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Specification for

Motor starters for voltages up to and including 1000 V a.c. and 1200 V d.c.

Part 3. Rheostatic rotor starters

Spécification des démarreurs de moteur pour les tensions inférieures et égales à 1000 V en courant alternatif et 1200 V en courant continu
Partie 3. Démarreurs rotoriques à résistances

Spezifikation für Motorstarter für Spannungen bis und einschließlich 1000 V Wechselstrom und 1200 V Gleichstrom
Teil 3. Widerstandsanlasser für Schleifringläufermotoren

British Standards Institution

Gr 8

Foreword

This British Standard has been prepared under the authority of the Power Electrical Engineering Standards Committee. It is identical with Publication 292 'Low-voltage motor starters' Part 3 'Rheostatic rotor starters' published by the International Electrotechnical Commission (IEC). It supersedes those requirements of BS 587 : 1957 'Motor starters and controllers' that relate to rheostatic rotor starters for voltages up to and including 1000 V a.c.

Because the text of an IEC Publication has been copied it includes some minor material not appropriate to a British Standard.

For the purposes of this British Standard the text of IEC 292-3 given in this publication should be modified as follows.

Terminology. The words 'British Standard' should replace 'Recommendation' wherever it appears.

Cross-references. The references to other IEC Publications should be replaced by references to British Standards as follows.

Reference to IEC Publication	Appropriate British Standard
IEC Publication 144 'Degrees of protection of enclosures for low-voltage switchgear and controlgear'	BS 5420 'Degrees of protection of enclosures of switchgear and controlgear for voltages up to and including 1000 V a.c. and 1200 V d.c.'*
IEC Publication 157 'Low-voltage switchgear and controlgear' Part 1 'Circuit-breakers'	BS 4752 'Switchgear and controlgear for voltages up to and including 1000 V a.c. and 1200 V d.c.' Part 1 'Circuit-breakers'*
IEC Publication 158 'Low-voltage controlgear' Part 1 'Contactors'	BS 5424 'Controlgear for voltages up to and including 1000 V a.c. and 1200 V d.c.' Part 1 'Direct-on-line (full voltage) a.c. starters'*
IEC Publication 292 'Low-voltage motor starters' Part 1 'Direct-on-line (full voltage) a.c. starters'	BS 4941 'Motor starters for voltages up to and including 1000 V a.c. and 1200 V d.c.' Part 1 'Direct-on-line (full voltage) a.c. starters'
IEC Publication 292-1A 'First supplement to Publication 292-1 (1969)'	Appendix C 'Co-ordination with short-circuit protective devices'
IEC Publication 337 'Control switches (low-voltage switching devices for control and auxiliary circuits, including contactor relays)' Part 1 'General requirements'	BS 4794 'Control switches (switching devices, including contactor relays, for control and auxiliary circuits up to and including 1000 V a.c. and 1200 V d.c.)' Part 1 'General requirements'

*In course of preparation.

CONTENTS

LOW-VOLTAGE MOTOR STARTERS

Part 3: Rheostatic rotor starters

1. General

1.1 *Scope*

This Recommendation applies to starters for industrial use, designed for starting an a.c. induction motor having a wound rotor, by cutting out resistors previously inserted in the rotor circuit, and to provide means for the protection of the motor against operating overloads, and to cause intentionally the motor to stop.

It applies only to starters, the main contacts of which are intended to be connected to supply circuits the rated voltage of which does not exceed 1 000 V a.c. In the case of asynchronous slip-ring motors (wound-rotors), the highest voltage between slip-rings shall be not greater than twice the rated insulation voltage of the switching devices inserted in the rotor circuit (see Clause 4.4.1.4).

Note. — This easement is based on the fact that the electric stresses are less severe in the rotor than in the stator and are of short duration.

This Recommendation applies also to starters for two directions of rotation when reversal of connections is made with the motor stopped (see Clause 4.4.6). Operations including inching and plugging will necessitate additional requirements and shall be subject to agreement between manufacturer and user.

This Recommendation applies to resistors which are part of the starter or constitute a unit specially designed to be associated with the starter.

The starters dealt with in this Recommendation are not designed to interrupt short-circuit currents. Therefore, suitable short-circuit protection (see IEC Publication 292-1A: First supplement to Publication 292-1) shall form part of the installation, but not necessarily in the starter.

The clauses of this Recommendation relating to overload protection may not apply in the case of controlgear associated with built-in over-temperature protective devices.

Note. — The expression " built-in " means " built into the motor ".

This Recommendation does not apply to:

— unbalanced starters, viz. where the resistances do not have the same value in all phases;

— equipments designed not only for starting, but also for adjustment of speed;

— liquid starters and those of the « liquid-vapour » type;

— static starters using semi-conductor elements.

1.2 *Object*

The object of this Recommendation is to state:

1. the characteristics of rheostatic rotor starters;
2. the conditions with which starters must comply with reference to:
   a) their operation and behaviour;
   b) 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 *Starter*

See IEC Publication 292-1.*

2.2 *Rheostatic starter*

A starter utilizing one or several resistors for obtaining, during starting, stated motor torque characteristics and/or for limiting the current. It comprises the mechanical switching devices necessary for cutting out the resistors.

Note. — A rheostatic starter generally consists of three basic parts which may be supplied either as a composite unit or as separate units to be connected at the place of utilization:
— the mechanical switching devices for supplying the stator (generally associated with an overload protective device);
— the resistors inserted in the stator or rotor circuit;
— the mechanical switching devices for cutting out the resistors successively.

2.2.1 *Rheostatic rotor starter*

A rheostatic starter for an asynchronous wound-rotor motor which, during the starting period, cuts out successively one or several resistors previously provided in the rotor circuit.

2.3 (Vacant)

2.4 *Manual starter*

See IEC Publication 292-1.

2.5 *Electromagnetic starter*

See IEC Publication 292-1.

2.6 *Motor-operated starter*

See IEC Publication 292-1.

2.7 *Pneumatic starter*

See IEC Publication 292-1.

* Whenever reference is made to IEC Publication 292-1, the clause with the same clause number applies, in some instances modified by the text which follows.

2.8 *Electro-pneumatic starter*

See I E C Publication 292-1.

2.9 *Over-current*

See I E C Publication 292-1.

2.10 *Overload*

See I E C Publication 292-1.

2.11 *Short-circuit current*

See I E C Publication 292-1.

2.12 *Overload relay or release*

See I E C Publication 292-1.

2.13 *Thermal overload relay or release*

See I E C Publication 292-1.

2.13 a *Magnetic overload relay or release*

An overload relay or release depending for its operation on the force exerted by a current flowing in the coil of an electromagnet.

Note. — Such a relay or release usually has an inverse time-delay/current characteristic.

2.14 *Current setting of an overload relay or release*

See I E C Publication 292-1.

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

See I E C Publication 292-1.

2.16 *Undercurrent relay*

A measuring relay which operates when the current through it is reduced below the operating value.

2.17 *Single-step starter*

A starter in which there is no intermediate accelerating position between the OFF and FULL ON positions.

Note. — This is a direct-on-line starter.

2.18 *n-step starter (see Figure 1)*

A starter in which there are $n - 1$ intermediate accelerating positions between the OFF and FULL ON positions.

