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Appareillage de commande à basse tension

Première partie: Contacteurs

Low-voltage controlgear

Part 1: Contactors



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE CONTROLGEAR

Part 1: Contactors

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 this international unification, the IEC expresses the wish that all National Committees having as yet no national rules, when preparing such rules, should use the IEC recommendations as the fundamental basis for these rules in so far as national conditions will permit.
- 4) The desirability is recognized of extending international agreement on these matters through an endeavour to harmonize national standardization rules with these recommendations in so far as national conditions will permit. The National Committees pledge their influence towards that end.

PREFACE

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

It forms the second edition of Publication 158-1 and supersedes the first edition issued in 1964.

Work was commenced in January 1968 and the draft of revision was examined during the meeting held in Brussels in October 1968. The final draft was submitted to the National Committees for approval under the Six Months' Rule in March 1969, a corrigendum being circulated in July 1969.

The following countries voted explicitly in favour of publication:

Australia	Poland
Austria	South Africa
Belgium	Sweden
Denmark	Switzerland
Finland	Turkey
France	Union of Soviet Socialist
Germany*	Republics
Iran	United Kingdom
Israel	United States of America**
Italy	Yugoslavia
Norway	

The Netherlands National Committee has cast a negative vote since it considers too high the values of the temperature-rise limits for insulated coils in air as stated in Clause 7.3.1.

* Except for the temperature-rise limits for insulated coils in air (Clause 7.3.1), deemed to be too high.

** With the exception of Appendix B.

LOW-VOLTAGE CONTROLGEAR

Part 1: Contactors

1. General

1.1 Scope

This Recommendation applies to contactors intended for closing and opening electric circuits and, if combined with suitable relays, for protecting these circuits against operating overloads which may occur therein.

It applies only to contactors, 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.

Notes 1. — In the present absence of international specifications, an agreement shall take place between manufacturer and user in the case of a voltage exceeding 1 000 V a.c. or 1 200 V d.c., the present Publication being considered as a basis wherever applicable.

2. — Contactors which are intended to provide short-circuit protection shall additionally satisfy the relevant conditions specified for circuit-breakers (IEC Publication 157-1).

1.2 Object

The object of this Recommendation is to state:

1. the characteristics of contactors;
2. the conditions with which contactors shall comply with reference to:
 - a) their operation and behaviour;
 - b) their dielectric properties;
 - c) the degrees of protection provided by their enclosures;
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 Definitions concerning contactors

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 Controlgear

A general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for the control of power consuming equipment.

2.1.4 *Contactor (mechanical)*

A mechanical switching device having only one position of rest, operated otherwise than by hand, capable of making, carrying and breaking currents under normal circuit conditions including operating overload conditions.

Notes 1. — A contactor is usually intended to operate frequently.

2. — A contactor may also be capable of making and breaking short-circuit currents.

3. — In French, a contactor the main contacts of which are closed in the position of rest is usually called "rupteur". The word "rupteur" has no equivalent in the English language.

2.1.5 (Vacant.)

2.1.6 *Electromagnetic contactor*

A contactor in which the force for closing or opening the main contacts is provided by an electro-magnet.

2.1.7 *Pneumatic contactor*

A contactor in which the force for closing or opening the main contacts is provided by a device using compressed air, without the use of electrical means.

2.1.8 *Electro-pneumatic contactor*

A contactor in which the force for closing or opening the main contacts is provided by a device using compressed air under the control of electrically operated valves.

2.1.9 *Latched contactor*

A contactor, the moving elements of which leave the position of rest when the operating means are energized, but which are prevented by means of a latching arrangement from returning to the position of rest when the operating means are de-energized. The latching and the release of the latching may be mechanical, magnetic, electrical, pneumatic, etc.

Note. — Because of the latching, the latched contactor actually acquires a second position of rest and, according to the definition 2.1.4, it is not a contactor. However, since the latched contactor in both its utilization and its design is more closely related to contactors in general than to any other classification of switching device, it is considered proper to require that it complies with the specifications for contactors wherever they are applicable.

