

Specification for

Motor starters for voltages above 1 kV a.c. and 1.2 kV d.c. —

Part 1: Direct-on-line (full voltage) a.c. starters

IEC title: High-voltage motor starters Part 1: Direct-on-line
(full voltage) a.c. starters

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Cooperating organizations

The Power Electrical Engineering Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- Associated Offices Technical Committee
- Association of Short Circuit Testing Authorities*
- British Electrical and Allied Manufacturers Association (BEAMA)
- British Railways Board*
- British Steel Corporation
- Department of Energy (Electricity)
- Electrical Contractors' Association
- Electrical Contractors' Association of Scotland
- Electrical Research Association*
- Electricity Supply Industry in England and Wales*
- Engineering Equipment Users' Association*
- Institute of Purchasing and Supply
- Institution of Electrical Engineers
- Ministry of Defence
- National Coal Board*
- National Economic Development Office*

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of this British Standard:

- Association of Supervisory and Executive Engineers
- Control and Automation Manufacturers Association (BEAMA)
- Department of The Environment (PSA)
- Electrical Installation Equipment Manufacturers' Association (BEAMA)
- Health and Safety Executive
- London Transport Executive
- The Transmission and Distribution Association (BEAMA)

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National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Committee and is identical with IEC Publication 632-1:1978 “*High-voltage motor starters — Part 1: Direct-on-line (full voltage) a.c. starters*” published by the International Electrotechnical Commission (IEC). It supersedes those requirements of BS 587:1957 “*Motor starters and controllers*” that relate to direct-on-line (full voltage) a.c. starters for voltages above 1 kV.

Terminology and conventions. The text of the international standard has been approved as suitable for publication, without deviation, as a British Standard. Some terminology and certain conventions are not identical with those used in British Standards; attention is especially drawn to the following.

The comma has been used in one of the figures as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Where page numbers are quoted in the text they refer to IEC page numbers.

Cross-references

International standard	Corresponding British Standard
IEC 71-1:1976 ^a	BS 5622 Guide for insulation co-ordination Part 1:1979 Terms, definitions, principles and rules (Identical)
IEC 85:1957	BS 2757:1956 Classification of insulating materials for electrical machinery and apparatus on the basis of thermal stability in service (Technically equivalent)

^a The reference to IEC Publication 71 at the foot of page 21 (IEC page 75) should be read as IEC Publication 71-1.

At present there is no British Standard corresponding to IEC Publication 466 “*High-voltage insulation-enclosed switchgear and controlgear*” referred to in the text, since such equipment is not normally used in the United Kingdom, but the references constitute informative matter only and, as no mandatory requirements are involved, the validity of this British Standard is not affected. Related British Standards for IEC 56, IEC 282-1:1974, IEC 298:1969 and IEC 470:1974 are BS 5311, BS 2692-1:1975, BS 5227:1975 and BS 775-2:1974 respectively.

Manufacturers’ and purchasers’ options. Although not stated in the object clause (1.2), the document gives, at several points, a choice at the option of either the manufacturer or the prospective purchaser.

In the case of the manufacturer’s options it is understood that the option selected will be recorded in the type test report.

In the case of the purchaser’s options, attention is drawn particularly to clauses 1, 4, 6, 7, 8, B.4 and B.6, which should be considered in conjunction with Appendix A, when ordering.

Textual error. In Figure 8, the phrase “Fuse did not operated” should be read as “Fuse did not operate”.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 32, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

1 General

1.1 Scope

This standard applies to direct-on-line starters for industrial use, intended to start and accelerate a motor to normal speed and to provide means for the protection of the motor and its associated circuits against operating overloads, and to cause intentionally the motor to stop.

This standard applies also to reversing starters and includes inching and plugging duties.

Breaking of short-circuit currents is outside the scope of this standard.

NOTE Suitable short-circuit protection should be ensured by protective devices (e.g. fuses or circuit breakers) which may form part of the installation or of the starter itself. These protective devices should comply with their relevant IEC Standards, and Appendix B gives requirements for their co-ordination with the starter.

It applies only to starters, the main contacts of which are intended to be connected to circuits the rated voltage of which exceeds 1 000 V a.c. but does not exceed 12 000 V a.c. for non-exposed installations.

Since such starters are normally for 3-phase motors with 3-pole switching, this standard is drafted accordingly. Variations necessary for any other arrangement are subject to special agreement. It does not apply to starters using static main switching devices.

NOTE The use of starters in exposed installations is subject to special agreement. Where necessary, reference should be made to the appropriate equipment IEC Standard (e.g. IEC Publications 298, High-voltage Metal-enclosed Switchgear and Controlgear, and 466, High-voltage Insulation-enclosed Switchgear and Controlgear).

The clauses of this standard relating to overload protection may not be applicable in the case of controlgear relying for its operation on built-in over-temperature protective devices.

