CEI 60947-4-1
(Deuxième édition – 2000)

Appareillage à basse tension –

Partie 4-1: Contacteurs et démarreurs de moteurs – Contacteurs et démarreurs électromécaniques

IEC 60947-4-1
(Second edition – 2000)

Low-voltage switchgear and controlgear –

Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters

CORRIGENDUM 1

Page 36

5.3.2.4 Courant thermique conventionnel rotorique (I_{thr})

Au lieu de

$$\int_0^t si^2 \, dt$$

lire

$$\int_0^t i^2 \, dt$$

Page 78

Tableau 7 – Pouvoirs de fermeture et de coupure – Conditions d'établissement et de coupure correspondant aux catégories d'emploi

Supprimer AC-7a et AC-7b ainsi que les données correspondantes.

Page 37

5.3.2.4 Conventional rotor thermal current (I_{thr})

Instead of

$$\int_0^t si^2 \, dt$$

read

$$\int_0^t i^2 \, dt$$

Page 79

Table 7 – Making and breaking capacities – Making and breaking conditions according to utilization category

Delete AC-7a and AC-7b together with the relevant data.

Juillet 2001

July 2001

Table 8 – Conventional operational performance –
Making and breaking conditions according to utilization category

Replace the existing table with the following new table:

Table 8 – Conventional operational performance –
Making and breaking conditions according to utilization category

Utilization category	Make and break test conditions					
	I_c/I_e	U_r/U_e	Cos ϕ	On-time [2] s	Off-time s	Number of operating cycles
AC-1	1,0	1,05	0,80	0,05	[3]	6 000[11]
AC-2	2,0	1,05	0,65	0,05	[3]	6 000[11]
AC-3	2,0	1,05	[1]	0,05	[3]	6 000[11]
AC-4	6,0	1,05	[1]	0,05	[3]	6 000[11]
AC-5a	2,0	1,05	0,45	0,05	[3]	6 000[11]
AC-5b	1,0[7]	1,05	[7]	0,05	[4]	6 000[11]
AC-6	[9]	[9]	[9]	[9]	[9]	[9]
AC-8a	1,0	1,05	0,80	0,05	[3]	30 000
AC-8b[10]	6,0	1,05	0,35	1	[5]	5 900
				10	[6]	100
			L/R ms			
DC-1	1,0	1,05	1,0	0,05	[3]	6 000[8]
DC-3	2,5	1,05	2,0	0,05	[3]	6 000[8]
DC-5	2,5	1,05	7,5	0,05	[3]	6 000[8]
DC-6	1,0[7]	1,05	[7]	0,05	[4]	6 000[8]

I_c = current made or broken. Except for AC-5b, AC-6 or DC-6 categories, the making current is expressed in d.c. or a.c. r.m.s. symmetrical values but it is understood that for a.c. the actual peak value during the making operation may assume a higher value than the symmetrical peak value.

I_e = rated operational current

U_r = power frequency or d.c. recovery voltage

U_e = rated operational voltage

1) Cos ϕ = 0,45 for $I_e \leq 100$ A; 0,35 for $I_e > 100$ A.

2) The time may be less than 0,05 s, provided that contacts are allowed to become properly seated before re-opening.

3) These off-times shall be not greater than the values specified in table 7a.

4) Off-time is 60 s.

5) Off-time is 9 s.

6) Off-time is 90 s.

7) Tests to be carried out with an incandescent light load.

8) 3 000 operating cycles with one polarity and 3 000 operating cycles with reverse polarity.

9) Under consideration.

10) Tests for category AC-8b shall be accompanied by tests for category AC-8a. The tests may be made on different samples.

11) For manually operated switching devices, the number of operating cycles shall be 1 000 on-load, followed by 5 000 off-load.

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Appareillage à basse tension –

**Partie 4-1:
Contacteurs et démarreurs de moteurs –
Contacteurs et démarreurs électromécaniques**

Low-voltage switchgear and controlgear –

**Part 4-1:
Contactors and motor-starters –
Electromechanical contactors and motor-staters**

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Международная Электротехническая Комиссия

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
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6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60947-4-1 has been prepared by subcommittee 17B: Low-voltage switchgear and controlgear, of IEC technical committee 17: Switchgear and controlgear.

This standard should be used in conjunction with IEC 60947-1.

This second edition cancels and replaces the first edition published in 1990, the corrigendum (1991), amendment 1 (1994), amendment 2 (1996) and amendment 3 (2000).

The text of this standard is based on first edition, amendment 1, amendment 2 and the following documents:

FDIS	Report on voting
17B/1049/FDIS	17B/1083/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 3.

The committee has decided that the contents of this publication will remain unchanged until 2003. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

The provisions of the general rules dealt with in part 1 (IEC 60947-1) are applicable to this standard, where specifically called for. Clauses and subclauses, tables, figures and annexes of the general rules thus applicable are identified by reference to part 1, e.g. 1.2.3 of part 1, table 4 of part 1 or annex A of part 1.

Annexes A and B form an integral part of this standard.

Annexes C and D are for information only.

LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

Part 4-1: Contactors and motor-starters – Electromechanical contactors and motor-starters

1 Scope and object

This part of IEC 60947 applies to the types of equipment listed in 1.1 and 1.2 whose main contacts are intended to be connected to circuits the rated voltage of which does not exceed 1 000 V a.c. or 1 500 V d.c.

Starters and/or contactors dealt with in this standard are not normally designed to interrupt short-circuit currents. Therefore, suitable short-circuit protection (see 9.3.4) shall form part of the installation but not necessarily of the contactor or the starter.

In this context, this standard gives requirements for:

– contactors associated with overload and/or short-circuit protective devices;
– starters associated with separate short-circuit protective devices and/or with separate short-circuit and integrated overload protective devices;
– contactors or starters combined, under specified conditions, with their own short-circuit protective devices. Such combinations, e.g. combination starters (see 3.2.7) or protected starters (see 3.2.8) are rated as units.

Circuit-breakers and fuse-combination units used as short-circuit protective devices in combination starters and in protected starters shall comply with the requirements of IEC 60947-2 and IEC 60947-3, as the case may be.

Equipment covered by this standard is as follows.

1.1 AC and d.c. contactors

AC and d.c. contactors intended for closing and opening electric circuits and, if combined with suitable relays (see 1.2), for protecting these circuits against operating overloads which may occur therein.

NOTE Contactors combined with suitable relays and which are intended to provide short-circuit protection shall additionally satisfy the relevant conditions specified for circuit-breakers (IEC 60947-2).

This standard applies also to the actuators of contactor relays and to the contacts dedicated exclusively to the coil circuit of a contactor.

1.2 AC motor-starters

AC motor-starters intended to start and accelerate motors to normal speed, to ensure continuous operation of motors, to switch off the supply from the motor and to provide means for the protection of motors and associated circuits against operating overloads.

Starters the operation of which depends on thermal electrical relays for motor protection complying with IEC 60255-8, or motor-incorporated thermal protective devices dealt with in IEC 60034-11 do not necessarily meet all the relevant requirements of this standard.

Overload relays for starters, including those based on solid state technology, shall meet the requirements of this standard.

1.2.1 Direct-on-line (full voltage) a.c. starters

Direct-on-line starters intended to start and accelerate a motor to normal speed, to provide means for the protection of the motor and its associated circuits against operating overloads, and to switch off the supply from the motor.

This standard applies also to reversing starters.

1.2.2 Reduced voltage a.c. starters

Reduced voltage a.c. starters intended to start and accelerate a motor to normal speed by connecting the line voltage across the motor terminals in more than one step or by gradually increasing the voltage applied to the terminals, to provide means for the protection of the motor and its associated circuits against operating overloads, and to switch off the supply from the motor.

Automatic change-over devices may be used to control the successive switching operations from one step to the others. Such automatic change-over devices are, for example, time-delay contactor relays or specified time all-or-nothing relays, under-current devices and automatic acceleration control devices (see 5.10).

1.2.2.1 Star-delta starters

Star-delta starters intended to start a three-phase motor in the star connection, to ensure continuous operation in the delta connection, to provide means for the protection of the motor and its associated circuits against operating overloads, and to switch off the supply from the motor.

The star-delta starters dealt with in this standard are not intended for reversing motors rapidly and, therefore, utilization category AC-4 does not apply.

NOTE In the star connection, the current in the line and the torque of the motor are about one-third of the corresponding values for delta connection. Therefore, star-delta starters are used when the inrush current due to the starting is to be limited, or when the driven machine requires a limited torque for starting. Figure 1 indicates typical curves of starting current, of starting torque of the motor and of torque of the driven machine.

1.2.2.2 Two-step auto-transformer starters

Two-step auto-transformer starters, intended to start and accelerate an a.c. induction motor from rest with reduced torque to normal speed and to provide means for the protection of the motor and its associated circuits against operating overloads, and to switch off the supply from the motor.

This standard applies to auto-transformers which are part of the starter or which constitute a unit specially designed to be associated with the starter.

Auto-transformer starters with more than two steps are not covered by this standard.

The auto-transformer starters dealt with in this standard are not intended for inching duty or reversing motors rapidly and, therefore, utilization category AC-4 does not apply.

NOTE In the starting position, the current in the line and the torque of the motor related to the motor starting with rated voltage are reduced approximately as the square of the ratio (starting voltage):(rated voltage). Therefore, auto-transformer starters are used when the inrush current due to the starting is to be limited or when the driven machine requires a limited torque for starting. Figure 2 indicates typical curves of starting current, of starting torque of the motor and of torque of the driven machine.

1.2.3 Rheostatic rotor starters

Starters intended to start an a.c. induction motor having a wound rotor by cutting out resistors previously inserted in the rotor circuit, to provide means for the protection of the motor against operating overloads and to switch off the supply from the motor.

In the case of asynchronous slip-ring motors (wound-rotors), the highest voltage between open slip-rings shall be not greater than twice the rated insulation voltage of the switching devices inserted in the rotor circuit (see 5.3.1.1.2).

NOTE This requirement 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 standard applies also to starters for two directions of rotation when reversal of connections is made with the motor stopped (see 5.3.5.5). Operations including inching and plugging necessitate additional requirements and shall be subject to agreement between manufacturer and user.

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

1.3 This standard does not apply to:

- d.c. starters;
- star-delta starters, rheostatic rotor starters, two-step auto-transformer starters intended for special applications and designed for continuous operation in the starting position;
- unbalanced rheostatic rotor starters, i.e. where the resistances do not have the same value in all phases;
- equipment designed not only for starting, but also for adjustment of speed;
- liquid starters and those of the "liquid-vapour" type;
- semiconductor contactors and starters making use of semiconductor contactors in the main circuit;
- rheostatic stator starters;
- contactors or starters designed for special applications;
- auxiliary contacts of contactors and contacts of contactor relays. These are dealt with in IEC 60947-5-1.

1.4 The object of this standard is to state:

a) the characteristics of contactors and starters and associated equipment;

b) the conditions with which contactors or starters shall comply with reference to:
   1) their operation and behaviour,
   2) their dielectric properties,
   3) the degrees of protection provided by their enclosures, where applicable,
   4) their construction;

c) the tests intended for confirming that these conditions have been met, and the methods to be adopted for these tests;

d) the information to be given with the equipment or in the manufacturer's literature.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 60947. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 60947 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60034-1:1996, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-11:1978, *Rotating electrical machines – Part 11: Built-in thermal protection – Chapter 1: Rules for protection of rotating electrical machines*

IEC 60050(441):1984, *International Electrotechnical Vocabulary (IEV) – Chapter 441: Switchgear, controlgear and fuses*

IEC 60076-1:1993, *Power transformers – Part 1: General*

IEC 60085:1984, *Thermal evaluation and classification of electrical insulation*

IEC 60112:1979, *Method for determining the comparative and the proof tracking indices of solid insulating materials under moist conditions*

IEC 60255-8:1990, *Electrical relays – Part 8: Thermal electrical relays*

IEC 60269-1:1998, *Low-voltage fuses – Part 1: General requirements*

IEC 60269-2:1986, *Low-voltage fuses – Part 2: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application)*

IEC 60269-2-1:1998, *Low-voltage fuses – Part 2-1: Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application) – Sections I to V: Examples of types of standardized fuses*

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

IEC 60947-1:1999, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-2:1995, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers**

IEC 60947-3:1999, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-5-1:1997, *Low-voltage switchgear and controlgear – Part 5: Control circuit devices and switching elements – Section 1: Electromechanical control circuit devices***

IEC 61000-4-2:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 2: Electrostatic discharge immunity test – Basic EMC publication****

IEC 61000-4-3:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated radio-frequency electromagnetic field immunity test*****

IEC 61000-4-4:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 4: Electrical fast transient/burst immunity test – Basic EMC publication*

IEC 61000-4-5:1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 5: Surge immunity test*

IEC 61095:1992, *Electromechanical contactors for household and similar purposes*

IEC 61810-1:1998, *Electromechanical all-or-nothing relays – Part 1: General requirements*

CISPR 11:1997, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

3 Definitions

For the purpose of this part of IEC 60947, the definitions of clause 2 of IEC 60947-1 together with the following additional definitions apply.

3.1 Definitions concerning contactors

3.1.1
contactor (mechanical)
mechanical switching device having only one position of rest, operated otherwise than by hand, capable of making, carrying and breaking currents under normal circuit conditions including operating overload conditions

NOTE Contactors may be designated according to the method by which the force for closing the main contacts is provided.

[IEV 441-14-33]

* There is a consolidated edtion 2.1 (1998) that includes IEC 60947-2 (1995) and its amendment 1 (1997).

** There is a consolidated edtion 2.1 (1999) that includes IEC 60947-5-1 (1997) and its amendment 1 (1999).

*** There is a consolidated edtion 1.1 (1999) that includes IEC 61000-4-2 (1995) and its amendment 1 (1998).

**** There is a consolidated edtion 1.1 (1998) that includes IEC 61000-4-3 (1995) and its amendment 1 (1998).

The followings notes are not included in IEV 441-14-33:

NOTE 1 The term "operated otherwise than by hand" means that the device is intended to be controlled and kept in working position from one or more external supplies.

NOTE 2 In French, a contactor the main contacts of which are closed in the position of rest is usually called a "rupteur". The word "rupteur" has no equivalent in the English language.

NOTE 3 A contactor is usually intended to operate frequently.

3.1.2
electromagnetic contactor
contactor in which the force for closing the normally open main contacts or opening the normally closed main contacts is provided by an electromagnet

3.1.3
pneumatic contactor
contactor in which the force for closing the normally open main contacts or opening the normally closed main contacts is provided by a device using compressed air, without the use of electrical means

3.1.4
electro-pneumatic contactor
contactor in which the force for closing the normally open main contacts or opening the normally closed main contacts is provided by a device using compressed air under the control of electrically operated valves

3.1.5
latched contactor
contactor, the moving elements of which are prevented by means of a latching arrangement from returning to the position of rest when the operating means are de-energized

NOTE 1 The latching, and the release of the latching, may be mechanical, electromagnetic, pneumatic, etc.

NOTE 2 Because of the latching, the latched contactor actually acquires a second position of rest and, according to the definition of a contactor, it is not, strictly speaking, a contactor. However, since the latched contactor in both its utilization and its design is more closely related to contactors in general than to any other classification of switching device, it is considered proper to require that it complies with the specifications for contactors wherever they are appropriate.

[IEV 441-14-34]

3.1.6
vacuum contactor (or starter)
contactor (or starter) in which the main contacts open and close within a highly evacuated envelope

3.1.7
position of rest (of a contactor)
position which the moving elements of the contactor take up when its electromagnet or its compressed-air device is not energized [IEV 441-16-24]

3.2 Definitions concerning starters

3.2.1
starter
combination of all the switching means necessary to start and stop a motor in combination with suitable overload protection [IEV 441-14-38]

3.2.2
direct-on-line starter
starter which connects the line voltage across the motor terminals in one step [IEV 441-14-40]

3.2.3
reversing starter
starter intended to cause the motor to reverse the direction of rotation by reversing the motor primary connections while the motor may be running

3.2.4
two-direction starter
starter intended to cause the motor to reverse the direction of rotation by reversing the motor primary connections only when the motor is not running

3.2.5
reduced voltage starter
starter which connects the line voltage across the motor terminals in more than one step or by gradually increasing the voltage applied to the terminals

3.2.5.1
star-delta starter
starter for a three-phase induction motor such that in the starting position the stator windings are connected in star and in the final running position they are connected in delta [IEV 441-14-44]

3.2.5.2
auto-transformer starter
starter for an induction motor which uses for starting one or more reduced voltages derived from an auto-transformer [IEV 441-14-45]

NOTE *(not included in IEV 441-14-45)* An auto-transformer is defined as follows in 3.1.2 of IEC 60076-1:

"A transformer in which at least two windings have a common part."