2.1.10 *Main circuit*

All the conducting parts of a contactor included in the circuit which it is designed to close or open.

2.1.11 *Pole of a contactor*

The portion of a contactor associated exclusively with one electrically separated conducting path of its main circuit and excluding those portions which provide a means for mounting and operating all poles together.

Note. — A contactor is called single-pole if it has only one pole. If it has more than one pole, it may be called multipole (two-pole, three-pole, etc.) provided the poles are or can be coupled in such a manner as to operate together.

2.1.12 *Main contact*

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

2.1.13 *Breaking current*

The current in a pole of a contactor at the instant of initiation of the arc during a breaking operation.

For a.c., it is the r.m.s. value of the a.c. component.

2.1.14 *Breaking capacity*

A value of breaking current that the contactor is capable of breaking at a stated voltage and under prescribed conditions of use and behaviour.

2.1.15 *Making capacity*

A value of current that the contactor is capable of making at a stated voltage and under prescribed conditions of use and behaviour.

For a.c., it is the r.m.s. value of the a.c. component.

2.1.16 *Recovery voltage*

The voltage which appears across the terminals of a pole of a contactor 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 (Clause 2.1.16.2) alone exists.

2.1.16.1 *Transient recovery voltage (restriking voltage)*

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 contactor. It includes the voltage shift of the neutral of a poly-phase 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.

2.1.16.2 *Power-frequency recovery voltage*

The recovery voltage after the transient voltage phenomena have subsided.

Notes 1. — The power-frequency recovery voltage may be referred to as a percentage of the rated voltage.

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

2.1.17 *Short-time withstand current*

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

2.1.18 *Over-current*

Any current exceeding the rated current.

2.1.19 *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.

2.1.20 *Conducting part*

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

2.1.21 *Clearance*

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

2.1.21.1 *Clearance between poles*

The clearance between any conducting parts of adjacent poles.

2.1.21.2 *Clearance to earth*

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

2.1.21.3 *Clearance between open contacts (gap)*

The total clearance between the contacts, or any conducting parts connected thereto, of a pole of a contactor in the open position.

2.1.22 *Creepage distance*

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

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

2.1.23 *Accidentally dangerous part*

A conducting part which can be touched readily by an operator and which is normally not alive, but which may become alive, for instance as a result of an insulation failure.

Note. — Typical accidentally dangerous parts are walls of enclosures, operating handles, etc.

2.1.24 *Ambient air temperature*

The temperature, determined under prescribed conditions, of the air surrounding the complete contactor (e.g., for enclosed contactors, it is the air outside the enclosure).

2.2 *Definitions concerning positions, control and auxiliary circuits of a contactor*

2.2.1 *Position of rest*

The position which the moving elements of the contactor take up when its electro-magnet or its compressed-air device is not energized.

2.2.2 *Control circuit*

All the conducting parts of a contactor (other than the main circuit) used for the closing operation or opening operation, or both, of the contactor.

Note. — Pneumatic contactors do not include control circuits.

2.2.3 *Control contact*

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

Note. — A control contact is part of the design of a contactor.

2.2.4 *Auxiliary circuit*

All the conducting parts of a contactor intended to be included in a circuit other than the main circuit and the control circuits of the contactor.

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.

2.2.5 *Auxiliary contact*

A contact included in an auxiliary circuit of a contactor and mechanically operated by the contactor.

Note. — An auxiliary contact is intended to satisfy supplementary requirements such as signalling, interlocking, etc., and as such it may be part of a control circuit of another switching device.

2.2.6 *a-contact (make contact)*

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

2.2.7 *b-contact (break contact)*

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

2.2.8 *Closed position*

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

2.2.9 *Open position*

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

2.2.10 *Operation (of a contactor)*

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

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.

2.2.11 *Operating cycle (of a contactor)*

A succession of operations from one position to the other and back to the first position.

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

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

2.2.12 *Closing operation*

An operation by which the contactor is brought from the open position to the closed position.