Example: A three-step rheostatic rotor starter has two sections of resistors used for starting.

2.19 *Starting time t_s*

The length of time while the starting resistors or parts of them carry current.

3. Classification

3.1 (See IEC Publication 292-1.)

3.2 (See IEC Publication 292-1.)

3.3 (See IEC Publication 292-1.)

3.4 According to the degree of protection provided by the enclosure, distinction is made in accordance with IEC Publication 144.

3.5 According to the method of changing starting steps, starters are designated as:

— automatic change-over (i.e. independent of the operator), e.g.: controlled by a timer or an undercurrent relay;

— non-automatic change-over (i.e. dependent on the operator), e.g.: controlled by hand or by push-buttons;

— semi-automatic change-over, i.e. for which the successive orders of the operator during starting are executed only after having been checked by an automatic device.

3.6 According to the means of cooling of resistors, starters are designed as:

— having resistors cooled by convection;

— having resistors cooled by forced air;

— having resistors cooled by immersion in oil.

4. Characteristics of rheostatic rotor starters

Note. — If, for special applications, the intermediate steps are not considered as transitional positions for starting, but on the contrary as normal operating connections, an agreement as to the special characteristics required shall be reached between manufacturer and user.

4.1 *Summary of characteristics*

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

— characteristics of starting (see Clause 4.4.6);

— types of switching devices (see Clause 4.2);

— types and characteristics of automatic acceleration control devices (see Clause 4.8);

— types and characteristics of relays and releases (see Clause 4.3) and number of these devices;

— degrees of protection provided by enclosures (see IEC Publication 144: Degrees of protection of enclosures for low-voltage switchgear and controlgear);

— rated quantities (see Clause 4.4);

— control circuits and air-supply systems (see Clause 4.5);

— auxiliary circuits (see Clause 4.6) ;

— types and characteristics of starting resistors (see Clause 4.9);

— co-ordination with short-circuit protective devices (see IEC Publication 292-1A: First supplement to Publication 292-1).

4.2 *Types of switching devices*

The following shall be stated:

4.2.1 Number of poles, according to their function: for supplying the stator or for short-circuiting resistors.

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

4.2.3 *Method of operation* for example: dependent manual operation, dependent power operation (e.g.: contactor), stored energy operation, etc.

In the case of manual starters, the type of operating device shall be stated: handle, lever, push-buttons, etc.

4.3 *Types and characteristics of relays and releases*

Note. — In the remainder of the Recommendation, 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).
4. Instantaneous over-current relay or release (when applicable).
5. Other relays or releases (e.g.: phase unbalance relay, control switch associated with devices for the thermal protection of the starter).

Note. — Types referred to in Items 4 and 5 require consultation between manufacturer and user according to the particular application.

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 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.

Notes 1. — Depending on the nature of the relay, the opening conditions are given in Clause 7.5.3.2 or in Clause 7.5.3.3.

2. — The overload relay is commonly inserted in the stator circuit. As a result, in the case of a rheostatic rotor starter, it cannot efficiently protect the rotor circuit and more particularly the resistors (generally more easibly damageable than the rotor itself or the switching devices in case of a faulty starting); protection of the rotor circuit shall be the subject of a specific agreement between manufacturer and user (see inter alia Clause 7.1.1).

4.3.3 *Designation and current settings of overload relays*

See IEC Publication 292-1.

4.3.4 *Time-current characteristics of overload relays*

See IEC Publication 292-1.

4.3.5 *Influence of ambient air temperature*

See IEC Publication 292-1.

4.4 *Rated quantities*

The rated quantities established for a rheostatic rotor starter shall be stated in accordance with Clauses 4.4.1 to 4.4.8, but it is not necessary to establish all the rated quantities listed.

4.4.1 *Rated voltages*

A rheostatic rotor starter is defined by the following rated voltages:

Note. — For rated voltages of control circuits, see Clause 4.5.1.

4.4.1.1 *Rated stator operational voltages*

A rated stator operational voltage (U_{es}) of a rheostatic rotor starter is a value of voltage which, combined with a rated stator operational current, determines the application of the stator circuit including its mechanical switching devices and to which are referred the making and breaking capacities, the type of duty and the starting characteristics.

Note. — It is expressed as the voltage between phases.

4.4.1.2 *Rated rotor operational voltages*

A rated rotor operational voltage (U_{er}) of a rheostatic rotor starter is a value of voltage which, combined with a rated rotor operational current, determines the application of the rotor circuit including its mechanical switching devices and to which are referred the making and breaking capacities, the type of duty and the starting characteristics.

It is taken as equal to the voltage measured between slip-rings, with the motor stopped and the rotor open-circuited, when the stator is supplied at its rated voltage.

4.4.1.3 *Rated stator insulation voltage*

The rated stator insulation voltage (U_{is}) of a rheostatic rotor starter is the value of voltage which designates the devices inserted in the stator supply as well as the unit they are part of, and to which dielectric tests, clearances and creepage distances are referred.

Unless otherwise stated, the rated stator insulation voltage is the value of the maximum rated stator operational voltage of the starter. In no case shall the maximum rated operational voltage exceed the corresponding rated insulation voltage.

4.4.1.4 *Rated rotor insulation voltage*

The rated rotor insulation voltage (U_{ir}) of a rheostatic rotor starter is the value of voltage which designates the devices inserted in the rotor circuit as well as the unit they are part of (connecting links, resistors, enclosure), and to which dielectric tests, clearances and creepage distances are referred.

It shall be noted that the voltage corresponding to the rated rotor insulation voltage is only applied for a short duration during the starting period. For this reason, it is permissible that the rated rotor operational voltage exceed the rated rotor insulation voltage by 100%.

Further, it shall be noted that the maximum voltage between the different live parts (e.g.: the switching devices, the resistors, the connecting parts, etc.) of the rotor circuit of the starter will vary and account may be taken of this fact in choosing the equipment and its disposition.

4.4.2 *Rated currents*

A rheostatic rotor starter is defined by the following rated currents, related to the FULL ON position, viz. after cutting out resistors with the motor running at its normal speed.

4.4.2.1 *Rated stator thermal current*

The rated stator thermal current (I_{ths}) of a rheostatic rotor starter equipped with suitable overload relays is the maximum current it can carry on eight-hour duty (see Clause 4.4.4.1) without the temperature rise of its several parts exceeding the limits specified in Clause 7.3 (Tables V and VI) when tested in accordance with Clause 8.2.2.

4.4.2.2 *Rated rotor thermal current*

The rated rotor thermal current (I_{thr}) of a rheostatic rotor starter is the maximum current that those parts of the starter through which the rotor current flows in the FULL ON position, viz. after cutting out resistors, can carry on eight-hour duty (see Clause 4.4.4.1) without their temperature rises exceeding the limits specified in Clause 7.3 (Tables V and VI) when tested in accordance with Clause 8.2.2.

Notes 1. — For those elements (switching devices, connecting links, resistors) through which a current of practically no value flows in the FULL ON position, it shall be verified that, for the rated duties (see Clause 4.4.4) stated by the manufacturer, the value of the integral $\int_0^{t_s} i^2 dt$ does not lead to temperature rises higher than those appearing in Clause 7.3.