3.2.6
rheostatic starter
starter utilizing one or several resistors for obtaining, during starting, stated motor torque characteristics and for limiting the current [IEV 441-14-42]

NOTE *(not included in IEV 441-14-42)* 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 resistor(s) inserted in the stator or rotor circuit;
- the mechanical switching devices for cutting out the resistor(s) successively.

3.2.6.1
rheostatic stator starter
rheostatic starter for a squirrel cage motor which, during the starting period, cuts out successively one or several resistors previously provided in the stator circuit

3.2.6.2
rheostatic rotor starter
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
[IEV 441-14-43]

3.2.7
combination starter (see figure 3)
equipment consisting of a starter, a manual externally operated switching device and a short-circuit protective device, mounted and wired in a dedicated enclosure. The switching and short-circuit protective devices may be a fuse combination unit, a switch with fuses or a circuit-breaker with or without an isolating function

NOTE 1 A dedicated enclosure is an enclosure specifically designed and dimensioned for its application in which all tests are conducted.

NOTE 2 The manually operated switching device and the short-circuit protective device may be just one device and may incorporate the overload protection as well.

3.2.8
protected starter
equipment consisting of a starter, a manually operated switching device and a short-circuit protective device, mounted and wired, enclosed or unenclosed according to the instructions of the starter manufacturer

NOTE The manually operated switching device and the short-circuit protective device may be one single device and may incorporate the overload protection as well.

3.2.9
manual starter
starter in which the force for closing the main contacts is provided exclusively by manual energy [IEV 441-14-39]

3.2.10
electromagnetic starter
starter in which the force for closing the main contacts is provided by an electromagnet

3.2.11
motor-operated starter
starter in which the force for closing the main contacts is provided by an electric motor

3.2.12
pneumatic starter
starter in which the force for closing the main contacts is provided by using compressed air, without the use of electrical means

3.2.13
electro-pneumatic starter
starter in which the force for closing the main contacts is provided by using compressed air under the control of electrically operated valves

3.2.14
single-step starter
starter in which there is no intermediate accelerating position between the OFF and ON positions

NOTE This starter is a direct-on-line starter (see 3.2.2).

3.2.15
two-step starter
starter in which there is only one intermediate accelerating position between the OFF and ON positions

Example: A star-delta starter is a two-step starter.

3.2.16
***n*-step starter** (see figure 4)
starter in which there are (n-1) intermediate accelerating positions between the OFF and ON positions

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

[IEV 441-14-41]

3.2.17
phase loss sensitive thermal overload relay or release
multipole thermal overload relay or release which operates in the case of overload and also in case of loss of phase in accordance with specified requirements

3.2.18
under-current (under-voltage) relay or release
measuring relay or release which operates automatically when the current through it (or the voltage applied to it) is reduced below a pre-determined value

3.2.19
starting time (of a rheostatic starter)
period of time during which the starting resistors or parts of them carry current

3.2.20
starting time (of an auto-transformer starter)
period of time during which the auto-transformer carries current

NOTE to 3.2.19 and 3.2.20 The starting time of a starter is shorter than the total starting time of the motor which takes into account the last period of acceleration following the switching operation ON position.

3.2.21
open transition (with an auto-transformer starter or star-delta starter)
circuit arrangement such that the supply to the motor is interrupted and reconnected when changing over from one step to another

NOTE The transition stage is not considered an additional step.

3.2.22
closed transition (with an auto-transformer starter or star-delta starter)
circuit arrangement such that the supply to the motor is not interrupted (even momentarily) when changing over from one step to another

NOTE The transition stage is not considered an additional step.

3.2.23
inching (jogging)
energizing a motor or solenoid repeatedly for short periods to obtain small movements of the driven mechanism

3.2.24
plugging
stopping or reversing a motor rapidly by reversing the motor primary connections while the motor is running

3.3 Characteristic quantities

3.3.1 Transient recovery voltage (abbreviation: TRV) [IEV 441-17-26]

Subclause 2.5.34 of part 1 applies with the following addition.

NOTE 3 *(not included in IEV 441-17-26)* In a vacuum contactor or starter, the highest transient recovery voltage may occur on an other pole than the first pole to clear.

4 Classification

Subclause 5.2 gives all the data which may be used as criteria for classification.

5 Characteristics of contactors and starters

5.1 Summary of characteristics

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

- type of equipment (5.2);
- rated and limiting values for main circuits (5.3);
- utilization category (5.4);
- control circuits (5.5);
- auxiliary circuits (5.6);
- types and characteristics of relays and releases (5.7);
- co-ordination with short-circuit protective devices (5.8);
- switching overvoltages (5.9);
- types and characteristics of automatic change-over devices and automatic acceleration control devices (5.10);
- types and characteristics of auto-transformers for two-step auto-transformer starters (5.11);
- types and characteristics of starting resistors for rheostatic rotor starters (5.12).

5.2 Type of equipment

The following shall be stated (see also clause 6).

5.2.1 Kind of equipment

- contactor;
- direct-on-line a.c. starter;
- star-delta starter;
- two-step auto-transformer starter;
- rheostatic rotor starter;
- combination or protected starter.

5.2.2 Number of poles

5.2.3 Kind of current (a.c. or d.c.)

5.2.4 Interrupting medium (air, oil, gas, vacuum, etc.)

5.2.5 Operating conditions of the equipment

5.2.5.1 Method of operation

For example: manual, electromagnetic, motor-operated, pneumatic, electro-pneumatic.

5.2.5.2 Method of control

For example:

- automatic (by pilot switch or sequence control);
- non-automatic (such as by hand operation or by push-buttons);
- semi-automatic (i.e. partly automatic, partly non-automatic).

5.2.5.3 Method of change-over for particular types of starters

The change-over for star-delta starters, rheostatic rotor starters or auto-transformer starters may be automatic, non-automatic or semi-automatic (see figures 4 and 5).

5.2.5.4 Method of connecting for particular types of starters

For example: open transition starter, closed transition starter (see figure 5).

5.3 Rated and limiting values for main circuits

The rated values established for a contactor or starter shall be stated in accordance with subclauses 5.3.1 to 5.4, and 5.8 and 5.9, but it may not be necessary to specify all the values listed.

NOTE The rated values established for a rheostatic rotor starter are stated in accordance with 5.3.1.2, 5.3.2.3, 5.3.2.4, 5.3.2.6, 5.3.2.7 and 5.3.5.5 but it is not necessary to specify all the values listed.

5.3.1 Rated voltages

A contactor or starter is defined by the following rated voltages.

5.3.1.1 Rated operational voltage (U_e)

Subclause 4.3.1.1 of part 1 applies.

5.3.1.1.1 Rated stator operational voltage (U_{es})

For rheostatic rotor starters, a rated stator operational voltage is a value of voltage which, when 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. In no case shall the maximum rated operational voltage exceed the corresponding rated insulation voltage.

NOTE The rated stator operational voltage is expressed as the voltage between phases.

5.3.1.1.2 Rated rotor operational voltage (U_{er})

For rheostatic rotor starters, the value of rated operational voltage is that of the voltage which, when 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.

This voltage 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.

The rated rotor operational 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 %.

The maximum voltage between the different live parts (e.g. switching devices, resistors, 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.

5.3.1.2 Rated insulation voltage (U_i)

Subclause 4.3.1.2 of part 1 applies.

5.3.1.2.1 Rated stator insulation voltage (U_{is})

For rheostatic rotor starters, the rated stator insulation voltage is the value of voltage which is designated for the devices inserted in the stator supply as well as the unit they are part of, and to which dielectric tests 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.

5.3.1.2.2 Rated rotor insulation voltage (U_{ir})

For rheostatic rotor starters, the rated rotor insulation voltage is the value of voltage which is designated to 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 and creepage distances are referred.

5.3.1.3 Rated impulse withstand voltage (U_{imp})

Subclause 4.3.1.3 of part 1 applies.

5.3.1.4 Rated starting voltage of an auto-transformer starter

The rated starting voltage of an auto-transformer starter is the reduced voltage derived from the transformer.

Preferred values of rated starting voltage are 50 %, 65 % or 80 % of the rated operational voltage.

5.3.2 Currents or powers

A contactor or a starter is defined by the following currents.

NOTE In the case of a star-delta starter, these currents relate to the delta connection and, in the case of a two-step auto-transformer or rheostatic rotor starter, to the ON position.

5.3.2.1 Conventional free air thermal current (I_{th})

Subclause 4.3.2.1 of part 1 applies.

5.3.2.2 Conventional enclosed thermal current (I_{the})

Subclause 4.3.2.2 of part 1 applies.

5.3.2.3 Conventional stator thermal current (I_{ths})

The conventional stator thermal current of a starter may be either free air current I_{ths} or enclosed current I_{thes}, in line with 5.3.2.1 and 5.3.2.2.

For a rheostatic rotor starter, the stator thermal current is the maximum current it can carry on eight-hour duty (see 5.3.4.1) without the temperature rise of its several parts exceeding the limits specified in 8.2.2 when tested in accordance with 9.3.3.3.

5.3.2.4 Conventional rotor thermal current (I_{thr})

The conventional rotor thermal current of a starter may be either free air current I_{thr} or enclosed current I_{ther}, in line with 5.3.2.1 and 5.3.2.2.

For rheostatic rotor starters, the rotor thermal current is the maximum current that those parts of the starter through which the rotor current flows in the ON position, viz. after cutting out resistors, can carry on eight-hour duty (see 5.3.4.1) without their temperature rise exceeding the limits specified in 8.2.2 when tested in accordance with 9.3.3.3.

NOTE 1 For those elements (switching devices, connecting links, resistors) through which a current of practically no value flows in the ON position, it should be verified that, for the rated duties (see 5.3.4) stated by the manufacturer, the value of integral

$$\int_0^t si^2 dt$$

does not lead to temperature rises higher than those appearing in 8.2.2.

NOTE 2 When resistors are built-in into the starter, the temperature rise should be taken into account.

5.3.2.5 Rated operational currents (I_e) or rated operational powers

A rated operational current of a contactor or a starter is stated by the manufacturer and takes into account the rated operational voltage (see 5.3.1.1), the conventional free air or enclosed thermal current, the rated current of the overload relay, the rated frequency (see 5.3.3), the rated duty (see 5.3.4), the utilization category (see 5.4) and the type of protective enclosure, if any.

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

For starters, the rated operational current (I_e) is the current in the ON position of the starter.

5.3.2.6 Rated stator operational current (I_{es}) or rated stator operational power

For rheostatic rotor starters, a rated stator operational current 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 5.3.1.1.1), the conventional free air or enclosed thermal current, the rated frequency (see 5.3.3), the rated duty (see 5.3.4), the starting characteristics (see 5.3.5.5) 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 stator current.

5.3.2.7 Rated rotor operational current (I_{er})

For rheostatic rotor starters, a rated rotor operational current is stated by the manufacturer and takes into account the rated rotor operational voltage (see 5.3.1.1.2), the conventional free air or enclosed rotor thermal current, the rated frequency (see 5.3.3), the rated duty (see 5.3.4), the starting characteristics (see 5.3.5.5) 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 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 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 5.3.5.5).

5.3.2.8 Rated uninterrupted current (I_u)

Subclause 4.3.2.4 of part 1 applies.

5.3.3 Rated frequency

Subclause 4.3.3 of part 1 applies.

5.3.4 Rated duties

Subclause 4.3.4 of part 1 applies.

5.3.4.1 Eight-hour duty (continuous duty)

Subclause 4.3.4.1 of part 1 applies with the following addition.

For a star-delta starter, a two-step auto-transformer starter or a rheostatic rotor-starter, the continuous duty is the duty in which the starter is in the ON position and the main contacts of the switching devices which constitute it, which are closed in this position, remain closed while each of them carries a steady current long enough for the starter to reach thermal equilibrium, but not for more than 8 h without interruption.

5.3.4.2 Uninterrupted duty

Subclause 4.3.4.2 of part 1 applies with the following addition.

For a star-delta starter, a two-step auto-transformer starter or a rheostatic rotor starter, the uninterrupted duty is the duty in which the starter is in the ON position and the main contacts of the switching devices which constitute it, which are closed in this position, remain closed without interruption while each of them carries a steady current for periods of more than 8 h (weeks, months or even years).

5.3.4.3 Intermittent periodic duty or intermittent duty

Subclause 4.3.4.3 of part 1 applies with the following addition.

For a reduced voltage starter, the intermittent duty is the duty in which the starter is in the ON position and the main contacts of the switching devices which constitute it 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.

Preferred classes of intermittent duty are:

- for contactors: 1, 3, 12, 30, 120, 300 and 1 200 (operating cycles per hour);
- for starters: 1, 3, 12 and 30 (operating cycles per hour).

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

For starters, an operating cycle comprises starting, running to full speed and switching off the supply from the motor.

NOTE In the case of starters 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 subject to agreement between manufacturer and user.

5.3.4.4 Temporary duty

Subclause 4.3.4.4 of part 1 applies.

5.3.4.5 Periodic duty

Subclause 4.3.4.5 of part 1 applies.

5.3.5 Normal load and overload characteristics

Subclause 4.3.5 of part 1 applies with the following additions.

5.3.5.1 Ability to withstand motor switching overload currents

Requirements to meet these conditions are given for contactors in 8.2.4.4.

5.3.5.2 Rated making capacity

Requirements for the various utilization categories (see 5.4) are given in 8.2.4.1. The rated making and breaking capacities are only valid when the contactor or the starter is operated in accordance with the requirements of 8.2.1.1 and 8.2.1.2.

5.3.5.3 Rated breaking capacity

Requirements for the various utilization categories (see 5.4) are given in 8.2.4.1. The rated making and breaking capacities are only valid when the contactor or the starter is operated in accordance with the requirements of 8.2.1.1 and 8.2.1.2.

5.3.5.4 Conventional operational performance

This performance is specified as a series of making and breaking operations in 8.2.4.2.

5.3.5.5 Starting and stopping characteristics of starters (see figure 6)

Typical service conditions for starters are:

a) one direction of rotation with the motor being switched off during running in normal service conditions (utilization categories AC-2 and AC-3);

b) two directions of rotation, but the running in the second direction is realized after the starter has been switched off and the motor has completely stopped (utilization categories AC-2 and AC-3);

c) one direction of rotation, or two directions of rotation as in item b), but with the possibility of infrequent inching (jogging). For this service condition, direct-on-line starters are usually employed (utilization category AC-3);

d) one direction of rotation with frequent inching (jogging). Usually direct-on-line starters (utilization category AC-4) are used for this duty;

e) one or two directions of rotation, but with the possibility of infrequent plugging for stopping the motor, plugging being associated, if so provided, with rotor resistor braking (reversing starter with braking). Usually a rheostatic rotor starter is used for this duty condition (utilization category AC-2);

f) two directions of rotation, but with the possibility of reversing the supply connections to the motor while it is running in the first direction (plugging), in order to obtain its rotation in the other direction, with switching off the motor running in normal service conditions. Usually a direct-on-line reversing starter is used for this duty condition (utilization category AC-4).

Unless otherwise stated, starters are designed on the basis of the starting characteristics of the motors compatible with the making capacities of table 7. These making capacities cover both the transient and steady-state starting currents of the great majority of standard motors. However, the starting currents for some large motors may attain peak values corresponding to power factors considerably lower than those specified for the test circuit in table 7. In these cases, the operational current of the contactor or starter should be decreased to a value lower than its rated value such that the making capacity of the contactor or starter is not exceeded.

5.3.5.5.1 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 various steps of the starting process, are nearly proportional under normal operating conditions.

The following definitions deal mainly with the characteristics of the rotor circuit:

U_{er} = rated rotor operational voltage;

I_{er} = rated rotor operational current;

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

where

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

I_1 is the current in the rotor circuit immediately before shorting out a resistor section;

I_2 is the current in the rotor circuit immediately after shorting out a resistor section;

I_m = $1/2\ (I_1 + I_2)$;

T_e is the rated motor operational torque;

t_s is the starting time (see 3.2.19);

k is the severity of start = $\frac{I_m}{I_{er}}$.