2.2.13 *Opening operation*

An operation by which the contactor is brought from the closed position to the open position.

3. **Classification**

3.1 According to the method of control, contactors are designated as:

- electromagnetic,
- pneumatic,
- electro-pneumatic.

Note. — This Recommendation may also concern contactors fitted with other types of control as far as it is practically applicable.

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

- air break,
- oil-immersed break.

3.3 According to the degree of protection provided by the enclosure. Full details are given in IEC Publication 144, Degrees of Protection of Enclosures for Low-voltage Switchgear and Control-gear.

4. **Characteristics of contactors**

4.1 *Summary of characteristics*

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

Type of contactor (see Clause 4.2);

Rated values (see Clause 4.3);

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

Auxiliary circuits (see Clause 4.5);

Degrees of protection of enclosures (see Clause 3.3).

4.2 *Type of contactor*

The following shall be stated:

4.2.1 *Number of poles*

4.2.2 *Kind of current*

Kind of current, 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 control* (see Clause 3.1)

4.3 *Rated values*

The rated values established for a contactor shall be stated in accordance with Clauses 4.3.1 to 4.3.8, but it is not necessary to establish all the rated values listed.

4.3.1 *Rated voltages*

A contactor is defined by the following rated voltages:

4.3.1.1 *Rated operational voltages*

A rated operational voltage (U_e) of a contactor is a value of voltage which, combined with a rated operational current, determines the application of the contactor and to which are referred the making and breaking capacities, the type of duty, and the utilization category.

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

Notes 1. — A contactor may be assigned a number of combinations of rated operational voltages and rated operational currents for different duties and utilization 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 contactor 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 contactor. In no case shall the maximum rated operational voltage exceed the rated insulation voltage.

4.3.2 *Rated currents*

A contactor is defined by the following rated currents:

4.3.2.1 *Rated thermal current*

The rated thermal current (I_{th}) of a contactor is the maximum current it can carry on eight-hour duty (see Clause 4.3.4.1) without the temperature rise of its several parts exceeding the limits specified in Clause 7.3 (Tables V and VI) when tested according to Clause 8.2.2.

Note. — The rated thermal current can differ according to the type of enclosure.

4.3.2.2 *Rated operational currents or rated operational powers*

A rated operational current (I_e) of a contactor is stated by the manufacturer and takes into account the rated operational voltage (see Clause 4.3.1.1), the rated frequency (see Clause 4.3.3), the rated duty (see Clause 4.3.4), the utilization category (see Clause 4.3.6) and the type of protective enclosure.

In the case of contactors for motors, the indication of a rated operational current may be replaced or supplemented by the indication of the maximum rated power output, at the rated operational voltage considered, of the motor for which the contactor is intended. The manufacturer shall be prepared to state the relationship assumed between the current and the power.

4.3.3 *Rated frequency*

The supply frequency for which a contactor is designed and to which the other characteristic values 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 contactor 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 contactor.

4.3.4.2 *Uninterrupted duty*

Duty in which the main contacts of a contactor 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 contacts) (see Table VI).

4.3.4.3 *Intermittent periodic duty or intermittent duty*

Duty in which the main contacts of a contactor remain closed for periods bearing a definite relation to the no-load periods, both periods being too short to allow the contactor to reach thermal equilibrium.

Intermittent duty is characterized by the value of the current, the duration of current flow and by the on-load factor which is the ratio of the in-service period to the entire period, often expressed as a percentage.

Example: An intermittent duty comprising a current flow of 100 A for 4 min in every 10 min may be stated as: "Intermittent duty 100 A, 4 min/10 min" or "Intermittent duty 100 A, 6 operating cycles per hour, 40%".

Standard values of on-load factor are 15%, 25%, 40% and 60%.