2. — When resistors are built-in into the starter, certain additional conditions may be necessary in order to take into account the mutual influences.

4.4.2.3 *Rated stator operational currents or rated stator operational powers*

A rated stator operational current (I_{es}) of a rheostatic rotor starter is stated by the manufacturer and takes into account the rated current of the overload relay installed in this starter, the rated stator operational voltage (see Clause 4.4.1.1), the rated frequency (see Clause 4.4.3), the rated duty (see Clause 4.4.4), the starting characteristics (see Clause 4.4.6) and the type of protective enclosure.

The indication of a rated stator operational current may be replaced by the indication of the maximum rated power output, at the rated stator operational voltage considered, of the motor for which the stator elements of the starter are intended. The manufacturer shall be prepared to state the relationship assumed between the motor power and the rotor current.

4.4.2.4 *Rated rotor operational currents*

A rated rotor operational current (I_{er}) of a rheostatic rotor starter is stated by the manufacturer and takes into account the rated rotor operational voltage (see Clause 4.4.1.2), the rated frequency (see Clause 4.4.3), the rated duty (see Clause 4.4.4), the starting characteristics (see Clause 4.4.6) and the type of protective enclosure.

It is taken as equal to the current flowing in the connections to the rotor when the latter is short-circuited and the motor is running at rated full load and the stator is supplied at its rated voltage and rated frequency.

When the rotor part of a rheostatic rotor starter is rated separately, the indication of a rated rotor operational current may be supplemented by the indication of the maximum rated power output, for motors having the rated rotor operational voltage considered, of the motor for which that part of the starter (switching devices, connecting links, relays, resistors) is intended. This power varies in particular with the breakaway torque foreseen and consequently takes into account the starting characteristics (see Clause 4.4.6).

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*

Whatever the duty envisaged, the starter shall be capable of permitting two successive operating cycles, starting from the cold state, the time interval between two starts being equal to twice the starting time t_s.

The rated duties considered as normal are as follows:

4.4.4.1 *Eight-hour duty*

The duty in which the starter is in the FULL ON position and the main contacts of the switching devices which constitute it, which are closed in this position, remain closed whilst each of them carries a steady current long enough for the starter to reach thermal equilibrium, but not for more than 8 hours without interruption.

Notes 1. — This is the basic duty on which the rated thermal currents of the starter are determined.

2. — "Interruption" means breaking of the current by operation of the starter up to the OFF position.

4.4.4.2 *Uninterrupted duty*

The duty in which the starter is in the FULL ON position and the main contacts of the switching devices which constitute it, which are closed in this position, remain closed without interruption whilst each of them carries a steady current for periods of more than 8 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 VI).

4.4.4.3 *Intermittent periodic duty or intermittent duty*

The duty in which the main contacts of the switching devices constituting the 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 values of current, the durations of current flow and by the on-load factor, which is the ratio of the in-service period of the switching device which is closed the longest to the entire period, often expressed as a percentage.

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

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, rheostatic rotor starters 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.

For a rheostatic rotor starter, an operating cycle comprises the starting operation until the cutting out of all the starting resistors, followed by the stopping of the motor.

Note. — For intermittent duty, the difference between the thermal time-constant of the overload relay and that of the motor may render a thermal 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.

4.4.4.4 *Temporary duty*

A duty in which the main contacts of the switching devices constituting the 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 for the duration of current flow in the switching device which is closed the longest.

4.4.5 *Making and breaking capacities*

The making and breaking capacities of a rheostatic rotor starter are defined in accordance with the starting characteristics as specified in Clause 4.4.6.1.

Note. — Certain starters may also be subjected to requirements as to their making and breaking capacities in the case of a short-circuit occurring where they are installed. They must then comply with the requirements of this Recommendation and with the requirements of IEC Publication 157-1: "Low-voltage switchgear and controlgear — Part 1: Circuit-breakers" (2nd edition, Clauses 8.2.4 and 8.2.5) for the rated short-circuit making and breaking capacities and for the rated short-time withstand current.

4.4.5.1 *Rated making capacity*

The rated making capacity of a rheostatic rotor starter is a value of stator or rotor current 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 voltages and rated operational currents, and to the starting characteristics, according to Table II.

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

Note. — The peak value of the current during the first half-cycles following closing of the starter may be appreciably greater than the peak value of the current under steady conditions which corresponds to the r.m.s. value used in the definition of making capacity, depending on the characteristics of the circuit and the instant on the voltage wave when closing occurs. A starter shall 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 the d.c. component, within the limits which result from power-factors indicated in Table II.

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

4.4.5.2 *Rated breaking capacity*

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

The breaking conditions which shall be specified are:

— the recovery voltage;

— the characteristics of the test circuit.

The rated breaking capacity is stated by reference to the rated operational voltages and rated operational currents, and to the stopping characteristics, according to Table II.

A starter shall be capable of breaking any value of current up to its highest rated breaking capacity, according to Clause 4.4.6.

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

4.4.6 *Starting and stopping characteristics (see Figure 2)*

According to the type of the machine driven and to its utilization, a rheostatic rotor starter can ensure the following service conditions:

a) one direction of rotation with switching off the motor during running in normal service conditions;

b) two directions of rotation, but the running in the second direction is realized only after the starter has been switched off and the motor has completely stopped.

Note. — Rheostatic rotor starters may also be utilized for:

α) one direction of rotation, or two directions of rotation as in Paragraph *b)*; but with the possibility of inching, that is to say energizing the circuits of the motor once or repeatedly for short periods to obtain small movements of the driven mechanism;

β) one or two directions of rotation; but with the possibility of plugging, that is to say reversing the supply connections of the motor while it is running until it has completely stopped, this reversal being associated, if so provided, with rotor resistor braking (reversing-starter with braking);

γ) two directions of rotation; but with the possibility of reversing the supply connections of the motor while it is running in the first direction, in order to obtain its rotating in the other direction, with switching-off of the motor during running in normal service conditions;

δ) braking by injection of direct current into the stator circuit.

However, such conditions are special conditions and shall be subject to agreement between manufacturer and user.

4.4.6.1 *Starting characteristics of rheostatic rotor starters*

A distinction shall be drawn between the currents and voltages in the stator and rotor circuits of slip-ring motors. However, the changes of the current values in stator and rotor circuits, caused by the starting process, are nearly proportional under normal operating conditions.

The following clauses deal mainly with the characteristics of the rotor circuit.

U_{er} = rated rotor operational voltage;

I_{er} = rated rotor operational current;

I_1 = the current in the rotor circuit immediately before short-circuiting a resistor section;

I_2 = the current in the rotor circuit immediately after short-circuiting a resistor section;

$$I_m = \frac{1}{2}(I_1 + I_2)$$

Z_r = characteristic impedance of the rotor of an a.c. slip-ring induction motor;

$$Z_r = \frac{U_{er}}{\sqrt{3}\, I_{er}}$$

t_s = starting time (see Clause 2.19);

Note. — It is assumed that the starter is designed to give, during starting, approximately equal values of I_1 and approximately equal values of I_2.

$$k = \text{severity of start} = \frac{I_m}{I_{er}}$$

The preferred severities of start are:

starting with half torque : $I_m / I_{er} = 0.7$

starting with full torque : $I_m / I_{er} = 1.4$

starting with high torque : $I_m / I_{er} = 2.0$

These values incorporate an adequate reserve for acceleration, if the counter-torque of the driven machine does not exceed respectively 0.5, 1 and 1.4 times the rated motor torque during the starting period.