It is recognized that many rheostatic rotor starter applications have very specific starting requirements which may result not only in a different number of starting steps and different values of I_1 and I_2, but also in the values of I_1 and I_2 being different for individual resistor sections. Therefore, no attempt has been made to lay down standard parameters, but the following factors should be taken into consideration:

– for most applications, between two and six starting steps are adequate depending upon load torque, inertia and the severity of start required;

– the resistor sections should be designed to have adequate thermal ratings bearing in mind the starting time of the drive, which will be dependent upon load torque and load inertia.

5.3.5.5.2 Standard conditions for making and breaking corresponding to the starting characteristics for rheostatic rotor starters

These conditions are given in table 7 and apply to starting with high torque. (For the designation of the mechanical switching devices, see figure 4.)

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

The conditions for making and breaking as given in table 7 for AC-2 utilization category are considered as standard.

The starter circuit shall be designed to open all rotor resistor switching devices before or approximately simultaneously with the opening of the stator switching device. Otherwise, the stator switching device shall comply with AC-3 requirements.

5.3.5.5.3 Starting characteristics for two-step auto-transformer starters

Unless otherwise stated, the auto-transformer starters and specifically the auto-transformers are designed on the condition that the starting time (see 3.2.20) for all classes of duty (see 5.3.4) shall not exceed 15 s. The number of starting cycles per hour assumes equal periods between starts except that, in the event of two operating cycles being made in rapid succession, the starter and the auto-transformer shall be allowed to cool to ambient air temperature before a further start is made.

When a starting time in excess of 15 s is required, this shall be the subject of agreement between manufacturer and user.

5.3.6 Rated conditional short-circuit current

Subclause 4.3.6.4 of part 1 applies.

5.4 Utilization category

Subclause 4.4 of part 1 applies with the following additions.

For contactors and starters, the utilization categories as given in table 1 are considered standard. Any other type of utilization shall be based on agreement between manufacturer and user, but information given in the manufacturer's catalogue or tender may constitute such an agreement.

Each utilization category is characterized by the values of the currents, voltages, power-factors or time-constants and other data of tables 7 and 8, and by the test conditions specified in this standard.

For contactors or starters defined by their utilization category, it is therefore unnecessary to specify separately the rated making and breaking capacities as these values depend directly on the utilization category as shown in table 7.

The voltage for all utilization categories is the rated operational voltage of a contactor or a starter other than a rheostatic rotor starter, and the rated stator operational voltage for a rheostatic rotor starter.

All direct-on-line starters belong to one or more of the following utilization categories: AC-3, AC-4, AC-7b, AC-8a and AC-8b.

All star-delta and two-step auto-transformer starters belong to utilization category AC-3.

Rheostatic rotor starters belong to utilization category AC-2.

5.4.1 Assignment of utilization categories based on the results of tests

a) A contactor or starter which has been tested for one utilization category or at any combination of parameters (such as highest operational voltage and current, etc.) can be assigned other utilization categories without testing provided that the test currents, voltages, power-factors or time-constants, number of operating cycles, on and off times given in tables 7 and 8, and the test circuit for the assigned utilization categories are not more severe than those at which the contactor or starter has been tested and the temperature rise has been verified at a current not less than the highest assigned rated operational current in continuous duty.

For example, when tested for utilization category AC-4, a contactor may be assigned utilization category AC-3 provided I_e for AC-3 is not higher than 1,2 I_e for AC-4 at the same rated operational voltage.

b) DC-3 and DC-5 contactors are assumed to be capable of opening and closing loads other than those on which they have been tested provided that:

- the voltage and current do not exceed the specified values of U_e and I_e;
- the energy J stored in the actual load is equal to or less than the energy J_c stored in the load with which they were tested.

The values of the energy stored in the test circuit are as follows:

Utilization category	Stored energy J_c
DC-3	$0{,}00525 \times U_e \times I_e$
DC-5	$0{,}0315 \times U_e \times I_e$

The values of the constants 0,00525 and 0,0315 are derived from:

$$J_c = 1/2\ LI^2$$

where the time-constant has been replaced by:

$2{,}5 \times 10^{-3}$ s (DC-3) and:

15×10^{-3} s (DC-5)

and where $U = 1{,}05\ U_e$, $I = 4\ I_e$ and L is the inductance of the test circuit.

(See table 7 of this standard.)

Table 1 – Utilization categories

Kind of current	Utilization categories	Typical applications
AC	AC-1	Non-inductive or slightly inductive loads, resistance furnaces
	AC-2	Slip-ring motors: starting, switching off
	AC-3	Squirrel-cage motors: starting, switching off motors during running[1)]
	AC-4	Squirrel-cage motors: starting, plugging, inching
	AC-5a	Switching of electric discharge lamp controls
	AC-5b	Switching of incandescent lamps
	AC-6a	Switching of transformers
	AC-6b	Switching of capacitor banks
	AC-7a[3)]	Slightly inductive loads in household appliances and similar applications
	AC-7b[3)]	Motor-loads for household applications
	AC-8a	Hermetic refrigerant compressor motor[2)] control with manual resetting of overload releases
	AC-8b	Hermetic refrigerant compressor motor[2)] control with automatic resetting of overload releases
DC	DC-1	Non-inductive or slightly inductive loads, resistance furnaces
	DC-3	Shunt-motors: starting, plugging, inching Dynamic breaking of d.c. motors
	DC-5	Series-motors: starting, plugging, inching Dynamic breaking of d.c. motors
	DC-6	Switching of incandescent lamps

1) AC-3 category may be used for occasional inching (jogging) or plugging for limited time periods such as machine set-up; during such limited time periods, the number of such operations should not exceed five per minute or more than ten in a 10-min period.

2) A hermetic refrigerant compressor motor is a combination consisting of a compressor and a motor, both of which are enclosed in the same housing, with no external shaft or shaft seals, the motor operating in the refrigerant.

3) For AC-7a and AC-7b, see IEC 61095.

5.5 Control circuits

Subclause 4.5 of part 1 applies.

5.6 Auxiliary circuits

Subclause 4.6 of part 1 applies.

5.7 Characteristics of relays and releases (overload relays)

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

5.7.1 Summary of characteristics

The characteristics of relays and releases shall be stated in the following terms, whenever applicable:

- types of relay or release (see 5.7.2);
- characteristic values (see 5.7.3);
- designation and current settings of overload relays (see 5.7.4);
- time-current characteristics of overload relays (see 5.7.5);
- influence of ambient air temperature (see 5.7.6).

5.7.2 Types of relay or release

a) Release with shunt coil (shunt trip).

b) Under-voltage and under-current opening relay or release.

c) Overload time-delay relay the time-lag of which is:

  1) substantially independent of previous load (e.g. time-delay magnetic overload relay);

  2) dependent on previous load (e.g. thermal overload relay);

  3) dependent on previous load (e.g. thermal overload relay) and also sensitive to phase loss (see 3.2.17).

d) Instantaneous over-current relay or release (when applicable).

e) Other relays or releases (e.g. phase loss sensitive relay, control relay associated with devices for the thermal protection of the starter).

NOTE Types referred to in items d) and e) require consultation between manufacturer and user according to the particular application.

5.7.3 Characteristic values

a) Release with shunt coil, under-voltage (under-current) opening relay or release:

  - rated voltage (current);
  - rated frequency;
  - operating voltage (current).

b) Overload relay:

  - designation and current settings (see 5.7.4);
  - rated frequency, when necessary (for example in the case of a current transformer operated overload relay);
  - time-current characteristics (or range of characteristics), when necessary;
  - trip class according to classification in table 2, or the value of the maximum tripping time, in seconds, under the conditions specified in 8.2.1.5.1, table 3, column D, when this time exceeds 30 s;
  - number of poles;
  - nature of the relay: thermal, magnetic or solid state.

Table 2 – Trip classes of thermal, time-delay magnetic or solid state overload relays

Trip class	Tripping time T_p under the conditions specified in 8.2.1.5.1, table 3, column D s
10A	$2 < T_p \leq 10$
10	$4 < T_p \leq 10$
20	$6 < T_p \leq 20$
30	$9 < T_p \leq 30$

NOTE 1 Depending on the nature of the relay, the tripping conditions are given in 8.2.1.5.

NOTE 2 In the case of a rheostatic rotor starter, the overload relay is commonly inserted in the stator circuit. As a result, it cannot efficiently protect the rotor circuit and more particularly the resistors (generally more easily damageable than the rotor itself or the switching devices in case of a faulty start); protection of the rotor circuit should be the subject of a specific agreement between manufacturer and user (see, inter alia, 8.2.1.1.3).

NOTE 3 In the case of a two-step auto-transformer starter, the starting auto-transformer is normally designed for use during the starting period only: as a result, it cannot be efficiently protected by the overload relay in the event of faulty starting. Protection of the auto-transformer should be the subject of specific agreement between manufacturer and user (see 8.2.1.1.4).

NOTE 4 The lower limiting values of T_p are selected to allow for differing heater characteristics and manufacturing tolerances.

5.7.4 Designation and current settings of overload relays

Overload relays are designated by their current setting (or the upper and lower limits of the current setting range, if adjustable) and their trip class.

The current setting (or current setting range) shall be marked on the relays.

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, operating coils 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 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.

5.7.5 Time-current characteristics of overload relays

Typical time-current characteristics shall be given in the form of curves supplied by the manufacturer. These curves shall indicate how the tripping time, starting from the cold state (see 5.7.6), varies with the current up to a value of at least eight times the full-load current of the motor with which it is intended that the relay be used. The manufacturer shall be prepared to indicate, by suitable means, the general tolerances applicable to these curves and the conductor cross-sections used for establishing these curves (see 9.3.3.2.2, item c)).

NOTE It is recommended that the current be plotted as abscissae and the time as ordinates, using logarithmic scales. 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 5.6.1 of IEC 60269-1, in IEC 60269-2 (figure 1) and in figures 4(I), 3(II) and 4(II) of IEC 60269-2-1.

5.7.6 Influence of ambient air temperature

The time-current characteristics (see 5.7.5) refer to a stated value of ambient air temperature, and are based on no previous loading of the overload relay (viz. from an initial cold state). 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 variation in ambient air temperature on the characteristics of overload relays.

5.8 Co-ordination with short-circuit protective devices

Contactors and starters are characterized by the type, ratings and characteristics of the short-circuit protective devices (SCPD) to be used to provide over-current protection beyond the crossover current between the starter and the SCPD and adequate protection of the contactor and starter against short-circuit currents. Requirements are given in 8.2.5.1, in 8.2.5.2, in clause B.4 of this standard, and in 4.8 of part 1.

5.9 Switching overvoltages

Subclause 4.9 of part 1 applies.

Requirements are given in 8.2.6.

5.10 Types and characteristics of automatic change-over devices and automatic acceleration control devices

5.10.1 Types

a) Time-delay devices, e.g. time-delay contactor relays (see IEC 60947-5-1) applicable to control-circuit devices or specified-time all-or-nothing relays (see IEC 61810-1).
b) Undercurrent devices (undercurrent relays).
c) Other devices for automatic acceleration control:
   - devices dependent on voltage;
   - devices dependent on power;
   - devices dependent on speed.

5.10.2 Characteristics

a) The characteristics of time-delay devices are:
   - the rated time-delay or its range, if adjustable;
   - for time-delay devices fitted with a coil, the rated voltage, when it differs from the starter line voltage.
b) The characteristics of the undercurrent devices are:
   - the rated current (thermal current and/or rated 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.

5.11 Types and characteristics of auto-transformers for two-step auto-transformer starters

Account being taken of the starting characteristics (see 5.3.5.5.3), starting auto-transformers shall be characterized by:

– the rated voltage of the auto-transformer;
– the number of taps available for adjusting the starting torque and current;
– the starting voltage, i.e. the voltage at the tapping terminals, as a percentage of the rated voltage of the auto-transformer;
– the current they can carry for a specified duration;
– the rated duty (see 5.3.4);
– the method of cooling { air-cooling; oil-cooling.

The auto-transformer can be:

– either built-in into the starter, in which case the resulting temperature rise has to be taken into account in determining the ratings of the starter;
– or provided separately, in which case the nature and dimensions of the connecting links have to be specified by agreement between the manufacturer of the transformer and the manufacturer of the starter.

5.12 Types and characteristics of starting resistors for rheostatic rotor starters

Account being taken of the starting characteristics (see 5.3.5.5.1), the starting resistors shall be characterized by:

– the rated rotor insulation voltage (U_{ir});
– 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 5.3.4);
– the method of cooling { free air; forced air; oil-immersion.

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 the manufacturer of the resistors and the manufacturer of the starter.

6 Product information

6.1 Nature of information

The following information shall be given by the manufacturer.

6.1.1 Identification

a) manufacturer's name or trade mark;

b) type designation or serial number;

c) number of this standard, if the manufacturer claims compliance.

6.1.2 Characteristics, basic rated values and utilization

Characteristics:

d) rated operational voltages (see 5.3.1.1);

e) utilization category and rated operational currents (or rated powers), at the rated operational voltages of the equipment (see 5.3.2.5 and 5.4);

f) either the value of the rated frequency/frequencies, e.g. 50 Hz or 50 Hz/60 Hz, or the indication "d.c." (or the symbol ⎓);

g) rated duty with the indication of the class of intermittent duty, if any (see 5.3.4).

Associated values:

h) rated making and breaking capacities. These indications may be replaced, where applicable, by the indication of the utilization category (see table 7).

Safety and installation:

i) rated insulation voltage (see 5.3.1.2);

j) rated impulse withstand voltage (see 5.3.1.3), when determined;

k) IP code, in case of an enclosed equipment (see 8.1.11);

l) pollution degree (see 7.1.3.2);

m) rated conditional short-circuit current (see 5.3.6) and type of co-ordination of the contactor or starter (see 8.2.5.1) and the type, current rating and characteristics of the associated SCPD;

rated conditional short-circuit current (see 5.3.6) of the combination starter or protected starter and type of co-ordination (see 8.2.5.1);

n) switching overvoltages (see 5.9).

Control circuits:

The following information concerning control circuits shall be placed either on the coil or on the equipment:

o) rated control circuit voltage (U_c), nature of current and rated frequency;

p) if necessary, nature of current, rated frequency and rated control supply voltage (U_s).

Air supply systems for starters or contactors operated by compressed air:

q) rated supply pressure of the compressed air and limits of variation of this pressure, if they are different from those specified in 8.2.1.2.

Auxiliary circuits:

r) ratings of auxiliary circuits (see 5.6).

Overload relays and releases:

s) characteristics according to 5.7.

Additional information for certain types of contactor and starter:

Rheostatic rotor starters:

t) circuit diagram;

u) severity of start (see 5.3.5.5.1);

v) starting time (see 5.3.5.5.1).

Auto-transformer starters:

w) rated starting voltage(s), i.e. voltage(s) at the tapping terminals.

NOTE This value may be expressed as a percentage of the rated operational voltage of the starter.

Vacuum contactors and starters:

x) maximum permissible altitude of the site of installation, if less than 2 000 m.

EMC:

y) environment 1 or 2: see 7.3.1 of part 1;

z) special requirements, if applicable, for example shielded or twisted conductors.

NOTE Unshielded or untwisted conductors are considered as normal installation conditions.

6.2 Marking

Subclause 5.2 of part 1 applies to contactors, starters and overload relays with the following additions.

Data under items d) to x) in 6.1.2 shall be included on the nameplate or on the equipment or in the manufacturer's published literature.

Data under items c) and k) in 6.1.2 shall preferably be marked on the equipment.

6.3 Instructions for installation, operation and maintenance

Subclause 5.3 of part 1 applies with the following addition.

Information shall be provided by the manufacturer to advise the user on the measures to be taken with regard to the equipment in the event of a short-circuit and the measures to be taken with regard to the equipment, if any, concerning EMC.

In the case of protected starters (see 3.2.8), the manufacturer shall also provide the necessary mounting and wiring instructions.

7 Normal service, mounting and transport conditions

Clause 6 of part 1 applies with the following additions.

