the peak value of the cut-off current of the fuse.

The suitability of the association may be evaluated by considering the maximum total operating $I^2t$ value of the fuse, over the range from the rated short-circuit capacity of the circuit-breaker to the prospective short-circuit current of the proposed application, but not exceeding the short-circuit capacity of the association. This value shall not exceed the maximum let-through $I^2t$ of the circuit-breaker at its rated short-circuit breaking capacity or other limiting value stated by the manufacturer.

In the ultimate, only the appropriate tests can verify thoroughly the suitability of the association of fuse and circuit-breaker at all currents up to the limiting value of the breaking capacity of the fuse.

D5.3 *Current for verification of current co-ordination under short-circuit conditions*

The short-circuit test is made with the maximum prospective current $I_A$, for the proposed application. This shall not exceed the maximum prospective short-circuit current assigned by the manufacturer to the association.

In addition, if $I_B$ is close to the rated breaking capacity ($I_{cn}$) of the circuit-breaker, for example greater than 80% of $I_{cn}$, an additional series of tests shall be made at a value of prospective current equal to 120% of $I_{cn}$. At least one fuse must operate.

Such additional tests may be made on a new and clean circuit-breaker at the manufacturer's request.

If tests are made in accordance with Clause D5.2, the following procedure shall apply:

| Order of tests | Test sub-clauses applicable to circuit-breakers of short-circuit performance categories | |
|---|---|---|
| | P-1 | P-2 |
| Short-circuit test at current $I_A$ | CO<br>8.2.4 | CO<br>8.2.4 |
| Conditions after test | 8.2.4.10<br>and<br>8.2.4.10.1 | 8.2.4.10<br>and<br>8.2.4.10.2 |

D5.4 *Results to be obtained*

See Clause D3.3.