Since the starting current and the motor torque T_m are in practice sufficiently proportional in the range from starting with half torque to starting with high torque, the following relation applies:

$$k \approx \frac{T_m}{T_{rated}}$$

Unless otherwise stated by the motor manufacturer or the installer, it is assumed that the voltage drop in the rotor circuit (rotor, switching devices and connecting links) at the rated rotor operational current is (where P is the motor output):

For $P \leqslant 10$ kW : $0.1\ U_{er}$;

For 10 kW $< P \leqslant 63$ kW : $0.06\ U_{er}$;

For 63 kW $< P \leqslant 400$ kW : $0.035\ U_{er}$;

For 400 kW $< P \leqslant 1\,000$ kW : $0.02\ U_{er}$.

The values given in Table I are considered as standard in this Recommendation. If stated by the manufacturer of the motor, or in order to take account of the characteristics of the driven machinery, other values may be chosen by the manufacturer of the starter.

TABLE I

Starting characteristics

Motor output P (kW) for start with			Starting time t_s (in seconds)	Number of operating cycles per hour for classes of intermittent duty (*)			Standard number of starting steps (**)
half torque	full torque	high torque		0.03	0.1	0.3	
$P \leqslant 20$	$P \leqslant 10$	$P \leqslant 7$	6	3	12	30	3
$20 < P \leqslant 200$	$10 < P \leqslant 100$	$7 < P \leqslant 70$	12	3	12	30	4
$P > 200$	$P > 100$	$P > 70$	20	3	12	—	6

(*) The number of operating cycles per hour assumes equal periods between two successive starts. The figures given apply to starters cooled by air; for starters cooled by immersion in oil, the figures shall be based on an agreement between manufacturer and user.

(**) In certain cases, more or less steps may be required; in particular, for motors of 100 kW and upwards additional step or steps may be necessary to limit the initial starting current and accelerating torque.

4.4.6.2 *Standard conditions for making and breaking corresponding to the starting characteristics*

These conditions are given in Table II below and apply to starting with high torque (For the designation of the mechanical switching devices, see Figure 1).

Note. — Conditions for starting with full torque and half torque are under consideration.

The conditions for making and breaking as given in Table II are considered as standard in this Recommendation. Any other type of starting shall be based on agreement between manufacturer and user; information given in the manufacturer's catalogue or tender may take the place of such an agreement.

TABLE II

Verification of rated making and breaking capacities (1)

Mechanical switching devices	Make			Break		
	I/I_{es}	U/U_{es}	$\cos\varphi$ (2)	I/I_{es}	U_{rs}/U_{es}	$\cos\varphi$ (2)
CL	4	1.1	0.65	4	1.1	0.65
	I/I_{er}	U/U_{er}	$\cos\varphi$ (2)	I/I_{er}	U_{rr}/U_{er}	$\cos\varphi$ (2)
CR_R and CC_R	4	0.8	0.95	4	0.8	0.95

where:

CL = Switching device in the stator circuit
CR_R = Switching device for cutting out resistors in the rotor circuit
CC_R = Switching device for short-circuiting the rotor
I_{es} = Rated stator operational current (see Clause 4.4.2.3)
I_{er} = Rated rotor operational current (see Clause 4.4.2.4)
U_{es} = Rated stator operational voltage (see Clause 4.4.1.1)
U_{er} = Rated rotor operational voltage (also see Clause 4.4.1.2)
I = Current made or broken
U = Voltage before make
U_{rs} = Stator recovery voltage
U_{rr} = Rotor recovery voltage

(1) The conditions for making are expressed in r.m.s. values, but it is understood that the peak value of the d.c. component, corresponding to the power-factor of the circuit, may assume a higher value (see Clause 4.4.5.1, Note).

(2) Tolerance for $\cos\varphi$: $\pm$ 0.05.

The starter circuit shall normally be designed to open all rotor resistor switching devices before or approximately simultaneously with the opening of the stator switching device. When this design is not possible, the stator switching device shall comply with AC-3 requirements.

4.4.7 *Mechanical endurance*

See IEC Publication 292-1.

4.4.8 *Electrical endurance*

With respect to its resistance to electrical wear, a rheostatic rotor starter is characterized by the number of on-load operating cycles which can be made without repair or replacement.

Since the operation of a rheostatic rotor starter is subjected to large variations in the service conditions, it is deemed convenient not to give standard values. However, it is recommended that the manufacturer indicate the electrical endurance of the starter for stated service conditions; this electrical endurance may be estimated from the results of tests on the component parts of the starter.

4.5 *Control circuits and air-supply systems*

See IEC Publication 292-1.

4.5.1 *For control circuits*

See IEC Publication 292-1.

4.5.2 *For air-supply systems*

See IEC Publication 292-1.

4.6 *Auxiliary circuits*

See IEC Publication 292-1.

4.7 *Co-ordination with short-circuit protective devices*

See IEC Publication 292-1A.

4.8 *Types and characteristics of automatic acceleration control devices*

4.8.1 *Types*

Timers, e.g.: time-delay contactor relays (see IEC Publication 337-1) or specified-time all-or-nothing relays (see IEC Publication 255-2).

Undercurrent devices (undercurrent relays).

Devices dependent on voltage.

Devices dependent on power.

Devices dependent on speed.

4.8.2 *Characteristics*

a) The characteristics of timers are:

— the rated time delay, or range of time delay if adjustable;

— for timers fitted with a coil, the rated voltage.

b) The characteristics of the undercurrent devices are:

— the rated current (rated thermal current and/or short-time withstand current, according to the indications given by the manufacturer);

— the current setting or its range, if adjustable.

c) The characteristics of the other devices shall be determined by agreement between manufacturer and user.

4.9 *Types and characteristics of starting resistors*

Account being taken of the starting characteristics (see Clause 4.4.6.1) and of Clause 4.4.4 dealing with successive starts, the starting resistors shall be characterized by:

— their resistance value;

— the mean thermal current, defined by the value of steady current they can carry for a specified duration;

— the rated duty (see Clause 4.4.4);

— the method of cooling: convection;
forced air;
immersion in oil.

They can be:

— either built-in into the starter, in which case the resulting temperature rise has to be limited in order not to cause any damage to the other parts of the starter;

— or provided separately, in which case the nature and dimensions of the connecting links have to be specified by agreement between manufacturer of the resistors and manufacturer of the starter.

5. **Nameplates**

Each starter shall be provided with a nameplate carrying the following data, marked in a durable manner, and located in a place such that they are visible and legible when the starter is installed:

a) the manufacturer's name or trademark;

b) type designation or serial number;

c) rated operational voltages (see Clauses 4.4.1.1 and 4.4.1.2);

d) rated operational currents (or rated powers), at the rated operational voltages of the starter (see Clauses 4.4.2.3 and 4.4.2.4);

e) rated duty, with the indication of the class of intermittent duty if any (see Clause 4.4.4);

f) severity of start (see Clause 4.4.6.1);

g) starting time, if different from the figure given in Table I (see Clause 4.4.6.1);

h) rated frequency, e.g.: ~ 50 Hz;

i) if different from those of the coil: nature of current, rated frequency and rated control supply voltage (U_s).