7.1.3.2 Degrees of pollution

Unless otherwise stated by the manufacturer, a contactor or a starter is for use in pollution degree 3 environmental conditions, as defined in 6.1.3.2 of part 1. However, other pollution degrees may be considered to apply, depending upon the micro-environment.

8 Constructional and performance requirements

8.1 Constructional requirements

NOTE Further requirements concerning materials and current-carrying parts are under consideration for subclauses 7.1.1 and 7.1.2 of part 1. Their application to this standard will be subject to further consideration.

8.1.1 Materials

Subclause 7.1.1 of part 1 applies (see note to 8.1).

8.1.2 Current-carrying parts and their connections

Subclause 7.1.2 of part 1 applies (see note to 8.1).

8.1.3 Clearances and creepage distances

For contactors and starters for which the manufacturer has declared a value of rated impulse withstand voltage (U_{imp}), minimum values are given in tables 13 and 15 of part 1.

For contactors and starters for which the manufacturer has not declared a value of U_{imp}, guidance is given in annex C.

8.1.4 Actuator

Subclause 7.1.4 of part 1 applies when the actuator is manually operated with the following addition.

The operating handle of the manually operated switching device of a combination starter shall be provided with means for padlocking it in the OFF position.

8.1.4.3 Mounting

Actuators mounted on removable panels or opening doors shall be so designed that, when the panels are replaced or the doors closed, the actuator will engage correctly with the associated mechanism.

8.1.5 Indication of the contact position

8.1.5.1 Indicating means

Subclause 7.1.5.1 of part 1 applies to manually operated starters.

8.1.5.2 Indication by the actuator

Subclause 7.1.5.2 of part 1 applies.

8.1.6 Additional safety requirements for equipment with isolating function

Subclause 7.1.6 of part 1 applies when isolating means are incorporated.

8.1.7 Terminals

Subclause 7.1.7 of part 1 applies with, however, the following additional requirement.

8.1.7.4 Terminal identification and marking

Subclause 7.1.7.4 of part 1 applies with additional requirements as given in annex A.

8.1.8 Additional requirements for contactors or starters provided with a neutral pole

Subclause 7.1.8 of part 1 applies.

8.1.9 Provisions for earthing

Subclause 7.1.9 of part 1 applies.

8.1.10 Enclosures for equipment

Subclause 7.1.10 of part 1 applies with the following additions.

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

For the specific case of combination starters, the cover or door shall be interlocked so that it cannot be opened without the manually operated switching device being in the open position. However, provision may be made to open the door or cover with the manually operated switching device in the ON position by the use of a tool.

8.1.11 Degrees of protection of enclosed contactors and starters

Subclause 7.1.11 of part 1 applies.

8.2 Performance requirements

8.2.1 Operating conditions

8.2.1.1 General

Subclause 7.2.1.1 of part 1 applies with the following additions.

8.2.1.1.1 Starters shall be so constructed that they:

a) are trip free;

b) can be caused to open their contacts by the means provided when running and at any time during the starting sequence;

c) will not function in other than the correct starting sequence.

8.2.1.1.2 Starters employing contactors shall not trip due to the shocks caused by operation of the contactors when tested according to 9.3.3.1, after the starter has carried its rated full load current at the reference ambient temperature (i.e. +20 °C) and has reached thermal equilibrium at both minimum and maximum settings of the overload relay, if adjustable.

8.2.1.1.3 For rheostatic starters, the overload relay shall be connected in the stator circuit. Special arrangements may be made to protect the rotor contactors and resistors against overheating, if requested by the user.

8.2.1.1.4 When starters are used in conditions in which the overheating of the starting resistors or transformers would represent an exceptional hazard, it is recommended that a suitable device be fitted to switch off the starter automatically before a dangerous temperature is reached.

8.2.1.1.5 The moving contacts of multipole equipment intended to make and break together shall be so mechanically coupled that all poles make and break substantially together, whether operated manually or automatically.

8.2.1.2 Limits of operation of contactors and power-operated starters

Electromagnetic contactors, whether used separately or in starters, shall close satisfactorily at any value between 85 % and 110 % of their rated control supply voltage U_s. Where a range is declared, 85 % shall apply to the lower value and 110 % to the higher.

The limits between which contactors shall drop out and open fully are 75 % to 20 % for a.c. and 75 % to 10 % for d.c. of their rated control supply voltage U_s. Where a range is declared, 20 % or 10 %, as the case may be, shall apply to the higher value and 75 % to the lower.

Limits for closing are applicable after the coils have reached a stable temperature corresponding to the indefinite application of 100 % U_s in an ambient temperature of +40 °C.

Limits for drop-out are applicable with the coil circuit resistance at –5 °C. This can be verified by calculation using values obtained at normal ambient temperature.

The limits apply to d.c. and a.c. at declared frequency.

Electro-pneumatic and pneumatic contactors shall close satisfactorily with the air supply pressure between 85 % and 110 % of the rated pressure and open between 75 % and 10 % of the rated pressure.

8.2.1.3 Limits of operation of under-voltage relays and releases

Subclause 7.2.1.3 of part 1 applies.

8.2.1.4 Limits of operation of shunt-coil operated releases (shunt trip)

Subclause 7.2.1.4 of part 1 applies.

8.2.1.5 Limits of operation of current operated relays and releases

8.2.1.5.1 Limits of operation of time-delay overload relays when all poles are energized

The relays shall comply with the requirements of table 3 when tested as follows:

a) with the overload relay or starter in its enclosure, if normally fitted, and at *A* times the current setting, tripping shall not occur in less than 2 h starting from the cold state, at the value of reference ambient air temperature stated in table 3. However, when the overload relay terminals have reached thermal equilibrium at the test current in less than 2 h, the test duration can be the time needed to reach such thermal equilibrium;

b) when the current is subsequently raised to *B* times the current setting, tripping shall occur in less than 2 h;

c) for class 10 A overload relays energized at *C* times the current setting, tripping shall occur in less than 2 min starting from thermal equilibrium, at the current setting, in accordance with 18.2 of IEC 60034-1;

d) for class 10, 20 and 30 overload relays energized at *C* times the current setting, tripping shall occur in less than 4, 8 or 12 min respectively, starting from thermal equilibrium, at the current setting;

e) at *D* times the current setting, tripping shall occur within the limits given in table 2 for the appropriate trip class, starting from the cold state.

In the case of overload relays having a current setting range, the limits of operation shall apply when the relay is carrying the current associated with the maximum setting and also when the relay is carrying the current associated with the minimum setting.

For non-compensated overload relays, the current multiple/ambient temperature characteristic shall not be greater than 1,2%/K.

NOTE 1,2%/K is the derating characteristic of PVC-insulated conductors.

An overload relay is regarded as compensated if it complies with the relevant requirements of table 3 at +20 °C and is within the limits shown in figure 7 at other temperatures.

Table 3 – Limits of operation of time-delay overload relays when energized on all poles

Type of overload relay	Multiples of current setting				Reference ambient air temperature
	A	*B*	*C*	*D*	
– Thermal type not compensated for ambient air temperature variations – Magnetic type	1,0	1,2	1,5	7,2	+40 °C
Thermal type compensated for ambient air temperature variations	1,05	1,2	1,5	7,2	+20 °C

8.2.1.5.2 Limits of operation of three-pole thermal overload relays energized on two poles

With reference to table 4:

The overload relay or starter shall be tested in its enclosure if normally fitted. With the relay energized on three poles, at *A* times the current setting, tripping shall not occur in less than 2 h, starting from the cold state, at the value of the ambient air temperature stated in table 4.

Moreover, when the value of the current flowing in two poles (in phase loss sensitive relays, those carrying the higher current) is increased to *B* times the current setting, and the third pole de-energized, tripping shall occur in less than 2 h.

The values shall apply to all combinations of poles.

In the case of thermal overload relays having an adjustable current setting, the characteristics shall apply both when the relay is carrying the current associated with the maximum setting and when the relay is carrying the current associated with the minimum setting.

Table 4 – Limits of operation of three-pole thermal overload relays when energized on two poles only

Type of thermal overload relay	Multiples of current setting		Reference ambient air temperature
	A	*B*	
Compensated for ambient air temperature variations. Not phase loss sensitive	3 poles 1,0	2 poles 1,32 1 pole 0	+20 °C
Not compensated for ambient air temperature variations. Not phase loss sensitive	3 poles 1,0	2 poles 1,25 1 pole 0	+40 °C
Compensated for ambient air temperature variations. Phase loss sensitive	2 poles 1,0 1 pole 0,9	2 poles 1,15 1 pole 0	+20 °C

8.2.1.5.3 Limits of operation of instantaneous magnetic overload relays

For all values of the current setting, instantaneous magnetic overload relays shall trip with an accuracy of ±10 % of the value of the published current value corresponding to the current setting.

NOTE Magnetic instantaneous overload relays covered by this standard are not intended for short-circuit protection.

8.2.1.5.4 Limits of operation of automatic change over by under-current relays

– for star-delta starters from star to delta, and
– for auto-transformer starters from the starting to the ON position

The lowest drop-out current of an under-current relay shall be not greater than 1,5 times the actual current setting of the overload relay which is active in the starting or star connection. The under-current relay shall be able to carry any value of current, from its lowest current setting to the stalled current in the starting position or the star connection, for the tripping times determined by the overload relay at its highest current setting.

8.2.2 Temperature rise

The requirements of 7.2.2, 7.2.2.1, 7.2.2.2 and 7.2.2.3 of part 1 apply to contactors and starters in a clean, new condition.

The temperature rises of the several parts of the contactor or starter measured during a test carried out under the conditions specified in 9.3.3.3 shall not exceed the limiting values stated in table 5 of this standard and in 7.2.2.1 and 7.2.2.2 of part 1.

Table 5 – Temperature rise limits for insulated coils in air and in oil

Class of insulating material	Temperature rise limit (measured by resistance variation) K	
	Coils in air	Coils in oil
A	85	60
E	100	60
B	110	60
F	135	–
H	160	–
NOTE The classification of insulations is that given in clause 2 of IEC 60085.		

Because, in an auto-transformer starter, the auto-transformer is energized only intermittently, a maximum temperature rise of 15 K greater than the figures in table 5 is permissible for the windings of the transformer when the starter is operated according to the requirements of 5.3.4 and 5.3.5.5.3.

NOTE The temperature rise limits given in table 5 of this standard and in 7.2.2.2 of part 1 are applicable only if the ambient air temperature remains within the limits –5 °C, +40 °C.

8.2.2.4 Main circuit

The main circuit of a contactor or a starter which carries current in the ON position, including the over-current releases which may be associated with it, shall be capable of carrying, without the temperature rises exceeding the limits specified in 7.2.2.1 of part 1 when tested in accordance with 9.3.3.3.4:

- for a contactor or starter intended for continuous duty: its conventional thermal current (see 5.3.2.1 and/or 5.3.2.2);
- for a contactor or starter intended for uninterrupted duty, intermittent duty or temporary duty: its relevant rated operational current (see 5.3.2.5).

8.2.2.5 Control circuits

Subclause 7.2.2.5 of part 1 applies.

8.2.2.6 Windings of coils and electromagnets

8.2.2.6.1 Uninterrupted and eight-hour duty windings

With the maximum value of current according to 8.2.2.4 flowing through the main circuit, the windings of the coils, including those of electrically operated valves of electro-pneumatic contactors or starters, shall withstand, under continuous load and at the rated frequency, if applicable, their maximum rated control supply voltage without the temperature rise exceeding the limits specified in table 5 of this standard and in 7.2.2.2 of part 1.

8.2.2.6.2 Intermittent duty windings

With no current flowing through the main circuit, the windings of the coils shall withstand, at the rated frequency, if applicable, their maximum rated control supply voltage applied as detailed in table 6 according to their intermittent duty class, without the temperature rise exceeding the limits specified in table 5 of this standard and in 7.2.2.2 of part 1.

Table 6 – Intermittent duty test cycle data

Intermittent duty class		One close-open operating cycle every	Interval of time during which the supply to the control coil is maintained
Contactors	Starters		
1	1	3 600 s	"ON" time should correspond to the on-load factor specified by the manufacturer
3	3	1 200 s	
12	12	300 s	
30	30	120 s	
120		30 s	
300		12 s	
1 200		3 s	

8.2.2.6.3 Specially rated (temporary or periodic duty) windings

Specially rated windings shall be tested under operating conditions corresponding to the most severe duty for which they are intended and their ratings shall be stated by the manufacturer.

NOTE Specially rated windings may include coils of starters which are energized during the starting period only, trip coils of latched contactors and certain magnetic valve coils for interlocking pneumatic contactors or starters.

8.2.2.7 Auxiliary circuits

Subclause 7.2.2.7 of part 1 applies.

8.2.3 Dielectric properties

The contactor or starter shall be capable of withstanding the dielectric tests specified in 9.3.3.4.

8.2.4 Normal load and overload performance requirements

Requirements concerning normal load and overload characteristics according to 5.3.5 are given in 8.2.4.1, 8.2.4.2 and 8.2.4.4.

8.2.4.1 Making and breaking capacities

Contactors or starters shall be capable of making and breaking currents without failure under the conditions stated in table 7 for the required utilization categories and the number of operations indicated, as specified in 9.3.3.5.

The off-time and on-time values given in tables 7 and 7a shall not be exceeded.

Table 7 – Making and breaking capacities – Making and breaking conditions according to utilization category

Utilization category	Make and break conditions					
	I_c/I_e	U_r/U_e	Cos φ	On-time [2)] s	Off-time s	Number of operating cycles
AC-1	1,5	1,05	0,8	0,05	6)	50
AC-2	4,0[8)]	1,05	0,65 [8)]	0,05	6)	50
AC-3[9)]	8,0	1,05	1)	0,05	6)	50
AC-4[9)]	10,0	1,05	1)	0,05	6)	50
AC-5a	3,0	1,05	0,45	0,05	6)	50
AC-5b	1,5[3)]	1,05	3)	0,05	60	50
AC-6a	10)					
AC-6b	5)					
AC-7a	1,5	1,05	0,8	0,05	6)	50
AC-7b	8,0	1,05	1)	0,05	6)	50
AC-8a	6,0	1,05	1)	0,05	6)	50
AC-8b	6,0	1,05	1)	0,05	6)	50
			— L/R ms			
DC-1	1,5	1,05	1,0	0,05	6)	50[4)]
DC-3	4,0	1,05	2,5	0,05	6)	50[4)]
DC-5	4,0	1,05	15,0	0,05	6)	50[4)]
DC-6	1,5[3)]	1,05	3)	0,05	60	50[4)]
Utilization category	Make conditions[9)]					
	I/I_e	U/U_e	Cos φ	On-time [2)] s	Off-time s	Number of operating cycles
AC-3	10	1,05[7)]	1)	0,05	10	50
AC-4	12	1,05[7)]	1)	0,05	10	50

I = current made. The making current is expressed in d.c. or a.c. r.m.s. symmetrical values but it is understood that, for a.c., the actual peak value during the making operation may assume a higher value than the symmetrical peak value.

I_c = current made and broken, expressed in d.c. or a.c. r.m.s. symmetrical values

I_e = rated operational current

U = applied voltage

U_r = power frequency or d.c. recovery voltage

U_e = rated operational voltage

Cos φ = power factor of test circuit

L/R = time-constant of test circuit

Table 7 – *(continued)*

1) Cos ϕ = 0,45 for $I_e \leq$ 100 A; 0,35 for $I_e >$ 100 A.

2) The time may be less than 0,05 s, provided that contacts are allowed to become properly seated before re-opening.

3) Tests to be carried out with an incandescent light load.

4) 25 operating cycles with one polarity and 25 operating cycles with reverse polarity.

5) Capacitive ratings may be derived by capacitor switching tests or assigned on the basis of established practice and experience. As a guide, reference may be made to the formula given in table 7b. This formula takes no account of thermal effects due to harmonic currents, and values derived must consequently be considered taking temperature rise into account.

6) See table 7a.

7) For U/U_e, a tolerance of ±20 % is accepted.

8) The values shown are for stator contactors. For rotor contactors, the test shall be made with a current of four times the rated rotor operational current and a power factor of 0,95.

9) The make conditions for utilization categories AC-3 and AC-4 shall also be verified. The verification may be made during the make and break test, but only with the manufacturer's agreement. In this case, the making current multiples shall be as shown for I/I_e and the breaking current as shown for I_c/I_e. 25 operating cycles shall be made at a control supply voltage equal to 110 % of the rated control supply voltage U_s and 25 operating cycles at 85 % of U_s. The off-times are to be determined from table 7a.