NOTE The expression "built-in" means built into the motor.

1.2 Object

The object of this standard is to state:

- 1) the characteristics of direct-on-line starters;
- 2) the conditions with which starters shall comply with reference to:
 - a) their construction, operation and behaviour;
 - b) their dielectric properties;

NOTE For enclosures, reference should be made to the appropriate equipment IEC Standard (e.g. IEC Publications 298 and 466).

- 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

2.1 starter

the combination of all the switching means necessary to start and stop the motor, in combination with suitable overload protection

2.2 direct-on-line starter

a starter which connects the line voltage across the motor terminals in one step

2.3 reversing starter

a starter intended to cause the motor to reverse the direction of rotation by reversing the motor primary connections while it is running

2.4 manual starter

a starter in which the force for closing the main contacts is provided by manual energy

2.5 electromagnetic starter

a starter in which the force for closing the main contacts is provided by an electromagnet (e.g. contactor starter)

2.6 motor-operated starter

a starter in which the force for closing the main contacts is provided by an electric motor

2.7 pneumatic starter

a starter in which the force for closing the main contacts is provided by a device using compressed air without the use of electrical means

2.8 electro-pneumatic starter

a starter in which the force for closing the main contacts is provided by a device using compressed air under the control of electrically operated valves

2.9 over-current

any current exceeding the rated current

2.10 overload

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

NOTE An overload may cause damage if maintained for a sufficient time.

2.11**short-circuit current**

an over-current resulting from a fault in an electrical circuit

2.12**overload relay or release**

an over-current relay or release intended for protection against overloads (including, where applicable, operating transformer(s) and interconnections)

2.13**thermal overload relay or release**

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

2.14**current setting of an overload relay or release**

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

2.15**current setting range of an overload relay or release**

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

2.16**non-exposed installation**

an installation in which the equipment is not subjected to over-voltages of atmospheric origin

NOTE Such installations are usually supplied by cable networks.

2.17**trip free starter**

a starter, 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.

2.18**phase failure sensitive thermal overload relay or release**

a multipole thermal overload relay or release which, in accordance with specified requirements, operates at a current value lower than its current setting in the case of current unbalance

3 Classification

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

- automatic (such as by pilot switch or sequence control);
- non-automatic (such as by hand operation or by push-buttons).

3.2 According to the method of operation, starters are designated as:

- manual;
- electromagnetic;
- motor operated;
- pneumatic;
- electro-pneumatic.

3.3 According to the interrupting medium, starters are divided into different groups, for example:

- air break;
- oil-immersed break;
- vacuum or other sealed media.

3.4 According to the degree of protection provided by the enclosure. See appropriate IEC Standard, e.g. IEC Publications 298 or 466.

4 Characteristics of starters**4.1 Summary of characteristics**

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

- Type of switching devices (see Sub-clause 4.2).
- Type and characteristics of relays and releases (see Sub-clause 4.3) and number of these devices.
- Degrees of protection of enclosures (see Sub-clauses 1.2 and 3.4).
- Rated values (see Sub-clause 4.4).
- Control circuits and compressed air supply systems (see Sub-clause 4.5).
- Auxiliary circuits (see Sub-clause 4.6).
- Co-ordination with short-circuit protective devices (see Sub-clause 4.7).

NOTE Pending consideration of over-voltages produced by starter switching, the manufacturer of the starter should be consulted in case of doubt as to their effect.

4.2 Types of switching devices

The following shall be stated:

4.2.1 Number of poles.**4.2.2** Interrupting medium (air, oil, vacuum, etc.).**4.2.3** Method of operation, for example: dependent power operation (e.g. contactor), stored energy operation.

In the case of manual starters, the type of operating device shall be stated: e.g. handle, lever, and for power operated starters, the type of control: e.g. push buttons, time switch, etc.

4.3 Types and characteristics of relays and releases

NOTE In the remainder of this standard, the words "overload relay" shall be taken to apply equally to an overload relay or an overload release as appropriate.

4.3.1 Types

- 1) Release with shunt coil (shunt trip).
- 2) Under-voltage opening relay or release.
- 3) Overload time-delay relay, the time-lag of which is:
 - a) substantially independent of previous load (e.g. time delay magnetic overload relay);
 - b) dependent on previous load (e.g. thermal overload relay);
 - c) dependent on previous load (e.g. thermal overload relay) and also sensitive to phase failure (see Sub-clause 2.18).
- 4) Instantaneous over-current relay or release (when applicable).
- 5) Other relays or releases (e.g. phase unbalance relay).