If not evident from information stated elsewhere by the manufacturer, the following should also be stated on the starter nameplate:

j) rated insulation voltages (see Clauses 4.4.1.3 and 4.4.1.4);

k) rated thermal currents (see Clauses 4.4.2.1 and 4.4.2.2);

l) rated making and breaking capacities.

The following information concerning the operating coils of the starter shall be placed either on the coil or on the starter:

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

n) rated coil voltage.

For starters operated by compressed air:

o) rated supply pressure of the compressed air and the limits of variation of this pressure, if they are different from those specified in Clause 7.5.2.

The following information shall be placed on the overload relay:

p) type number: 1 or 2 (see Clauses 4.3.3 and 7.5.3.2.1);

q) current setting or setting range or an identifying mark, according to Clause 4.3.3. The information given shall make it possible for a user to obtain the time-current characteristics from the manufacturer, or from his catalogue, or from data supplied with the starter.

Note. — If the available space on the nameplate is insufficient to carry all the above data, the starter shall carry at least the information under *a)* and *b)* permitting the complete data to be obtained from the manufacturer.

6. Standard conditions for operation in service

6.1 *Standard service conditions*

See IEC Publication 292-1.

6.1.1 *Ambient air temperature*

See IEC Publication 292-1.

6.1.2 *Altitude*

See IEC Publication 292-1.

6.1.3 *Atmospheric conditions*

See IEC Publication 292-1.

6.1.4 *Conditions of installation*

The starter shall be installed in accordance with the manufacturer's instructions.

If the temperature rise of any exterior of an enclosure exceeds 40 °C, it shall be stated by the manufacturer (e.g. in his catalogue) to enable the user to guard or locate the starter as to prevent accidental contact by personnel.

Note. — Particular attention shall be paid to the positioning or guarding where the temperature of air issuing from ventilation openings can be considered a hazard.

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. If any part of the starter is oil-immersed, the construction shall be such that ignitable gases do not accumulate, and arcing parts and fuses shall be so located that there is no risk of gas ignition.

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 shall be transmitted through insulating material other than ceramic, pure mica, 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.

If any part of the starter is oil-immersed, the tank shall be provided with means for indicating the correct oil level.

Starting resistors mounted within the starter enclosure shall be so located or guarded that the issuing heat is not detrimental to other apparatus and materials within the enclosure.

When starters are used in conditions in which overheating of the starting resistors would represent an exceptional hazard, it is recommended that a suitable device be fitted to switch off the starter in the event of overheating. In particular, in the case of oil-immersed resistors, the starter shall be equipped with a suitable device to switch off the starter in the event of overheating of the oil.

7.1.2 *Clearances and creepage distances*

See IEC Publication 292-1.

7.1.3 *Terminals*

See IEC Publication 292-1.

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.

The position of the terminals shall be such that the insulation of the external conductors is not damaged by heat from the starting resistors.

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7.1.3.2 *Earth terminal*

See IEC Publication 292-1.

7.2 *Enclosures*

7.2.1 (Vacant)

7.2.2 *Mechanical details*

See IEC Publication 292-1.

7.2.3 *Insulation*

See IEC Publication 292-1.

7.3 *Temperature rise*

7.3.1 *Results to be obtained*

See IEC Publication 292-1.

7.3.2 *Ambient air temperature*

See IEC Publication 292-1.

7.3.3 *Main circuits*

The stator main circuit and those parts of the rotor main circuit of a rheostatic rotor starter through which current flows in the FULL ON position shall be capable of carrying their rated thermal currents (see Clauses 4.4.2.1 and 4.4.2.2) without the temperature rises exceeding the limits specified in Table VI.

Further, the complete main circuits of a rheostatic rotor starter shall be capable of carrying the currents appearing during a start in rated duty (see Clauses 4.4.4 and 4.4.6.1) without the temperature rises exceeding the limits specified in Table VI.

Note. — Only the terminals intended for external connections are considered, in this Recommendation, as terminals of the starter. When the terminals are intended for the connection of insulated conductors, they have to meet the temperature-rise conditions specified in Table VI.

7.3.4 *Windings of control electro-magnets*

See IEC Publication 292-1.

Note. — Operating coils of rheostatic rotor starters which are energized during the starting period only may be considered as specially rated coils, mentioned in the first paragraph of the present clause.

7.3.5 *Auxiliary circuits*

See IEC Publication 292-1.

7.4 *Dielectric properties*

See IEC Publication 292-1.

TABLE VI

Temperature-rise limits for the various materials and parts

Type of material Description of part	Temperature-rise limit (measured by thermocouple)
Contact parts in air (main, control and auxiliary contacts):	
— copper — uninterrupted duty	45 °C
— copper — eight-hour, intermittent, or temporary duty	65 °C
— silver or silver-faced	(1)
— all other metals or sintered metals	(2)
Contact parts in oil	65 °C
Bare conductors including non-insulated coils	(1)
Metallic parts acting as springs	(3)
Metallic parts in contact with insulating materials	(4)
Parts of metal or of insulating material in contact with oil, excluding starting resistors	65 °C
Starting resistors mounted in the starter	(2)
Starting resistors mounted separately	(2)
Terminals for external insulated connections	70 °C (5)
Manual operating means:	
— parts of metal	15 °C
— parts of insulating material	25 °C
Exteriors of enclosures which include starting resistors	200 °C (6)
Exteriors of enclosures adjacent to cable entries	40 °C
Oil in oil-immersed apparatus (measured approximately at 10 mm below the surface of the oil)	60 °C (7)
Air issuing from ventilation openings	200 °C (6-7)

(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 starter 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) This limit may be exceeded if so stated by the manufacturer; in this case, the apparatus shall be protected against contact with combustible materials.

(7) May be measured by thermometer.

7.5 *Operating conditions*

7.5.1 *General*

Starters shall be trip-free at all the starting steps, including the FULL ON position.

For a starter employing contactors, it is also necessary to ensure that, when the starter has been carrying the full-load motor current continuously, at the ambient air temperature corresponding to the rated characteristics, the overload relay does not trip and open the coil circuit of the starter, as a result of mechanical shocks of operating the contactors.

7.5.2 *Limits of operation*

See IEC Publication 292-1.

7.5.3 *Opening by relays or releases*

7.5.3.1 *Opening by releases with shunt coil (shunt-trips)*

See IEC Publication 292-1.

7.5.3.2 *Opening by thermal and magnetic time-delay overload relays*

See IEC Publication 292-1.

7.5.3.2.1 *Opening by thermal and magnetic time-delay overload relays when all their poles are energized*

See IEC Publication 292-1.

7.5.3.2.2 *Opening by multipole thermal overload relays when only some of their poles are energized*

See IEC Publication 292-1.

7.5.3.3 *Opening by magnetic instantaneous overload relays*

See IEC Publication 292-1.

7.5.3.4 *Opening by undervoltage relays or releases*

See IEC Publication 292-1.

8. **Tests**

8.1 *Verification of the characteristics of a starter*

See IEC Publication 292-1.

8.1.1 *Type tests*

See IEC Publication 292-1.