10) The manufacturer shall verify the AC-6a rating by testing with a transformer or may derive the rating from the values for AC-3 according to table 7b.

Table 7a – Relationship between current broken I_c and off-time for the verification of rated making and breaking capacities

Current broken I_c A	Off-time s
$I_c \leq$ 100	10
100 < $I_c \leq$ 200	20
200 < $I_c \leq$ 300	30
300 < $I_c \leq$ 400	40
400 < $I_c \leq$ 600	60
600 < $I_c \leq$ 800	80
800 < $I_c \leq$ 1 000	100
1 000 < $I_c \leq$ 1 300	140
1 300 < $I_c \leq$ 1 600	180
1 600 < I_c	240

The off-time values may be reduced if agreed by the manufacturer.

Table 7b – Operational current determination for utilization categories AC-6a and AC-6b when derived from AC-3 ratings

Rated operational current	Determination from making current for utilization category AC-3
I_e (AC-6a) for switching of transformers having inrush current peaks of not more than 30 times peak of rated current	0,45 I_e (AC-3)
I_e (AC-6b) for switching of single capacitor banks in circuits having a prospective short-circuit current i_k at the location of the capacitor bank	$i_k \dfrac{x^2}{(x-1)^2}$ with $x = 13{,}3 \cdot \dfrac{I_e\,(\text{AC-3})}{i_k}$ and for $i_k > 205\, I_e$ (AC-3)

The expression for the operational current I_e (AC-6b) emanates from the formula for the highest inrush current peak:

$$I_{pmax} = \frac{U_e \cdot \sqrt{2}}{\sqrt{3}} \cdot \frac{1 + \sqrt{\frac{X_c}{X_L}}}{X_L - X_c}$$

where

U_e is the rated operational voltage;

X_L is the short-circuit impedance of the circuit;

X_c is the reactance of the capacitor bank.

This formula is valid on condition that capacitance on the supply side of the contactor or starter can be neglected and that there is no initial charge on the capacitor.

8.2.4.2 Conventional operational performance

Subclause 7.2.4.2 of part 1 applies with the following addition.

Contactors or starters shall be capable of making and breaking currents without failure under the conventional conditions stated in table 8 for the required utilization categories and the number of operating cycles indicated as specified in 9.3.3.6.

Table 8 – Conventional operational performance – Making and breaking conditions according to utilization category

Utilization category	Make and break test conditions					
	I_c/I_e	U_r/U_e	Cos ϕ	On-time [2] s	Off-time s	Number of operating cycles
AC-1	1,0	1,05	0,80	0,05	[3]	6 000[11]
AC-2	2,0	1,05	0,65	0,05	[3]	6 000[11]
AC-3	2,0	1,05	[1]	0,05	[3]	6 000[11]
AC-4	6,0	1,05	[1]	0,05	[3]	6 000[11]
AC-5a	2,0	1,05	0,45	0,05	[3]	6 000[11]
AC-5b	1,0[7]	1,05	[7]	0,05	[4]	6 000[11]
AC-6	[9]	[9]	[9]	[9]	[9]	[9]
AC-8a	1,0	1,05	0,80	0,05	[3]	30 000
AC-8b[10]	6,0	1,05	0,35	1	[5]	5 900
			L/R ms	10	[6]	100
DC-1	1,0	1,05	1,0	0,05	[3]	6 000[8]
DC-3	2,5	1,05	2,0	0,05	[3]	6 000[8]
DC-5	2,5	1,05	7,5	0,05	[3]	6 000[8]
DC-6	1,0[7]	1,05	[7]	0,05	[4]	6 000[8]

I_c = current made or broken. Except for AC-5b, AC-6 or DC-6 categories, the making current is expressed in d.c. or a.c. r.m.s. symmetrical values but it is understood that for a.c. the actual peak value during the making operation may assume a higher value than the symmetrical peak value.

I_e = rated operational current

U_r = power frequency or d.c. recovery voltage

U_e = rated operational voltage

1) Cos ϕ = 0,45 for $I_e \leq 100$ A; 0,35 for $I_e > 100$ A.

2) The time may be less than 0,05 s, provided that contacts are allowed to become properly seated before re-opening.

3) These off-times shall be not greater than the values specified in table 7a.

4) Off-time is 60 s.

5) Off-time is 9 s.

6) Off-time is 90 s.

7) Tests to be carried out with an incandescent light load.

8) 3 000 operating cycles with one polarity and 3 000 operating cycles with reverse polarity.

9) Under consideration.

10) Tests for category AC-8b shall be accompanied by tests for category AC-8a. The tests may be made on different samples.

11) For manually operated switching devices, the number of operating cycles shall be 1 000 on-load, followed by 5 000 off-load.

8.2.4.3 Durability

Subclause 7.2.4.3 of part 1 applies with the following additions.

8.2.4.3.1 Mechanical durability

The mechanical durability of a contactor or starter is verified by a special test conducted at the discretion of the manufacturer. Recommendations for conducting this test are given in annex B.

8.2.4.3.2 Electrical durability

Electrical durability of a contactor or starter is verified by a special test conducted at the discretion of the manufacturer. Recommendations for conducting this test are given in annex B.

8.2.4.4 Overload current withstand capability of contactors

Contactors with utilization categories AC-3 or AC-4 shall withstand the overload currents given in table 9, as specified in 9.3.5.

Table 9 – Overload current withstand requirements

Rated operational current	Test current "I"	Duration of test
≤630 A	8 × I_e max/AC-3	10 s
>630 A	6 × I_e max/AC-3*	10 s
* With a minimum value of 5 040 A.		

NOTE This test also covers duties where the current is less than shown in table 9 and the test duration is longer than 10 s, provided that the tested value of I^2t is not exceeded.

8.2.5 Co-ordination with short-circuit protective devices

8.2.5.1 Performance under short-circuit conditions (rated conditional short-circuit current)

The rated conditional short-circuit current of contactors and starters backed up by short-circuit protective device(s) (SCPD(s)), combination starters and protected starters shall be verified by short-circuit tests as specified in 9.3.4. These tests are mandatory:

a) at the appropriate value of prospective current shown in table 9 (test current "I"), and

b) at the rated conditional short-circuit current I_q, if higher than test current "I".

The rating of the SCPD shall be adequate for any given rated operational current, rated operational voltage and the corresponding utilization category.

Two types of co-ordination are permissible, "1" or "2". The test conditions for both are given in 9.3.4.2.1 and 9.3.4.2.2.

Type "1" co-ordination requires that, under short-circuit conditions, the contactor or starter shall cause no danger to persons or installation and may not be suitable for further service without repair and replacement of parts.

Type "2" co-ordination requires that, under short-circuit conditions, the contactor or starter shall cause no danger to persons or installation and shall be suitable for further use. The risk of contact welding is recognized, in which case the manufacturer shall indicate the measures to be taken as regards the maintenance of the equipment.

NOTE Use of an SCPD not in compliance with the manufacturer's recommendations may invalidate the co-ordination.

8.2.5.2 Co-ordination at the crossover current between starter and associated SCPD

Co-ordination at the crossover current between the starter and the SCPD is a special test. The way to verify it is described in clause B.4.

8.2.6 Switching overvoltages

Subclause 7.2.6 of part 1 applies to contactors and starters for which the manufacturer has declared a value of the rated impulse withstand voltage U_{imp}.

Suitable test circuits and measuring methods are under consideration.

8.2.7 Additional requirements for combination starters and protected starters suitable for isolation

Under consideration.

8.3 Electromagnetic compatibility (EMC)

8.3.1 General

Subclause 7.3.1 of part 1 applies with the following addition.

Power frequency magnetic field tests are not required because the devices are naturally submitted to such fields. Immunity is demonstrated by the successful completion of the operational performance capability tests (see 9.3.3.5 and 9.3.3.6).

This equipment is inherently sensitive to voltage dips and short time interruptions on the control supply; it shall react within the limits of 8.2.1.2 and this is verified by the operating limits tests given in 9.3.3.2.

8.3.2 Immunity

8.3.2.1 Equipment not incorporating electronic circuits

Subclause 7.3.2.1 of part 1 applies.

8.3.2.2 Equipment incorporating electronic circuits

Subclause 7.3.2.2 of part 1 applies.

The test results are specified using the performance criteria of IEC 61000-4. For convenience the performance criteria are quoted here and described in more detail in table 10.

Performance criteria	Test result
1	Normal performance within the specification limits
2	Temporary degradation, or loss of function or performance which is self-recoverable
3	Temporary degradation, or loss of function or performance which requires operator's intervention or system reset. Normal functions shall be restorable by simple intervention, for example by manual reset or restart. There shall not be any damaged component.

Table 10 – Specific acceptance criteria for immunity tests

Item	Acceptance criteria		
	1	2	3
Operation of power and control circuits	No maloperation	Temporary maloperation which cannot cause tripping Unintentional separation or closure of contacts is not accepted Self-recoverable	Tripping of overload relay Unintentional separation or closure of contacts Not self-recoverable
Operation of displays and auxiliary circuits	No changes to visible display information Only slight light intensity fluctuations of LEDs or movement of characters	Temporary visible changes, for example unwanted LED illumination No maloperation of auxiliary contacts	Permanent loss of display information Maloperation of auxiliary contacts

8.3.3 Emission

The level of severity required for environment 1 covers those required for environment 2.

The devices covered by this standard do not generate significant levels of harmonics and therefore no harmonic tests are required.

8.3.3.1 Equipment not incorporating electronic circuits

Subclause 7.3.3.1 of part 1 applies with the following addition.

Equipment incorporating only components such as diodes, varistors, resistors or capacitors is not required to be tested (e.g. in surge suppressors).

8.3.3.2 Equipment incorporating electronic circuits

Subclause 7.3.3.2 of part 1 applies with the following addition.

Radiated radio-frequency emission tests are required only for equipment incorporating circuits with fundamental switching frequency greater than 9 kHz, for example chopped supplies or high-frequency clocks of microprocessors.

9 Tests

9.1 Kinds of test

9.1.1 General

Subclause 8.1.1 of part 1 applies.

9.1.2 Type tests

Type tests are intended to verify compliance of the design of contactors and starters of all types with this standard. They comprise the verification of:

a) temperature rise limits (see 9.3.3.3);
b) dielectric properties (see 9.3.3.4);
c) rated making and breaking capacities (see 9.3.3.5);
d) change-over ability and reversibility, where applicable (see 9.3.3.5);
e) conventional operational performance (see 9.3.3.6);
f) operation and operating limits (see 9.3.3.1 and 9.3.3.2);
g) ability of contactors to withstand overload current (see 9.3.5);
h) performance under short-circuit conditions (see 9.3.4);
i) mechanical properties of terminals (see 8.2.4 of part 1);
j) degrees of protection of enclosed contactors and starters (see annex C of part 1).
k) EMC tests, where applicable (see 9.4).

9.1.3 Routine tests (see 9.3.6)

Subclause 8.1.3 of part 1 applies where sampling tests (see 9.1.4) are not made.

Routine tests for contactors and starters comprise:

- operation and operating limits (see 9.3.6.2);
- dielectric tests (see 9.3.6.3).

9.1.4 Sampling tests (see 9.3.6)

Sampling tests for contactors and starters comprise:

- operation and operating limits (see 9.3.6.2)
- dielectric tests (see 9.3.6.3).

Subclause 8.1.4 of part 1 applies with the following additions.

A manufacturer may use sampling tests instead of routine tests at his own discretion. Sampling shall meet or exceed the following requirements as specified in IEC 60410 (see table II-A: Single sampling plans for normal inspection):

- sampling based on AQL $\leq$ 1;
- acceptance number Ac = 0 (no defect accepted);
- rejection number Re = 1 (if 1 defect, the entire lot shall be tested);

Sampling shall be made at regular intervals for each specific lot.

Alternative statistical methods that ensure compliance with the above IEC 60410 requirements can be used, e.g. statistical methods controlling continuous manufacturing or process control with capability index.

Sampling tests for clearance verification according to 8.3.3.4.3 of part 1 are under consideration.

9.1.5 Special tests

Special tests are mechanical and electrical durability tests and verification of co-ordination at the crossover current between the starter and the SCPD (see annex B).

9.2 Compliance with constructional requirements

Subclause 8.2 of part 1 applies (see, however, note to 8.1).

9.3 Compliance with performance requirements

9.3.1 Test sequences

Each test sequence is made on a new sample.

NOTE 1 With the agreement of the manufacturer, more than one test sequence or all test sequences may be conducted on one sample. However, the tests are to be conducted in the sequence given for each sample.

NOTE 2 Some tests are included in the sequences solely to reduce the number of samples required, the results have no significance for the preceding or following tests in the sequence. Therefore, for convenience of testing and by agreement with the manufacturer, these tests may be conducted on separate new samples and omitted from the relevant sequence. This only applies to the following tests when called for:

Subclause 8.3.3.4.1, item 7) of part 1 – *Verification of creepage distances.*

Subclause 8.2.4 of part 1 – *Mechanical properties of terminals*;

Annex C of part 1 – *Degrees of protection of enclosed equipment.*

The test sequence shall be as follows.

a) Test sequence 1
   (i) verification of temperature rise (see 9.3.3.3)
   (ii) verification of operation and operating limits (see 9.3.3.1 and 9.3.3.2)
   (iii) verification of dielectric properties (see 9.3.3.4)
b) Test sequence 2
   (i) verification of rated making and breaking capacities, change-over ability and reversibility, where applicable (see 9.3.3.5)
   (ii) verification of conventional operational performance (see 9.3.3.6)
c) Test sequence 3
   performance under short-circuit conditions (see 9.3.4);
d) Test sequence 4 (applicable to contactors only)
   verification of ability to withstand overload currents (see 9.3.5);
e) Test sequence 5
   (i) verification of mechanical properties of terminals (see 8.2.4 of part 1);
   (ii) verification of degrees of protection of enclosed contactors and starters (see annex C of part 1).

There shall be no failure in any of the tests.

9.3.2 General test conditions

Subclause 8.3.2 of part 1 applies with the following addition.

Unless otherwise specified in the relevant test clause, the clamping torque for connections shall be that specified by the manufacturer or, if not specified, the torque given in table 4 of part 1.

9.3.3 Performance under no load, normal load and overload conditions

9.3.3.1 Operation

It shall be verified that contactors and starters operate according to the requirements of 8.2.1.1.2.

To verify the insensitivity of the starter to contactor operation, the starter shall be loaded to attain a steady state temperature as stated in 8.2.2 and the contactor operated in the normal switching sequence three times without intentional delay between operations. The starter shall not trip due to the contactor operation.

When the overload relay has a combined stop and reset actuating mechanism, with the contactor closed, the resetting mechanism shall be operated and this shall cause the contactor to drop out. When the overload relay has either a reset only or separate stop and reset actuating mechanisms, with the contactor closed and the resetting mechanism in the reset position, the tripping mechanism shall be operated and the contactor shall have been caused to drop out. These tests are to verify that the overload tripping action cannot be defeated by holding the resetting mechanism in the reset position.

In the case of rheostatic rotor starters, 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 resistors shall be verified for each section to be within ±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.

It shall also be verified that the open-circuit voltages on the tapping terminals of the auto-transformer are in accordance with the designed figures and that the phase sequence at the motor terminals of the two-step auto-transformer starter is correct in both the starting and ON positions of the starter.

9.3.3.2 Operating limits

9.3.3.2.1 Power-operated equipment

Contactors and starters shall be tested to verify their performance according to the requirements given in 8.2.1.2.

9.3.3.2.2 Relays and releases

a) Operation of under-voltage relays and releases

Under-voltage relays or releases shall be tested for compliance with the requirements of 8.2.1.3. Each limit shall be verified three times.

For the drop-out test, the voltage shall be reduced from the rated value to zero at an uniform rate in approximately 1 min.

b) Shunt-coil operated releases

Shunt-coil operated releases shall be tested for compliance with the requirements of 8.2.1.4. Operation shall be verified at 70 % and 110 % of rated voltage under all operating conditions of the starter.

c) Thermal and time-delay magnetic overload relays

Overload relays and starters shall be connected using conductors in accordance with tables 9, 10 and 11 of part 1 for test currents corresponding to:

– 100 % of the current setting of the overload relay for overload relays of trip class 10A;
– 125 % of the current setting of the overload relay for overload relays of trip classes 10, 20 and 30 and for overload relays for which a maximum tripping time greater than 30 s is specified (see 5.7.3).