4.3.2 Characteristics

- 1) Release with shunt coil and under-voltage opening relay or release:
 - rated voltage;
 - rated frequency.
- 2) Overload relay:
 - either the associated motor full-load current, or the ultimate trip current (see Sub-clause 7.5.3.2);
 - rated frequency (when necessary);
 - current setting (or range of settings);
 - time-current characteristics (or range of characteristics), when necessary;
 - number of poles;
 - nature of the relay: thermal or magnetic.

NOTE Depending on the nature of the relay, the opening conditions are given in Sub-clause 7.5.3.2.

4.3.3 Designation and current setting of overload relays

Overload relays are designated by their type and their current setting. An overload relay is said to be:

- of Type 1 if the current setting refers to the associated motor full-load current (see Sub-clause 7.5.3.2.1, Item 1);
- of Type 2 if the current setting is the ultimate trip current (see Sub-clause 7.5.3.2.1, Item 2).

Both types are designated by the current setting (or the upper and lower limits of the current setting range, if adjustable).

The current setting (or current setting range) shall be marked on the overload relay or its scale. The marking may be either directly in amperes, or as a function of the current value marked on the relay or on the heaters, if these are replaceable.

However, if the current setting is influenced by the conditions of use or other factors which cannot readily be marked on the relay, then the relay or any interchangeable parts thereof (e.g. heaters or current transformers) shall carry a number or an identifying mark which makes it possible to obtain the relevant information from the manufacturer or his catalogue or, preferably, from data furnished with the starter.

In the case of indirect (current transformer operated) overload relays, 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 relays. In either case, the ratio of the current transformer shall be stated.

4.3.4 Time-current characteristics of overload relays

The time-current characteristics shall be given in the form of curves supplied by the manufacturer. These shall indicate how the tripping time, starting from the cold state (see Sub-clause 4.3.5), varies with the current up to a value of at least seven times the full-load current of the motor with which it is intended that the relay be used, or the takeover current per Appendix B, Sub-clause B.6.3.3, whichever is the greater. 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-current characteristics are 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 282-1, High-voltage Fuses, Part 1: Current-limiting Fuses (Sub-clause 18.9).

4.3.5 Influence of ambient air temperature

The time-current characteristics (see Sub-clause 4.3.4) refer to a stated value of ambient air temperature.

This value of the ambient air temperature shall be clearly given on the time curves; the preferred values are + 20 °C or + 40 °C.

The overload relays shall be able to operate within the ambient air temperature range of – 5 °C to + 40 °C, and the manufacturer shall be prepared to state the effect of variations in ambient air temperature on the characteristics of overload relays.

4.4 Rated values

The rated values established for a starter shall be stated in accordance with Sub-clauses 4.4.1 to 4.4.8, but it is not necessary to establish all the rated values listed.

4.4.1 Rated voltages

A starter is defined by the following rated voltages:

4.4.1.1 Rated operational voltages

A rated operational voltage (U_o) of a starter is a value of voltage which, combined with a rated operational current, determines the application of the starter 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.

NOTE 1 For rated voltages of control circuits, see Sub-clause 4.5.1.

NOTE 2 A starter may be assigned a number of combinations of rated operational voltages and rated operational currents for different duties and utilization categories.

4.4.1.2 Rated insulation voltage

The rated insulation voltage (U_i) of a starter is the value of voltage which designates it, and to which dielectric tests (Sub-clause 7.4) are referred.

Unless otherwise stated, the rated insulation voltage is the value of the maximum rated operational voltage of the starter. In any case, the maximum rated operational voltage shall not exceed the rated insulation voltage. For polyphase circuits it is stated as the voltage between phases.

4.4.2 Rated currents

A starter is defined by the following rated currents:

4.4.2.1 Rated thermal current

The rated thermal current (I_{th}) of a starter equipped with suitable overload relays is the maximum current it can carry on eight-hour duty (see Sub-clause 4.4.4.1) without the temperature rise of its various parts exceeding the limits specified in Sub-clause 7.3 (Table V and Table VI) when tested according to Sub-clause 8.2.2.

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

The rated thermal current of the starter cannot be lower, without special agreement between manufacturer and user, than:

- the current setting (or the maximum value of the setting range) of the overload relay Type 1, with which the starter is equipped;
- 0.87 the current setting (or 0.87 the maximum value of the setting range) of the overload relay Type 2, with which the starter is equipped.

4.4.2.2 Rated operational currents or rated operational powers

A rated operational current (I_o) of a starter is stated by the manufacturer and takes into account the rated current of the overload relay installed in this starter, the rated operational voltage (see Sub-clause 4.4.1.1), the rated frequency (see Sub-clause 4.4.3), the rated duty (see Sub-clause 4.4.4), the utilization category (see Sub-clause 4.4.6), and the type of protective enclosure.

The indication of a rated operational current may be replaced or supplemented by the indication of the rated power output (kW) at the rated operational voltage of the motor for which the starter is intended. The manufacturer shall be prepared to state the relationship assumed between the current and the power.