4.3.4.3.1 *Classes of intermittent duty*

According to the number of operating cycles which they shall be capable of carrying out per hour, contactors are divided into the following classes:

- Class 0.03: up to 3 operating cycles per hour;
- Class 0.1 : up to 12 operating cycles per hour;
- Class 0.3 : up to 30 operating cycles per hour;
- Class 1 : up to 120 operating cycles per hour;
- Class 3 : up to 300 operating cycles per hour;
- Class 10 : up to 1 200 operating cycles per hour.

Note. — On the occasion of a future revision, Class 30 will be considered.

It is recalled that an operating cycle is a complete working cycle comprising one closing operation and one opening operation.

For intermittent duty with a large number of operating cycles per hour, the manufacturer shall indicate, either in terms of the true cycle if this is known, or in terms of conventional cycles designated by him, the values of the rated operational currents which shall be such that:

$$\int_0^T i^2 dt \leq I_{th}^2 \times T$$

where T is the total operating cycle time.

4.3.4.4 *Temporary duty*

Duty in which the main contacts of a contactor remain closed for periods of time insufficient to allow the contactor to reach thermal equilibrium, the current-carrying periods being separated by no-load periods of sufficient duration to restore equality of temperature with the cooling medium.

Standard values of temporary duty are 10 min, 30 min, 60 min and 90 min with contacts closed.

4.3.5 *Making and breaking capacities*

A contactor is defined by its making capacities and breaking capacities, in accordance with utilization categories as specified in Table II (see Clause 4.3.6).

Note. — Certain contactors associated with over-current devices may also be subject to requirements as to their making and breaking capacities in the case of a short-circuit occurring where they are installed. They shall then comply with the requirements of this Recommendation including Appendix C or alternatively with the requirements of IEC Publication 157-1, Low-voltage Distribution Switchgear, Part 1: Circuit-breakers, for the rated short-circuit making and breaking capacities and the rated short-time withstand current.

4.3.5.1 *Rated making capacity*

The rated making capacity of a contactor is a value of current determined under steady state conditions which the contactor can make without welding or undue erosion of the contacts or excessive display of flame, under specified making conditions.

The making conditions which shall be specified are:

- the voltage between poles before contact making;
- the characteristics of the test circuit.

The rated making capacity is stated by reference to the rated operational voltage and rated operational current and to the utilization category, according to Table II.

For a.c., the rated making capacity is expressed by the r.m.s. value of the symmetrical component of the current.

Note. — For a.c., the peak value of the current during the first half-cycles following closing of the contactor may be appreciably greater than the peak value of the current under steady state conditions used in the definition of making capacity, depending on the power-factor of the circuit and the instant on the voltage wave when closing occurs.

A contactor shall be capable of closing on a current corresponding to the symmetrical value of the current which defines its making capacity, whatever the value of the asymmetrical component may be, within the limits which result from power-factors indicated in Table II.

The rated making capacity is only valid when the contactor is operated in accordance with the requirements of Clause 7.5.

4.3.5.2 *Rated breaking capacity*

The rated breaking capacity of a contactor is a value of current which the contactor can break without undue erosion of the contacts or excessive display of flame, under specified breaking conditions at the rated operational voltage.

The breaking conditions which shall be specified are:

- the characteristics of the test circuit;
- the recovery voltage.

The rated breaking capacity is stated by reference to the rated operational voltage and rated operational current and to the utilization category, according to Table II.

A contactor shall be capable of breaking any value of the load current up to its highest rated breaking capacity according to Clause 4.3.6.

For a.c. the rated breaking capacity is expressed by the r.m.s. value of the symmetrical component of the current.

4.3.5.3 *Ability to withstand overload currents*

Under consideration.

4.3.6 *Utilization category*

The utilization categories as given in Table I are considered standard in this Recommendation. Any other type of utilization category shall be based on agreement between manufacturer and user, but information given in the manufacturer's catalogue or tender may constitute such an agreement.

Each utilization category is characterized by the values of the currents and voltages, expressed as multiples of the rated operational current and of the rated operational voltage, and by the power-factors or time-constants as shown in Table II and other test conditions used in the definitions of the rated making and breaking capacities.