Thermal and time-delay magnetic overload relays with all poles energized shall be tested as stated in 8.2.1.5.1.

Moreover, the characteristics defined in 8.2.1.5.1 shall be verified by tests at –5 °C, +20 °C, +40 °C.

Three-pole thermal overload relays energized on two poles only shall be tested as stated in 8.2.1.5.2 on all combinations of poles and at the maximum and minimum current settings for relays with adjustable settings.

d) Instantaneous magnetic overload relays

Each relay shall be tested separately. The current through the relay shall be increased at a rate suitable for an accurate reading to be made. The values shall be as stated in 8.2.1.5.3.

e) Under-current relays in automatic change-over

The limits of operation shall be verified in accordance with 8.2.1.5.4.

9.3.3.3 Temperature rise

9.3.3.3.1 Ambient air temperature

Subclause 8.3.3.3.1 of part 1 applies.

9.3.3.3.2 Measurement of the temperature of parts

Subclause 8.3.3.3.2 of part 1 applies.

9.3.3.3.3 Temperature rise of a part

Subclause 8.3.3.3.3 of part 1 applies.

9.3.3.3.4 Temperature rise of the main circuit

Subclause 8.3.3.3.4 of part 1 applies with the following additions:

The main circuit shall be loaded as stated in 8.2.2.4.

All auxiliary circuits which normally carry current shall be loaded at their maximum rated operational current (see 5.6) and the control circuits shall be energized at their rated voltages.

The starter shall be fitted with an overload relay complying with 5.7.4 and selected as follows:

– Non-adjustable relay

  The current setting shall be equal to the maximum operational current of the starter and the test shall be made at this current;

– Adjustable relay

  The maximum current setting shall be that which is nearest to but not greater than the maximum operational current of the starter.

  The test shall be made with that overload relay for which the current setting is nearest to the maximum of its scale.

NOTE The selection method described above is designed to ensure that the temperature rise of the field wiring terminals of the overload relay and the power dissipated by the starter are not less than those that will occur under any combination of relay and contactor. In cases where the effect of the overload relay on these values is insignificant (i.e. solid state overload relays), the test current shall always be the maximum operational current of the starter.

9.3.3.3.5 Temperature rise of control circuits

Subclause 8.3.3.3.5 of part 1 applies with the following addition.

The temperature rise shall be measured during the test of 9.3.3.3.4.

9.3.3.3.6 Temperature rise of coils and electromagnets

Subclause 8.3.3.3.6 of part 1 applies with the following additions.

a) Electromagnets of contactors or starters intended for uninterrupted or 8 h duty are subjected only to the conditions prescribed in 8.2.2.6.1, with the corresponding rated current flowing through the main circuit for the duration of the test. The temperature rise shall be measured during the test of 9.3.3.3.4.

b) Electromagnets of contactors or starters intended for intermittent duty shall be subjected to the test as stated above, and also to the test prescribed in 8.2.2.6.2 dealing with their duty class, with no current flowing through the main circuit.

c) Specially rated (temporary and periodic duty) windings shall be tested as stated in 8.2.2.6.3, without the current in the main circuit.

9.3.3.3.7 Temperature rise of auxiliary circuits

Subclause 8.3.3.3.7 of part 1 applies with the following addition.

The temperature rise shall be measured during the test of 9.3.3.3.4.

9.3.3.3.8 Temperature rise of starting resistors for rheostatic rotor starters

The temperature rise of resistors shall not exceed the limits specified in table 3 of part 1, when the starter is operated at its rated duty (see 5.3.4) and according to its starting characteristics (see 5.3.5.5.1).

The current through each section 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 the starting time for which the starter is rated (see 5.3.4 and 5.3.5.5.1); in practice, the current value I_m can be used.

Starting operations shall be evenly spaced in time according to the number of starts per hour.

The temperature rise of the enclosures and of the issuing air shall not exceed the limits specified in table 3 of part 1.

NOTE It is not practical 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 standard.

9.3.3.3.9 Temperature rise of the auto-transformer for two-step auto-transformer starters

The temperature rise of the auto-transformer shall not exceed the limits specified in table 5 increased by 15 % (see 8.2.2) and those specified in table 3 of part 1, when the starter is operated at its rated duty (see 5.3.4).

The current through each winding of the auto-transformer shall be thermally equivalent to the current carried when the controlled motor is operating with the maximum starting current and starting time for which the starter is rated (see 5.3.5.5.3); this condition is assumed to be reached when the current drawn from the auto-transformer during the starting time is equal to the maximum starting current specified in 5.3.5.5.3 multiplied by:

$$0{,}8 \times \frac{\text{starting voltage}}{U_e} \quad \text{(see 5.3.1.4)}$$

The operating cycles shall be evenly spaced in time according to the number of starts per hour (see 5.3.4.3).

In the event of two successive operating cycles (see 5.3.4.3), the temperature rise of the auto-transformer may exceed the maximum value given in 8.2.2 but no damage shall result to the auto-transformer.

In the case of an auto-transformer with several sets of taps, the test shall be made with the taps giving the highest power loss in the transformer; it shall be made over a period of time sufficient for the temperature rise to reach a constant value.

In order to facilitate this test, star-connected impedances may be used in place of a motor.

9.3.3.4 Dielectric properties

The test shall be made:

- in accordance with 8.3.3.4 of part 1, if the manufacturer has declared a value of the rated impulse withstand U_{imp} (see 5.3.1.3);
- in accordance with 9.3.3.4.1, 9.3.3.4.2, 9.3.3.4.3 and 9.3.3.4.4, if no value of U_{imp} has been declared, and for the verification of dielectric withstand in the relevant subclauses of this standard.

Equipment suitable for isolation shall be tested according to 8.3.3.4 of part 1, with a value of test voltage as specified in table 14 of part 1 and corresponding to the value of U_{imp} declared by the manufacturer. This requirement does not apply to the verification of dielectric withstand made during test sequences.

For equipment not suitable for isolation, tests to verify the impulse withstand voltage across open contacts are not required.

9.3.3.4.1 Condition of the contactor or starter for tests

Dielectric tests shall be made on contactors or starters mounted as for service, including internal wiring, and in a clean and dry condition.

When the base of the contactor or starter is of insulating material, metallic parts shall be placed at all the fixing points in accordance with the conditions of normal installation of the contactor or starter and these parts shall be considered as part of the frame of the contactor or starter. When the contactor or starter is in an insulating enclosure, the latter shall be covered externally by a metal foil connected to the frame.

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

9.3.3.4.2 Application of the test voltage

When the circuits of a contactor or starter include devices such as motors, instruments, snap switches and solid state devices which, according to their relevant specifications, have been subjected to dielectric test voltages lower than those specified in 9.3.3.4.3, such devices may, at the discretion of the manufacturer, be disconnected before subjecting the contactor or starter to the required test.

a) Main circuit

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

1) with the main contacts closed:
   - between all live parts of all poles connected together and the frame of the contactor or starter;
   - between each pole and all the other poles connected to the frame of the contactor or starter;

2) with the main contacts open:
   - between all live parts of all poles connected together and the frame of the contactor or starter;
   - between the terminals of one side connected together and the terminals of the other side connected together.

b) Control and auxiliary circuits

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

1) between all the control and auxiliary circuits which are not normally connected to the main circuit connected together and the frame of the contactor or starter;

2) where appropriate, between each part of the control and auxiliary circuits which may be isolated from the other parts during normal operation and all the other parts connected together.

9.3.3.4.3 Value of the test voltage

The test voltage shall have a practically sinusoidal waveform and a frequency between 45 Hz and 65 Hz.

The source of the test voltage shall be capable of supplying a short-circuit current of at least 0,2 A, when adjusted according to the test voltage measured off-load on the test side. The tripping device, if any, shall not trip at less than 0,1 A.

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

a) for the main circuit and for the control and auxiliary circuits which are not covered by item b) below: in accordance with table 11;

Table 11 – Dielectric test voltage according to rated insulation voltage

Rated insulation voltage U_i V	**Dielectric test voltage (a.c.) (r.m.s)** V
$U_i \leq 60$	1 000
$60 < U_i \leq 300$	2 000
$300 < U_i \leq 690$	2 500
$690 < U_i \leq 800$	3 000
$800 < U_i \leq 1\ 000$	3 500
$1\ 000 < U_i \leq 1\ 500$*	3 500
* For d.c. only.	

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

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

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

9.3.3.4.4 Results to be obtained

The test is considered to have been passed if there is no puncture or flashover.

9.3.3.5 Making and breaking capacities

Subclause 8.3.3.5 of part 1 applies with the following additions.

9.3.3.5.1 General test conditions

The tests shall be made, under the operating conditions stated in table 7, without failure, see 9.3.3.5.5 f).

The control supply voltage shall be 100 % of U_s, except that, for the make only test of utilization categories AC-3 and AC-4, the control supply voltage shall be 110 % of U_s for half the number of operating cycles and 85 % of U_s for the other half.

Connections to the main circuit shall be similar to those intended to be used when the contactor or starter is in service. If necessary, or for convenience, the control and auxiliary circuits, and in particular the magnet coil of the contactor or starter, may be supplied by an independent source. Such a source shall deliver the same kind of current and the same voltage as specified for service conditions.

The overload relay and the SCPD of the starter may be short-circuited for the purpose of carrying out the rated making and breaking capacity tests.

9.3.3.5.2 Test circuit

Subclause 8.3.3.5.2 of part 1 applies.

9.3.3.5.3 Characteristics of transient recovery voltage

Subclause 8.3.3.5.3 of part 1 applies to utilization categories AC-2, AC-3, AC-4, AC-7b, AC-8a and AC-8b (see table 1).

It is not necessary to adjust factor y or the oscillatory frequency for testing making capacity only (in AC-3 and AC-4).

9.3.3.5.4 Switching overvoltages

Subclause 8.3.3.5.4 of part 1 applies with the following addition:

The switching overvoltages shall be verified on the load side between phases for multipole devices and across the load for single-pole devices.

The test procedure is under consideration.

9.3.3.5.5 Rated making and breaking capacities

If the contactor in a starter has separately satisfied the requirements of item a) hereafter for the utilization category of the starter, the starter need not be tested.

a) Rated making and breaking capacities of contactors

   The contactor shall make and break the current corresponding to its utilization category and for the number of operating cycles given in table 7. See also item d) hereafter for reversing contactors.

   Contactors of utilization categories AC-3 and AC-4 shall be subjected to 50 making only operations followed by 50 making and breaking operations.

b) Rated making and breaking capacity of direct-on-line and two direction starters (AC-3, AC-7b) and stator switching devices of rheostatic rotor starters (AC-2)

   The starter shall make and break the current corresponding to its utilization category for the number of operating cycles given in table 7.

   Starters of utilization category AC-3 shall be subjected to 50 making only operations followed by 50 making and breaking operations.

c) Rated making and breaking capacities and change-over ability of star-delta starters (AC-3) and two-step auto-transformer starters (AC-3)

   The starter shall make and break the currents corresponding to its utilization category given in table 7.

   Both the starting and the ON or delta position of the starters shall first be subjected to 50 making only operations, the current being broken by a separate switching device.

The starter shall then be subjected to the 50 making and breaking operations. Each operating cycle shall consist of the following sequences:

- make the current in the starting or star position;
- break the current in the starting or star position;
- make the current in the ON or delta position;
- break the current in the ON or delta position;
- off period.

The load circuit shall be connected to the starter as would be the windings of a motor. The rated operational current of the starter (I_e) is the current in the ON or delta position.

NOTE In the case of star-delta starters, it is important that the test currents be measured in star and delta since the supply impedance has a significant effect on the transformation ratio.

When a transformer has more than one output voltage, it shall be connected to give the highest starting voltage.

The on-time in the starting and ON positions and the off-time shall be as stated in table 7.

d) Rated making and breaking capacities of direct-on-line and reversing starters (AC-4)

The starters shall make and break the currents given in table 7.

The 50 making only operations shall be done first, the current being broken by a separate switching device, followed by the 50 making and breaking operations.

The load circuit shall be connected to the starter as would be the windings of a motor.

For starters incorporating two contactors, two contactors A and B shall be used and wired as in normal application. Each sequence of the 50 operations shall be:

close A – open A – close B –
open B – off period

The change-over from "open A" to "close B" shall be made as fast as the normal control system will allow.

Mechanical or electrical interlocking means provided in the starter or available for associating contactors as reversing devices shall be used.

If the reversing circuit arrangement is such that both contactors can be energized simultaneously, ten additional sequences shall be conducted with both contactors energized simultaneously.

e) Rated making and breaking capacities of the rotor switching devices of a rheostatic rotor starter

Verification of the making and breaking capacities of the rotor switching devices shall be performed as in 9.3.3.5.5 b) for AC-2 category where $I_e = I_{er}$, the maximum rated rotor current for which the starter is designed. $U_e = U_{er}$ (rated rotor operational voltage) and U/U_e shall be 0,8. The power factor shall be 0,95. 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 which have previously satisfied the requirements corresponding to those specified above, no further tests are needed.

f) Behaviour and condition of the contactor or starter during and after the making and breaking capacity, change-over and reversing tests

During the tests within the limits of the specified making and breaking capacities of 9.3.3.5 and the verification of conventional operational performance of 9.3.3.6.1 to 9.3.3.6.6, there shall be no permanent arcing, no flash-over between poles, no blowing of the fusible element in the earth circuit (see 9.3.3.5.2) and no welding of the contacts.

The contacts shall operate when the contactor or starter is switched by the applicable method of control.

9.3.3.6 Operational performance capability

Subclause 8.3.3.6 of part 1 applies with the following additions.

Tests concerning the verification of conventional operational performance are intended to verify that a contactor or starter is capable of fulfilling the requirements given in table 8.

Connections to the main circuit shall be similar to those intended to be used when the contactor or starter is in service.

The overload relay and the SCPD of the starter may be short-circuited for the purpose of carrying out the tests.

The test circuit given in 9.3.3.5.2 is applicable and the load is to be tuned according to 9.3.3.5.3.

The control voltage shall be 100 % of the rated control supply voltage.

If the contactor in a starter has separately satisfied the requirements of 9.3.3.6.1 for the utilization category of the starter, the starter need not be tested.

9.3.3.6.1 Conventional operational performance of contactors

The contactor shall make and break the current corresponding to its utilization category and for the number of operating cycles given in table 8. See also 9.3.3.6.4.

9.3.3.6.2 Conventional operational performance of direct-on-line and two direction starters (AC-3) and stator switching devices of rheostatic rotor starters (AC-2)

The starter shall make and break the current corresponding to its utilization category and for the number of operating cycles given in table 8.

9.3.3.6.3 Conventional operational performance of star-delta starters (AC-3) and two-step auto-transformer starters (AC-3)

The starter shall make and break the current corresponding to its utilization category for the number of operating cycles given in table 8.

The test procedure shall be as stated in 9.3.3.5.5, item c), except that the 50 making only operations are not done.

9.3.3.6.4 Conventional operational performance of direct-on-line and reversing starters (AC-4)

The starter shall make and break the current corresponding to its utilization category for the number of operating cycles given in table 8.

The test procedure shall be as stated in 9.3.3.5.5, item d), except that the 50 making only operations and the 10 additional sequences of simultaneous energizing are not done.

9.3.3.6.5 Conventional operational performance of the rotor switching devices of a rheostatic rotor starter

Verification of conventional operational performance of the rotor switching devices shall be performed as in 9.3.3.6.1 for the AC-2 category given in table 8.

The test procedure shall be as stated in 9.3.3.5.5, item e).

9.3.3.6.6 Behaviour of the contactor or starter during, and its condition after, the conventional operational performance tests

The requirements of 9.3.3.5.5, item f), should be fulfilled and the dielectric properties of the contactor or starter shall be verified by a dielectric test on the contactor or starter using an essentially sinusoidal test voltage of twice the rated operational voltage with a minimum of 1 000 V. The test voltage shall be applied for 1 min as specified in 9.3.3.4.2, item a) 1).