8.1.2 *Routine tests*

They comprise:

a) operation tests (see Clause 8.3.2);

b) dielectric tests (see Clause 8.3.3);

c) verification of the resistance value of the starting resistors (see Clause 8.3.2).

8.1.3 *Special tests*

These are tests subjected to agreement between manufacturer and user.

8.2 *Type tests*

8.2.1 *General*

Unless otherwise specified or stated by the manufacturer, each type test shall be carried out on a starter in a clean and new condition.

All tests shall be made at the rated frequency.

For tests, the starter shall be mounted and installed as indicated by the manufacturer. The details of installation (type and size of enclosure, if any, size of conductors, etc.) shall be part of the test report.

8.2.2 *Verification of temperature-rise limits*

When the starting resistors are mounted within the starter enclosure or in such a way that they can significantly affect the temperature within the enclosure, the starting resistors or equivalent resistive loads shall be separately energized during the temperature-rise tests of Clauses 8.2.2.2, 8.2.2.3 and 8.2.2.4. The power dissipated in the resistors shall be calculated taking into account the rated duty (see Clause 4.4.4) and the starting characteristics (see Clause 4.4.6.1); it shall correspond to the average power dissipated in the starting resistors.

Note. — If equivalent resistive loads are used, they should be so located that the heat be generated in such a manner it as nearly as possible represents the heating produced by the starting resistors.

When the resistors are mounted apart from the starter or do not significantly affect the temperature within the starter enclosure, they may be disconnected during the tests.

8.2.2.1 *Ambient air temperature*

See IEC Publication 292-1.

8.2.2.2 *Temperature-rise tests of the main circuit*

The starter shall be fitted with the overload relay complying with Clause 4.3.3, and stated by the manufacturer to be suitable for the motor full-load current corresponding to the rated thermal current of the starter. If the starter is fitted with an adjustable relay, then that overload relay which is adjusted nearest to the maximum of its scale shall be used.

The starter and its auxiliary devices shall be mounted approximately as under usual service conditions, and shall be protected against undue external heating or cooling.

It is permissible, before beginning the tests, to operate the starter a few times with or without load.

For a starter with contactors, the contacts shall, where practicable, be closed by energizing the contactor-operating coils at their rated voltage and, if electro-pneumatic, at the rated pressure.

The temperature-rise test of the main circuit is made at the rated thermal currents of the stator and rotor circuits (see Clause 7.3.3) and the starter shall be in the FULL ON position.

The test shall be made over a period of time sufficient for the temperature rise to reach a constant value, but not exceeding 8 hours. In practice, this condition is reached when the variation does not exceed 1 °C per hour.

Notes 1. — 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.

2. — When a control electro-magnet is energized during the test, the temperature shall be measured when thermal equilibrium is reached in both the main circuit and the control electro-magnet.

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 VI.

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

For values of rated thermal current I_{th} up to and including 400 A:

a) The connections shall be single-core, p.v.c.-insulated, copper cables or wires with cross-section areas as given in Table IX of IEC Publication 292-1 (1st edition).

b) The test shall be carried out with single-phase current, with all poles connected in series; however, if the permanent connections of the rotor circuit prevent the use of single-phase current, a test supply having the appropriate number of phases shall be used.

c) The connections shall be in free air and spaced not less than the distance existing between the terminals.

d) The minimum length of each temporary connection from terminal to terminal shall be:

1 m for cross-sections up to and including 10 mm²;
2 m for cross-sections larger than 10 mm².

For values of rated thermal current I_{th} higher than 400 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.

8.2.2.3 *Temperature-rise tests on control electro-magnets*

See IEC Publication 292-1.

Note. — These tests do not apply to the coils mentioned in the Note to Clause 7.3.4.

8.2.2.4 *Temperature-rise tests of auxiliary circuits*

See IEC Publication 292-1.

8.2.2.4 a *Temperature-rise test of the starting resistors*

The temperature rise of the resistors (and of the oil in the case of oil-cooled resistors) shall not exceed the limits specified in Table VI when the starter is operated at its rated duty (see Clause 4.4.4) and according to its starting characteristics (see Clause 4.4.6.1).

The current through each part of the resistors shall be thermally equivalent to the current during the starting time when the controlled motor is operating with the maximum starting torque and starting time for which the starter is rated (see Clauses 4.4.4 and 4.4.6.1); in practice, the current value I_m can be used.

The starting sequences shall be evenly spaced in time according to the number of starts per hour, and the division of time over the steps shall be in accordance with Clause 4.4.6.1.

The test shall be made over a period of time sufficient for the temperature rise to reach a constant value, but not exceeding eight hours.

The temperature rises of the enclosures and of the issuing air shall not exceed the limits specified in Table VI.

Note. — It is impracticable to test the performance of starting resistors of every combination of motor output and rotor voltage and current; it is required only that a sufficient number of tests be made to prove, by interpolation or deduction, compliance with this Recommendation.

8.2.2.5 *Measurement of the temperature of parts*

See IEC Publication 292-1.

8.2.2.6 *Temperature rise of a part*

See IEC Publication 292-1.

8.2.2.7 *Corrections*

See IEC Publication 292-1.

8.2.3 *Verification of dielectric properties*

8.2.3.1 *Condition of the starter for tests*

See IEC Publication 292-1.

8.2.3.2 *Application of the test voltage*

See IEC Publication 292-1.

8.2.3.2.1 *Main circvit*

For these tests, any control and auxiliary circuits, which are not normally connected to the main circuit, shall be connected to the frame.

A — Stator circuit

The test voltage shall be applied for 1 min as follows:

a) with the main contacts of the stator circuit closed:

1. between all live parts of all poles connected together and the frame of the starter;

2. between each pole and all the other poles connected to the frame of the starter;

b) with the main contacts of the stator circuit open:

1. between all live parts of all poles connected together and the frame of the starter;

2. between the terminals of one side connected together, and the terminals of the other side connected together.

B — Rotor circuit

The test voltage shall be applied for 1 min between the rotor circuit terminals connected together and the frame of the starter:

a) with the main contacts of the rotor circuit closed;

b) with the main contacts of the rotor circuit open.

8.2.3.2.2 *Control and auxiliary circuits*

See IEC Publication 292-1.

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 65 Hz.

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

a)

1. *Stator circuit*

   For the main circuit and for the control and auxiliary circuits which are not covered by paragraph *b)* below: in accordance with Table X, where the value in the first column is that of the rated stator insulation voltage.

2. *Rotor circuit*

   For the main circuit and for the control and auxiliary circuits which are not covered by paragraph *b)* below: in accordance with Table X, where the value in the first column is that of the rated rotor insulation voltage.

TABLE X

Rated insulation voltages V	Dielectric test voltage (a.c.) (r.m.s.) V
Up to and including 60	1 000
61 — 300	2 000
301 — 660	2 500
661 — 800	3 000
801 — 1 000	3 500

b) For all 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.

8.2.4 *Verification of rated making and breaking capacities*

8.2.4.1 *General*

See IEC Publication 292-1.

8.2.4.2 *Condition of the starter for tests*

See IEC Publication 292-1.

8.2.4.3 *Test circuit for the verification of making and breaking capacities*

The making and breaking capacity tests shall be carried out with the conventional test circuit as specified in Appendix D of the present Recommendation.