4.4.3 Rated frequency

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

4.4.4 Rated duty

The rated duties considered as normal are as follows:

4.4.4.1 Eight-hour duty

Duty in which the main contacts of a starter remain closed, whilst carrying a steady current long enough for the starter to reach thermal equilibrium but not for more than 8 h without interruption.

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

NOTE 2 Interruption means breaking of the current by operation of the starter.

4.4.4.2 Uninterrupted duty

Duty in which the main contacts of a starter remain closed, whilst carrying a steady current without interruption for periods of more than 8 h (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 derating factor, or by special design consideration (e.g. silver contacts) (see Table VI).

4.4.4.3 Intermittent periodic duty or intermittent duty

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

For intermittent duty 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 time.

NOTE 1 For intermittent duty, the difference between the thermal time-constant of the overload relay and that of the motor may render a thermal overload relay unsuited for overload protection. It is recommended that for installations intended for intermittent duty the question of overload protection be covered by special agreement between manufacturer and user.

NOTE 2 For high operating cycles per hour the temperature rise of the contacts and associated parts may be significantly influenced by arc energy.

4.4.4.3.1 Classes of intermittent duty

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

- Class 0.01: up to 1 operating cycle per hour;
- 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.

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

4.4.4.4 Temporary duty

Duty in which the main contacts of a starter remain closed for periods of time insufficient to allow the starter 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.

4.4.5 Making and breaking capacities

A starter is defined by its making and breaking capacities, as specified in Table II, in accordance with utilization categories (see Sub-clause 4.4.6). For requirements when used in combination with short-circuit protective devices see Sub-clause 4.7.

4.4.5.1 Rated making capacity

The rated making capacity of a starter is a value of current determined under steady-state conditions which the starter 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.

The rated making capacity is expressed by the r.m.s. value of the symmetrical component of the current.

NOTE The peak value of the current during the first half-cycle following closing of the starter may be appreciably greater than the peak value of the current under steady state conditions depending on the power factor of the circuit, and the instant on the voltage wave when closing occurs. A starter should be capable of closing on a current corresponding to the a.c. component of the current which defines its making capacity, whatever the value of d.c. component may be, within the limits which result from power factors indicated in Table II.

The rated making capacity is based on the starter being operated in accordance with the requirements of Sub-clause 7.5.

4.4.5.2 Rated breaking capacity

The rated breaking capacity of a starter is a value of current which the starter 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 starter shall be capable of breaking any value of the load current between its minimum rated breaking current and its highest rated breaking capacity according to Sub-clause 4.4.6.

NOTE If a minimum breaking capacity less than that given in Table II is required, special arrangements should be agreed between manufacturer and user.

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

4.4.5.3 Ability to withstand overload currents

The starter shall be capable of carrying the current corresponding to the maximum rated breaking capacity, for the operation time of the overload relay, without damage or noticeable alterations.

4.4.6 Utilization category

The two utilization categories as given in Table I are considered standard in this standard. 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 take the place of 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 as shown in Table II and other test conditions used in the definition of the rated making and breaking capacities.

For starters 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 conditions of making and breaking shown in Table II correspond in principle to the applications listed in Table I.

Table I — Utilization categories

Category	Typical applications
AC-3	Starting and switching off motors during running — cage induction motors
AC-4	Starting, inching ^a , and plugging ^b ... cage induction motors
NOTE The application of starters to the switching of induction motors with individual power factor correction by capacitors shall be subject to special agreement between manufacturer and user.	
^a By inching (jogging) is understood energizing a motor once or repeatedly for short periods to obtain small movements of the driven mechanism.	
^b By plugging, is understood stopping or reversing the motor rapidly by reversing motor primary connections while the motor is running.	

**Table II — Verification of rated making and breaking capacities (see Sub-clause 8.2.4)
Conditions for making and breaking corresponding to the utilization categories^a**

Category	Make			Break					
				Minimum rated breaking current			Highest rated breaking capacity		
	I/I_e	U/U_e	$\cos \varphi^b$	I_c/I_e	U_r/U_e	$\cos \varphi^b$	I_c/I_e	U_r/U_e	$\cos \varphi^b$
AC-3	8	1.1	0.35	0.2	1.1	0.15	8	1.1	0.35
AC-4	10	1.1	0.35	0.2	1.1	0.15	8	1.1	0.35

I_e = rated operational current (see Sub-clause 4.4.2.2)

U_e = rated operational voltage (see Sub-clause 4.4.1.1)

I = current made

U = voltage before make

U_r = recovery voltage

I_c = current broken

^a 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 Sub-clause 4.4.5.1, Note).

^b Tolerance for $\cos \varphi$: ± 0.05 .

^c In the case of re-acceleration or plug braking it should be noted that at the instant of making, the voltage and current may be doubled.