9.3.4 Performance under short-circuit conditions

This subclause specifies test conditions for verification of compliance with the requirements of 8.2.5.1. Specific requirements regarding test procedure, test sequences, condition of equipment after the test and types of co-ordination are given in 9.3.4.1 and 9.3.4.2.

9.3.4.1 General conditions for short-circuit tests

9.3.4.1.1 General requirements for short-circuit tests

The general requirements of 8.3.4.1.1 of part 1 apply.

9.3.4.1.2 Test circuit for the verification of short-circuit ratings

Subclause 8.3.4.1.2 of part 1 applies except that, for type "1" co-ordination, the fusible element F and the resistor R_L are replaced by a solid 6 mm² wire of 1,2 m to 1,8 m in length, connected to the neutral, or with the agreement of the manufacturer, to one of the phases.

NOTE This larger size of wire is not used as a detector but to establish an "earth" condition allowing the damage to be evaluated.

9.3.4.1.3 Power-factor of the test circuit

Subclause 8.3.4.1.3 of part 1 applies.

9.3.4.1.4 Time-constant of the test circuit

Subclause 8.3.4.1.4 of part 1 applies.

9.3.4.1.5 Calibration of the test circuit

Subclause 8.3.4.1.5 of part 1 applies.

9.3.4.1.6 Test procedure

Subclause 8.3.4.1.6 of part 1 applies with the following additions.

The contactor or the starter and its associated SCPD, or the combination or protected starter, shall be mounted and connected as in normal use. They shall be connected in the test circuit using a maximum of 2,4 m of cable (corresponding to the operational current of the starter) for each main circuit.

If the SCPD is separate from the starter, it shall be connected to the starter using the cable specified above. (The total length of cable shall not exceed 2,4 m.)

Three-phase tests are considered to cover single-phase applications.

9.3.4.1.7 Vacant.

9.3.4.1.8 Interpretation of records

Subclause 8.3.4.1.8 of part 1 applies.

9.3.4.2 Conditional short-circuit current of contactors, starters, combination starters and protected starters

The contactor or starter and the associated SCPD, or the combination or the protected starter, shall be subjected to the tests given in 9.3.4.2.1 and 9.3.4.2.2. The tests shall be so conducted that conditions of maximum I_e and of maximum U_e for utilization category AC-3 are covered.

For a magnetically operated contactor or starter, the magnet shall be held closed by a separate electrical supply at the rated control supply voltage U_s. The SCPD used shall be as stated in 8.2.5.1. If the SCPD is a circuit-breaker with an adjustable current setting, the test shall be done with the circuit-breaker adjusted to the maximum setting for the declared type of co-ordination and discrimination.

During the test, all openings of the enclosure shall be closed as in normal service and the door or cover secured by the means provided.

A starter covering a range of motor ratings and equipped with interchangeable overload relays shall be tested with the overload relay with the highest impedance and the overload relay with the lowest impedance together with the corresponding SCPDs.

For type "1" co-ordination, a new test sample may be used for each operation stated in 9.3.4.2.1 and 9.3.4.2.2.

For type "2" co-ordination, one sample shall be used for the tests at the prospective current "r" (see 9.3.4.2.1) and one sample for the tests at current I_q (see 9.3.4.2.2).

By agreement of the manufacturer, the tests at *r* and I_q may be carried out on the same sample.

9.3.4.2.1 Test at the prospective current "*r*"

The circuit shall be adjusted to the prospective test current corresponding to the rated operational current I_e according to table 12.

The contactor or starter and the associated SCPD, or the combination or the protected starter, shall then be connected in the circuit. The following sequence of operations shall be performed:

a) One breaking operation of the SCPD shall be performed with all the switching devices closed prior to the test.
b) One breaking operation of the SCPD shall be performed by closing the contactor or starter on to the short-circuit.

Table 12 – Value of the prospective test current according to the rated operational current

Rated operational current I_e (AC-3)* A	Prospective current "*r*" kA
0 $I_e \leq 16$	1
$16 < I_e \leq 63$	3
$63 < I_e \leq 125$	5
$125 < I_e \leq 315$	10
$315 < I_e \leq 630$	18
$630 < I_e \leq 1\,000$	30
$1\,000 < I_e \leq 1\,600$	42
$1\,600 < I_e$	Subject to agreement between manufacturer and user

* If the contactor or starter is not specified according to utilization category AC-3, the prospective current "*r*" shall correspond to the highest rated operational current for any utilization category claimed by the manufacturer.

The power factor or the time-constant shall be according to table 16 of 8.3.4.1.4 of part 1.

9.3.4.2.2 Test at the rated conditional short-circuit current I_q

NOTE This test is done if the current I_q is higher than the current "*r*".

The circuit shall be adjusted to the prospective short-circuit current I_q equal to the rated conditional short-circuit current.

If the SCPD is a fuse and the test current is within the current-limiting range of the fuse, then, if possible, the fuse shall be selected to permit the maximum peak let-through current (I_p) and the maximum let-through energy (I^2t).

The contactor or starter and the associated SCPD, or the combination or the protected starter, shall then be connected to the circuit.

The following sequence of operations shall be performed:

a) One breaking operation of the SCPD shall be performed with all the switching devices closed prior to the test.

b) One breaking operation of the SCPD shall be performed by closing the contactor or starter on to the short-circuit.

If, in the case of a combination starter or a protected starter, the switching device of the SCPD complies with IEC 60947-2 or IEC 60947-3 and has a short-circuit breaking capacity or rated conditional short-circuit current less than the rated conditional short-circuit current of the combination starter or protected starter the following additional test shall be made.

c) One breaking operation of the SCPD shall be performed by closing the switching device (switch or circuit-breaker) on to the short-circuit. This operation may be performed either on a new sample (starter and SCPD) or on the first sample with the agreement of the manufacturer.

After this operation only conditions A to G of 9.3.4.2.3 shall be verified.

9.3.4.2.3 Results to be obtained

The contactor, starter, or the combination or protected starter, shall be considered to have passed the tests at the prospective current "r" and, where applicable, the prospective current I_q, if the following conditions are met for the claimed type of co-ordination.

Both types of co-ordination (all devices):

A The fault current has been successfully interrupted by the SCPD or the combination starter and the fuse or fusible element or solid connection between the enclosure and supply shall not have melted.

B The door or cover of the enclosure has not been blown open and it is possible to open the door or cover. Deformation of the enclosure is considered acceptable provided that the degree of protection by the enclosure is not less than IP2X.

C There is no damage to the conductors or terminals and the conductors have not been separated from the terminals.

D There is no cracking or breaking of an insulating base to the extent that the integrity of mounting of a live part is impaired.

Both types of co-ordination (combination starters and protected starters only):

E The circuit-breaker or the switch is capable of being opened manually by its operating means.

F Neither end of the SCPD is completely separated from its mounting means to an exposed conductive part.

G If a circuit-breaker with rated ultimate short-circuit breaking capacity less than the rated conditional short-circuit current assigned to the combination or protected starter is employed, the circuit-breaker shall be tested to trip as follows:

a) Circuit-breakers with instantaneous trip relays or releases: at 120 % of the trip current.

b) Circuit-breakers with overload relays or releases: at 250 % of the rated current of the circuit-breaker.

Type "1" co-ordination (all devices):

H There has been no discharge of parts beyond the enclosure. Damage to the contactor and the overload relay is acceptable. The starter may be inoperative after each operation. The starter shall therefore be inspected and the contactor and/or the overload relay and the release of the circuit-breaker shall be reset if necessary and, in the case of fuse protection, all fuse-links shall be replaced.

Type "1" co-ordination (combination and protected starters only):

I The adequacy of insulation is verified after each operation (at currents "*r*" and I_q) by a dielectric test on the complete unit under test (SCPD plus contactor/starter but before replacement of parts) using an essentially sinusoidal test voltage of twice the rated operational voltage U_e but not less than 1 000 V. The test voltage shall be applied for 1 min to the incoming supply terminals, with the switch or the circuit-breaker in the open position, as follows:

- between each pole and all other poles connected to the frame of the starter;
- between all live parts of all poles connected together and the frame of the starter;
- between the terminals of the line side connected together and the terminals of the other side connected together.

Type "2" co-ordination (all devices):

J No damage to the overload relay or other parts has occurred, except that welding of contactor or starter contacts is permitted, if they are easily separated (e.g. by a screwdriver) without significant deformation, but no replacement of parts is permitted during the test, except that, in the case of fuse protection, all fuse-links shall be replaced.

In the case of welded contacts as described above, the functionality of the device shall be verified by carrying out 10 operating cycles under the conditions of table 8 for the applicable utilization category.

K The tripping of the overload relay shall be verified at a multiple of the current setting and shall conform to the published tripping characteristics, according to 5.7.5, both before and after the short-circuit test.

L The adequacy of the insulation shall be verified by a dielectric test on the contactor, starter, combination or protected starter using an essentially sinusoidal test voltage of twice the rated operational voltage U_e but not less than 1 000 V. The test voltage shall be applied for 1 min, as specified in 9.3.3.4.2, item a) 1).

In the case of combination and protected starters, additional tests according to item a) 2) of 9.3.3.4.2 shall be made:

(i) with the contacts of the switch or of the circuit-breaker open and the contacts of the starter closed;

(ii) with the contacts of the switch or of the circuit-breaker closed and the contacts of the starter open.

9.3.5 Overload current withstand capability of contactors

For the test, the contactor shall be mounted, wired and operated as specified in 9.3.2.

All poles of the contactors are simultaneously subjected to one test with the overload current and duration values stated in 8.2.4.4. The test is performed at any convenient voltage and it starts with the contactor at room temperature.

After the test, the contactor shall be substantially in the same condition as before the test. This is verified by visual inspection.

NOTE The I^2t value (Joule integral) calculated from this test cannot be used to estimate the performance of the contactor under short-circuit conditions.

9.3.6 Routine tests and sampling tests

9.3.6.1 General

The tests shall be carried out under the same conditions as those specified for type tests in the relevant parts of 9.1.2 or under equivalent conditions. However, the limits of operation in 9.3.3.2 may be verified at the prevailing ambient air temperature and on the overload relay alone, but a correction may be necessary to allow for normal ambient conditions.

9.3.6.2 Operation and operating limits

For electromagnetic, pneumatic and electro-pneumatic contactors or starters, tests are carried out to verify operation within the limits specified in 8.2.1.2.

For manual starters, tests are carried out to verify the proper operation of the starter (see 8.2.1.2, 8.2.1.3 and 8.2.1.4).

NOTE In these tests it is not necessary to reach thermal equilibrium. The lack of thermal equilibrium may be compensated by using a series resistor or by appropriately decreasing the voltage limit.

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 with all poles equally energized at a multiple of the current setting, to check that the tripping time conforms (within tolerances) to the curves 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, calibration 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.

9.3.6.3 Dielectric tests

The tests shall be carried out on dry and clean contactors and starters. The value of the test voltage shall be in accordance with 9.3.3.4.3.

The duration of each test may be reduced to 1 s.

The test voltage shall be applied as follows:

a) between poles, with the main contacts closed (with the main contacts open if there is a shunt circuit between poles);
b) between poles and the frame of contactors or starters, with the main contacts closed. Where the contactor or starter is totally enclosed by insulating material, the device shall be mounted on a metal base as in normal service, and the test voltage shall be applied between the poles and the metal base;
c) across the terminals of each pole, with the main contacts open;
d) to the control and auxiliary circuits, as mentioned in 9.3.3.4.2, item b);
e) in the case of a rheostatic rotor starter, 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 9.3.3.4.1 is unnecessary.

The test is considered to have been passed if the conditions given in 9.3.3.4.4 have been satisfied.

9.4 EMC Tests

9.4.1 General

Subclauses 8.3.2.1, 8.3.2.3 and 8.3.2.4 of part 1 apply with the following additions.

With the agreement of the manufacturer, more than one EMC test or all EMC tests may be conducted on one and the same sample, which may initially be new or may have passed test sequences according to 9.3.1. The sequence of the EMC tests may be any convenient sequence.

The test report shall include any special measures that have been taken to achieve compliance, for example the use of shielded or special cables. If auxiliary equipment is used with the contactor or starter in order to comply with immunity or emission requirements, it shall be included in the report.

The test sample shall be in the open or closed position, whichever is the worse, and shall be operated with the rated control supply.

9.4.2 Immunity

The tests of table 13 are required. Special requirements are specified in 9.4.2.1 to 9.4.2.6.

If, during the EMC-tests, conductors are to be connected to the test sample, the cross-section and the type of the conductors are optional but shall be in accordance with the manufacturer's literature.

Table 13 – EMC immunity tests

Type of test	Severity level required
1,2/50 µs – 8/20 µs surges IEC 61000-4-5	2 kV line to earth 1 kV line to line
Fast transient bursts IEC 61000-4-4	2 kV
Electromagnetic field IEC 61000-4-3	10 V/m
Electrostatic discharges IEC 61000-4-2	4 kV/contact discharge 8 kV/air discharge

9.4.2.1 Performance of the test sample during and after the test

Unless otherwise specified, performance criterion 2 applies, see 8.3.2.2.

No loss of performance shall be permitted during or after the tests. After the test, the operating limits of 9.3.3.2 shall be verified.

9.4.2.2 Electrostatic discharge

The test shall be conducted using the methods of IEC 61000-4-2.

Except for metallic parts for which contact discharge is made, only air discharge is required. Tests are not possible if the device is an open frame or of degree of protection IP00. In this case, the manufacturer shall attach a label to the unit advising of the possibility of damage due to static discharges.

Ten positive and ten negative pulses shall be applied to each selected point, the time interval after each successive single discharge being 1 s.

Tests are not required on power terminals. The application of conductors is not required, except for energizing the coil.

9.4.2.3 Electromagnetic field

The tests shall be conducted using the methods of IEC 61000-4-3. The test procedure of IEC 61000-4-3 shall apply.

The device shall comply with performance criterion 1.

Tests are not required if the equipment is to be fully enclosed in an EMC specific purpose metallic enclosure installed as specified by the manufacturer.

9.4.2.4 Fast transient bursts

The tests shall be conducted using the methods of IEC 61000-4-4.

The bursts shall be applied to all main, control or auxiliary terminals, whether they comprise electronic or conventional contacts.

The test voltage shall be applied for the duration of 1 min.

9.4.2.5 Surges (1,2/50 µs – 8/20 µs)

The test shall be conducted using the methods of IEC 61000-4-5. Capacitive coupling shall be preferred. The surges shall be applied to all main, control or auxiliary terminals, whether they comprise electronic or conventional contacts.

The repetition rate shall be one surge per minute, with the number of pulses being five positive and five negative.

9.4.2.6 Harmonics

Under consideration.

9.4.3 Emission

For equipment designed for environment 2, a suitable warning shall be given to the user (for example in the instruction manual) stipulating that the use of this equipment in environment 1 may cause radio interference in which case the user may be required to employ additional mitigation methods.

9.4.3.1 Conducted radio-frequency emission tests

A description of the test, the test method and the test set-up are given in CISPR 11.

To pass, the equipment shall not exceed the levels given in table 14.

Table 14 – Conducted radio-frequency emission test limits

Frequency band MHz	Environment 2	Environment 1
0,15 – 0,5	79 dB(μV) quasi-peak 66 dB(μV) average	66 dB(μV) – 56 dB(μV) quasi-peak 56 dB(μV) – 46 dB(μV) average (decrease with log of frequency)
0,5 – 5,0	73 dB(μV) quasi-peak 60 dB(μV) average	56 dB(μV) quasi-peak 46 dB(μV) average
5 – 30	73 dB(μV) quasi-peak 60 dB(μV) average	60 dB(μV) quasi-peak 50 dB(μV) average

9.4.3.2 Radiated radio-frequency emission tests

A description of the test, the test method and the test set-up are given in CISPR 11.