8.2.4.4 *Verification of making capacity of the stator switching device*

The making current to be obtained during the test shall be as given in Table II.

The number of closing operations to be made is the following:

— For starters with contactors, the number is 100: 50 operations of which are made at 85% and 50 operations at 110% of the rated contactor coil voltage.

— For manual starters, the number is 20.

The time interval between an opening operation and the closing operation immediately following it shall be 5 s to 10 s.

Note. — For large starters, the maximum time interval of 10 s specified above may be increased by agreement between manufacturer and user.

The duration of the test current shall be not less than 50 ms (thereby exceeding the total bounce time, if any, of the contacts). However, if the mechanical switching device has satisfied the tests of IEC Publication 158-1 (Clause 8.4.1 of the 2nd edition), this test need not be repeated.

8.2.4.5 *Verification of breaking capacity of the stator switching device*

The breaking current to be obtained during the test shall be as given in Table II.

The total number of opening operations to be made is 25.

Five of these operations are carried out with the starter tripped by the overload relay; however, for large starters (of 630 A at least), only three operations are tripped by the overload. The time interval between two successive opening operations shall be as short as possible, taking into account the resetting characteristics of the overload relay.

The remaining operations of the 25 are carried out with the starter tripped under the control of the operator, with the overload relay short-circuited, if necessary. The duration of current flow shall not exceed 0.5 s per operation, and the time interval between two successive opening operations shall be 5 s to 10 s.

Note. — For large starters, the maximum time interval of 10 s specified above may be increased by agreement between manufacturer and user.

The overload relay shall be reset, if necessary, after each operation.

However, if the mechanical switching device has satisfied the tests of IEC Publication 158-1 (Clause 8.4.1 of the 2nd edition), these operations (tripped by the operator) need not be repeated.

8.2.4.6 *Verification of the making and breaking capacities of the rotor switching devices*

Verification of the making and breaking capacities of the rotor switching devices shall be performed as in Clauses 8.2.4.4 and 8.2.4.5, where I_{er} is the maximum rated rotor current for which the starter is designed.

The starting resistors may be disconnected for these tests and, for starters having more than two steps, the test shall be performed on each switching device in turn. Since the rotor switching devices in starters having more than two steps do not break and make at the full rotor voltage, the voltage for these tests may be reduced in the ratio

$$\frac{\text{Starting resistance switched}}{\text{Total starting resistance}} .$$

When a starter is so connected that the circuit is opened by the stator switch before the rotor switching devices open, no verification of the breaking capacity is necessary.

For rotor switching devices already tested to category AC-1 with a current and a voltage corresponding to Table II, no further test is needed.

8.2.4.7 *Behaviour of the starter during making and breaking tests*

During tests within the limits of specified making and breaking capacities and with the specified number of operations, there shall be no permanent arcing, no flashover between poles, no melting of the fuse in the earth circuit (see Clause 8.2.4.2) and no welding of the contacts.

If a starter is intended for open mounting or to be mounted with other apparatus in an enclosure having large dimensions with respect to the volume of the starter, arc and flames shall not extend beyond the safety area stated by the manufacturer.

8.2.5 *Verification of operating limits*

See IEC Publication 292-1.

8.2.6 *Verification of operating limits and characteristics of overload relays*

See IEC Publication 292-1.

8.2.7 *Verification of mechanical endurance*

8.2.7.1 *Condition of the starter for tests*

See IEC Publication 292-1.

8.2.7.2 *Operating conditions*

See IEC Publication 292-1.

8.2.7.3 *Test procedure*

The tests are carried out at the frequency of operating cycles corresponding to the class of intermittent duty. However, if the manufacturer considers that the starter can satisfy the required conditions when using a higher frequency of operating cycles, he may do so in order to reduce the duration of the test.

In the case of rheostatic rotor starters comprising electromagnetic and electropneumatic contactors, the duration of energization of each of the control coils shall be greater than the time of operation of the contactor and the time during which the coil is not energized shall be of such a duration that the contactor can come to rest. The built-in device causing time delay between closing of the rotor switching devices, if adjustable, may be set at its lowest value.

After each tenth of the total number of operating cycles given in Clause 4.4.7 has been carried out, it is permissible before carrying on with the test:

— to clean the whole starter without dismantling;

— to lubricate parts for which lubrication is prescribed by the manufacturer for normal service;

— to adjust the travel and the pressure of the contacts if the design of the starter enables this to be done, or to replace the contacts, if they are worn, the wear of the contacts not being taken into consideration during these tests of mechanical endurance.

This maintenance work shall not include any replacement of parts except for the contacts.

8.2.7.4 *Results to be obtained*

Following the tests of mechanical endurance, the starter shall still be capable of complying with the operating conditions specified in Clauses 7.5 and 8.2.5. There shall be no loosening of the parts used for connecting the conductors, and any timing relays or other devices for the automatic control of acceleration shall still be operating correctly.

8.3 *Routine tests*

8.3.1 *General*

See IEC Publication 292-1.

8.3.2 *Operation tests*

For electromagnetic, pneumatic and electro-pneumatic starters, tests are carried out to verify operation within the limits specified in Clause 7.5.2. Main contacts shall be in a new condition, and hence an adjustment may be necessary to the figure for minimum drop-out voltage which is specified in Clause 7.5.2 for worn contacts.

For manual starters, tests are carried out to verify the proper operation of the starter (see Clauses 7.5.3.1 and 7.5.3.4).

Tests shall be made to verify the calibration of overload relays. In the case of a thermal or a time-delay magnetic overload relay, this may be a single test at a multiple of the current setting to check that the tripping time conforms (within tolerances) to the curve supplied by the manufacturer; in the case of an instantaneous magnetic overload relay, the test shall be carried out at 1.1 times the current setting.

Note. — In the case of a time-delay magnetic overload relay comprising a time-delay device working with a fluid dashpot, verification may be carried out with the dashpot empty at a percentage of the current setting indicated by the manufacturer and capable of being justified by a special test.

Tests shall be performed to verify that the time setting of time-delay relays and the calibration of any other devices used for controlling the rate of starting are within the limits stated by the manufacturer.

The value of the starting resistances shall be verified for each step to be within $\pm$ 10% of the stated figures.

It shall also be verified that the rotor switching devices cut out the steps of resistors in the correct sequence.

8.3.3 *Dielectric tests*

The tests shall be carried out on dry and clean starters.

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 1 s.

The test voltage shall be applied as follows:

a) between poles of the stator switching device with the main contacts closed (with the main contacts open if there is a shunt circuit between poles);

b) between poles of the stator switching device and the frame of the starter with the main contacts closed;

c) across the terminals of each pole of the stator switching device with the main contacts open;

d) to the control and auxiliary circuits, as mentioned in Clause 8.2.3.2.2;

e) all the poles of the rotor switching devices will normally be connected through the starting resistors; the dielectric test is therefore confined to the application of the test voltage between the rotor circuit and the frame of the starter.

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

8.4 *Special tests*

No special tests are specified in this Recommendation.

APPENDIX A

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

See I E C Publication 292-1.