For contactors defined by their utilization category, it is therefore unnecessary to specify separately the rated making and breaking capacities as those values depend directly on the utilization category as shown in Table II.

The utilization categories of Table II correspond in principle to the applications listed in Table I.

TABLE I
Utilization categories

Category		Typical applications
A.C.	AC-1	Non-inductive or slightly inductive loads, resistance furnaces.
	AC-2	Slip-ring motors : Starting, plugging ¹⁾ .
	AC-3	Squirrel-cage motors : Starting, switching off motors during running.
	AC-4	Squirrel-cage motors : Starting, plugging ¹⁾ , inching ²⁾ .
D.C.	DC-1	Non-inductive or slightly inductive loads, resistance furnaces.
	DC-2	Shunt-motors : Starting, switching off motors during running.
	DC-3	Shunt-motors : Starting, plugging ¹⁾ , inching ²⁾ .
	DC-4	Series-motors : Starting, switching off motors during running.
	DC-5	Series-motors : Starting, plugging ¹⁾ , inching ²⁾ .

¹⁾ By plugging, is understood stopping or reversing the motor rapidly by reversing motor primary connections while the motor is running.

²⁾ By inching (jogging), is understood energizing a motor once or repeatedly for short periods to obtain small movements of the driven mechanism.

Note. — The application of contactors to the switching of rotor circuits, capacitors or tungsten filament lamps shall be subject to special agreement between manufacturer and user.

TABLE II

Verification of rated making and breaking capacities (See Clause 8.2.4)

Conditions for making and breaking corresponding to the several utilization categories⁽¹⁾

	Category	Value of the rated operational current	Make			Break		
			I/I_e	U/U_e	$\cos \varphi$ ⁽²⁾	I_e/I_e	U_r/U_e	$\cos \varphi$ ⁽²⁾
A.C.	AC-1	(All values)	1.5	1.1	0.95	1.5	1.1	0.95
	AC-2	(All values)	4	1.1	0.65	4	1.1	0.65
	AC-3	$I_e \leq 17 \text{ A}$	10	1.1	0.65	8	1.1	0.65
		$17 \text{ A} < I_e \leq 100 \text{ A}$	10	1.1	0.35	8	1.1	0.35
	AC-4	$I_e > 100 \text{ A}$	8 ⁽³⁾	1.1	0.35	6 ⁽⁴⁾	1.1	0.35
		$I_e \leq 17 \text{ A}$	12	1.1	0.65	10	1.1	0.65
		$17 \text{ A} < I_e \leq 100 \text{ A}$	12	1.1	0.35	10	1.1	0.35
		$I_e > 100 \text{ A}$	10 ⁽⁵⁾	1.1	0.35	8 ⁽³⁾	1.1	0.35
D.C.	DC-1	(All values)	I/I_e	U/U_e	L/R ⁽⁶⁾ (ms)	I_e/I_e	U_r/U_e	L/R ⁽⁶⁾ (ms)
			—	—	—	—	—	—
	DC-2	(All values)	4	1.1	2.5	4	1.1	2.5
	DC-3	(All values)	4	1.1	2.5	4	1.1	2.5
	DC-4	(All values)	4	1.1	15	4	1.1	15
	DC-5	(All values)	4	1.1	15	4	1.1	15

I_e Rated operational current (see Clause 4.3.2.2);

U_e Rated operational voltage (see Clause 4.3.1.1);

I Current made;

U Voltage before make;

U_r Recovery voltage;

I_e Current broken.

1) In a.c. the conditions for making are expressed in r.m.s. values, but it is understood that the peak value of asymmetrical current, corresponding to the power-factor of the circuit, may assume a higher value (see Clause 4.3.5.1, Note).

2) Tolerance for $\cos \varphi$: ± 0.05 .

3) With a minimum of 1 000 A for I or I_e .

4) With a minimum of 800 A for I_e .

5) With a minimum of 1 200 A for I .

6) Tolerance for L/R : $\pm 15\%$.