APPENDIX B

CLEARANCES AND CREEPAGE DISTANCES FOR LOW-VOLTAGE A.C. MOTOR STARTERS

See I E C Publication 292-1.

APPENDIX C

CO-ORDINATION WITH SHORT-CIRCUIT PROTECTIVE DEVICES

See I E C Publication 292-1A.

APPENDIX D

CONVENTIONAL TEST CIRCUIT FOR VERIFICATION OF MAKING AND BREAKING CAPACITIES

See Appendix D of I E C Publication 158-1.

Position of the mechanical switching devices

Mechanical switching device \ Position of the starter	Stop	Starting			FULL ON
		1st step	2nd step	3rd step	
C L	O	C	C	C	
C C_R	O	O	O	C	
C R_R	O	O	C	C	

O: mechanical switching device open

C: mechanical switching device closed

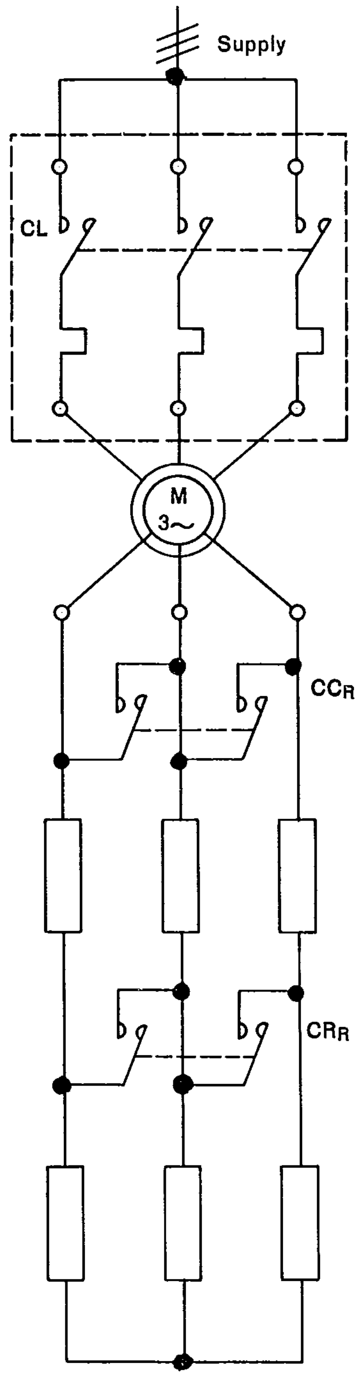

FIGURE 1

Example of three-phase diagram of a rheostatic rotor starter with three starting steps and one direction of rotation (in the case when all the mechanical switching devices are contactors).

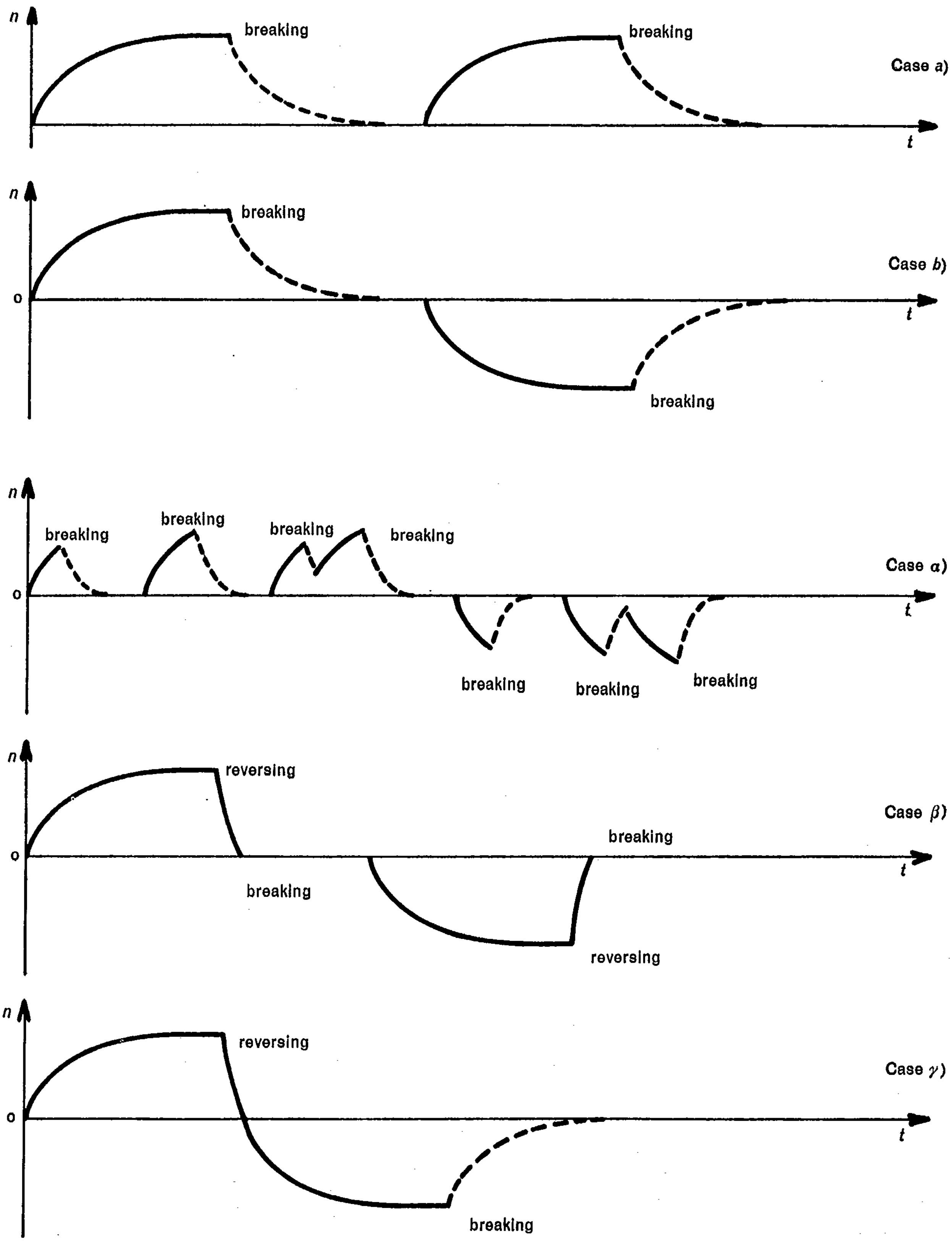

FIGURE 2

Examples of speed/time curves corresponding to cases *a)*, *b)*, α), β) and γ) of Clause 4.4.6 (the dotted parts of the curves correspond to the periods when no current flows through the motor).

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Contract requirements
Attention is drawn to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

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The following BSI references relate to the work on this standard:
Committee reference PEL/92/1 Draft for comment 75/21103 DC

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

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*British Electrical and Allied Manufacturers' Association
*British Railways Board
Department of Energy (Electricity)
Electrical Contractors' Association
Electrical Contractors' Association of Scotland
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*Electricity Supply Industry in England and Wales
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Association of Control Manufacturers (BEAMA)
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Department of the Environment (PSA)
Electrical Installation Equipment Manufacturers' Association (BEAMA)
Electrical Power Engineers' Association
London Transport Executive
Northern Ireland Electricity Service
Oil Companies Materials Association
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