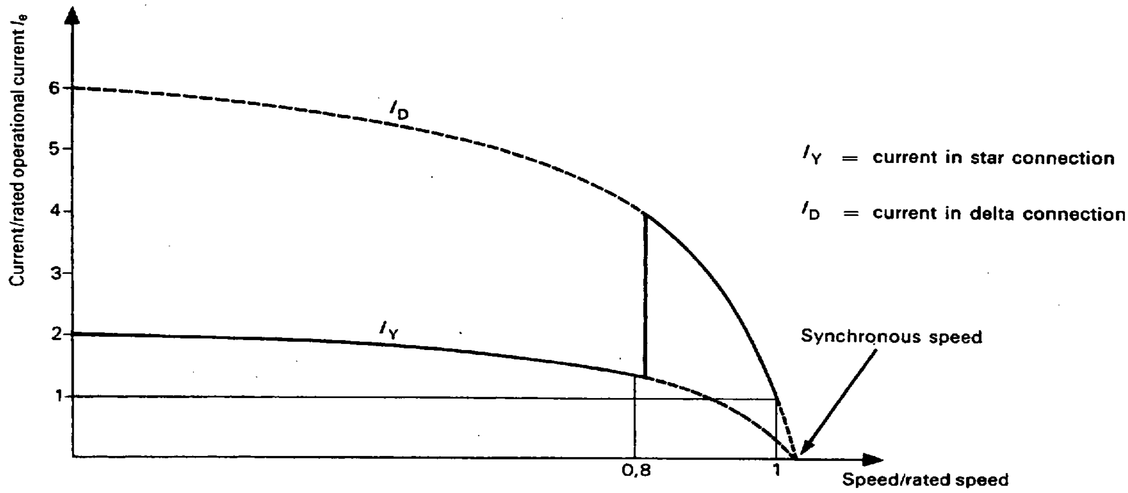
Tests are required where the control and auxiliary circuits contain components with fundamental switching frequencies greater than 9 kHz, for example switch-mode power supplies, etc.

To pass, the equipment shall not emit at higher levels than those given in table 15.

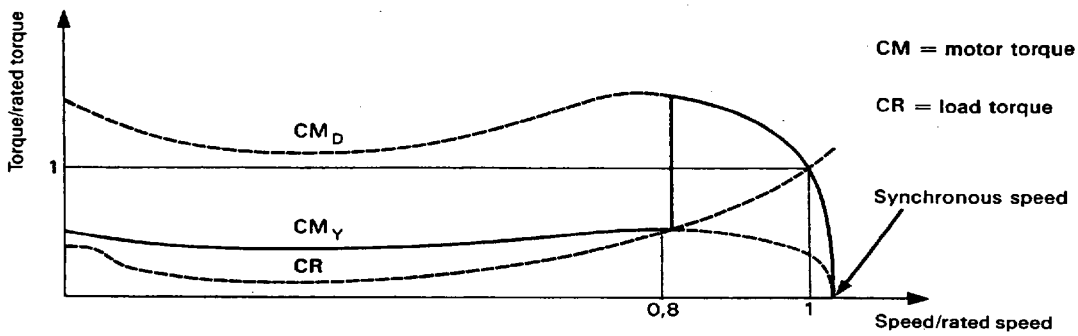
Tests are not required if the equipment is to be fully enclosed in an EMC specific purpose metallic enclosure installed as specified by the manufacturer.

Table 15 – Radiated emission test limits

Frequency band MHz	Environment 2*	Environment 1
30 – 230	30 dB(μV/m) quasi-peak at 30 m	30 dB(μV/m) quasi-peak at 10 m
230 – 1 000	37 dB(μV/m) quasi-peak at 30 m	37 dB(μV/m) quasi-peak at 10 m
* These tests may be carried at 10 m distance with the limits raised by 10 dB.		

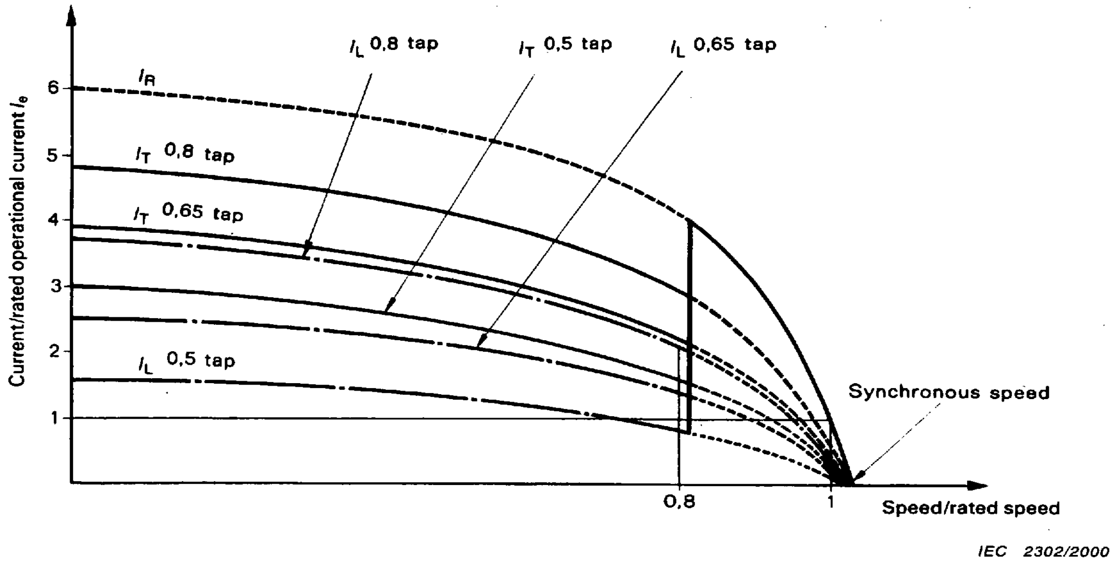


IEC 2300/2000



IEC 2301/2000

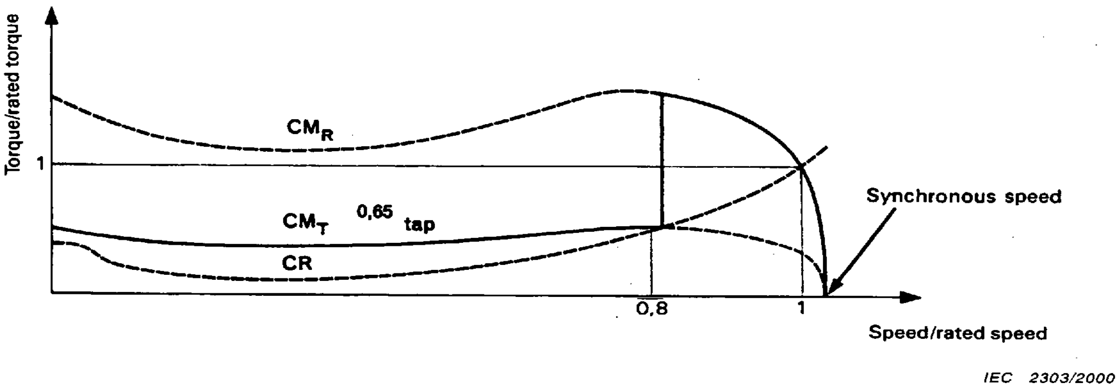
Figure 1 – Typical curves of currents and torques during a star-delta start (see 1.2.2.1)



I_R = motor current at rated voltage

I_T = motor current at reduced voltage

I_L = line current at reduced voltage



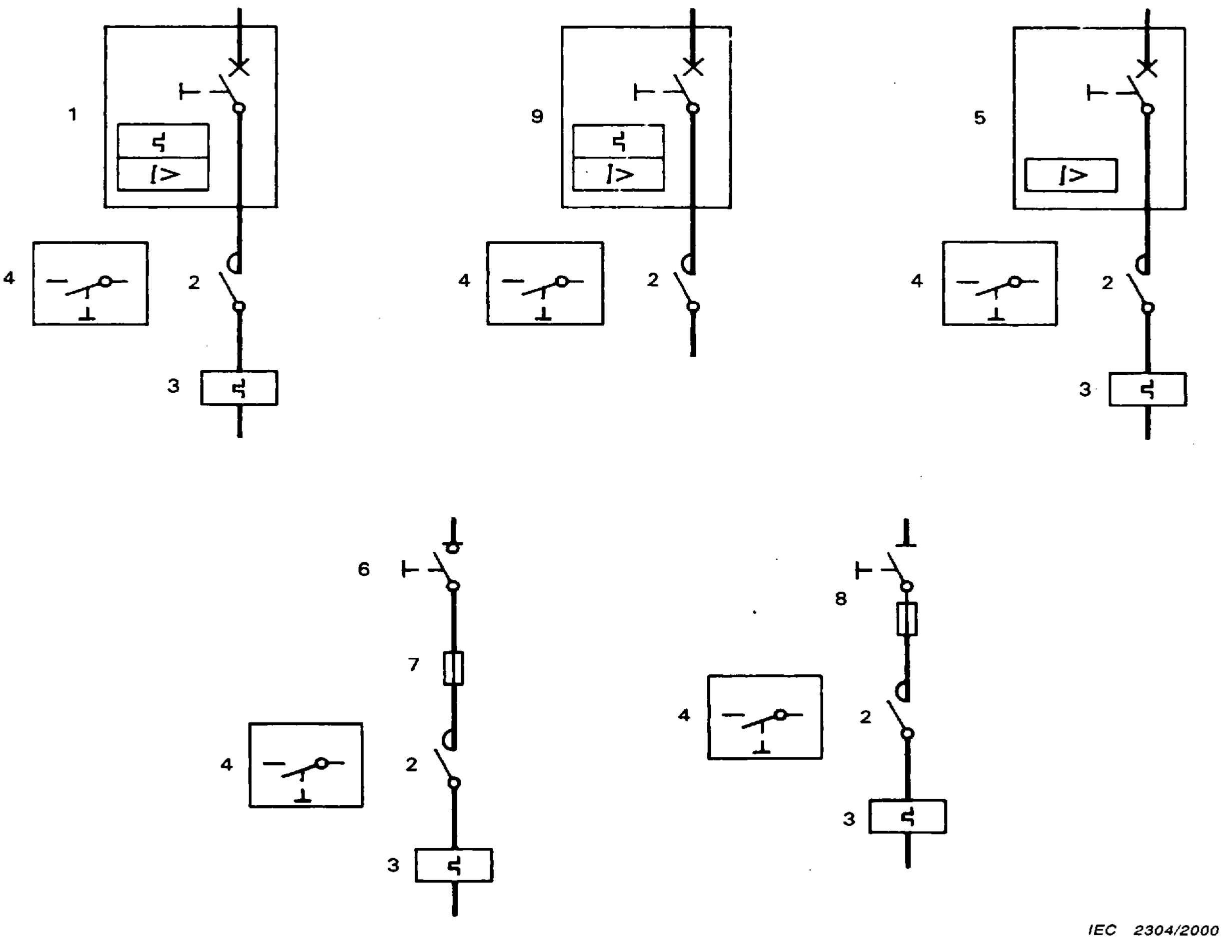
CR = load torque

CM = motor torque

CM_R = at rated voltage

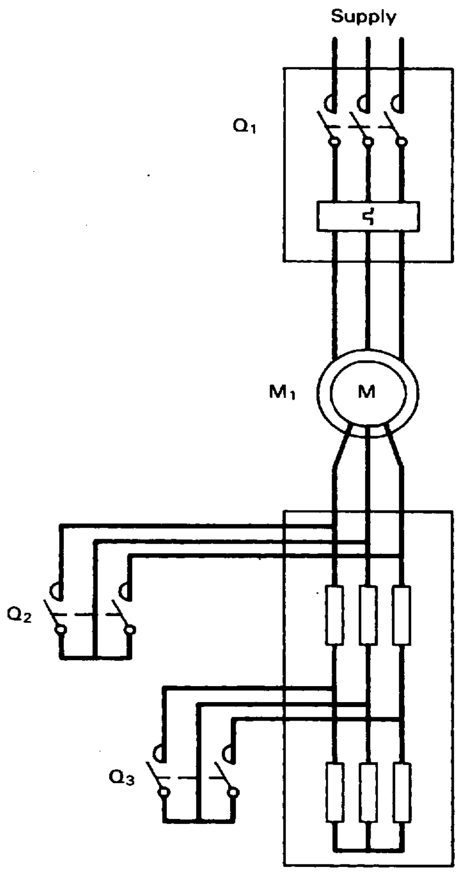
CM_T = at reduced voltage

Figure 2 – Typical curves of currents and torques during an auto-transformer start (see 1.2.2.2)



1 Circuit-breaker
2 Contactor
3 Overload relay
4 Control switch
5 Circuit-breaker magnetic trip only
6 Switch-disconnector
7 Fuse
8 Disconnector fuse
9 Circuit-breaker with overload release complying with this standard

Figure 3 – Typical variants of combination starters (see 3.2.7) **and protected starters** (see 3.2.8)



IEC 2305/2000

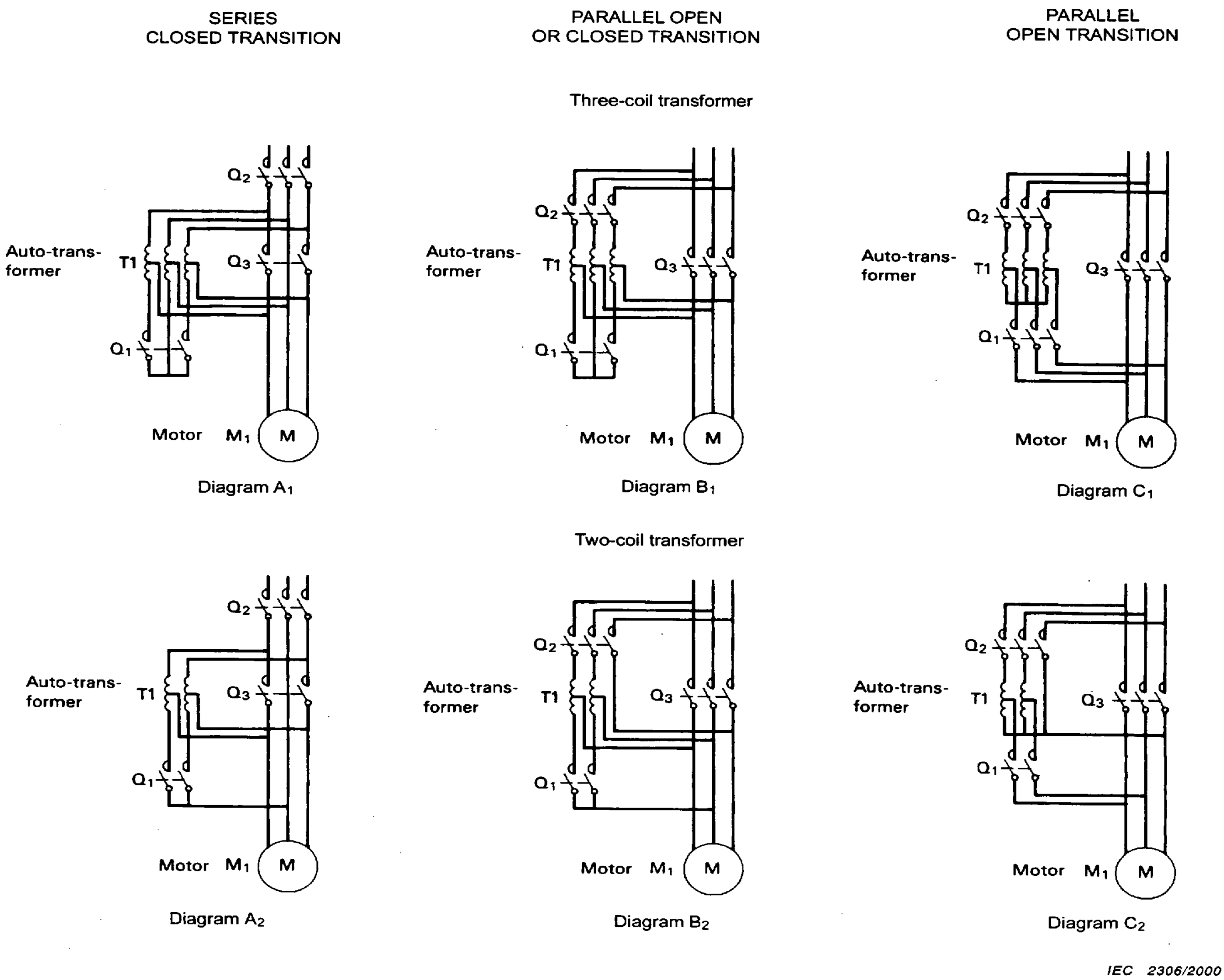
Position of the mechanical switching devices

Position of the starter / Mechanical switching device	Stop	Starting 1st step	2nd step	3rd step	ON
Q_1	O	C	C	C	
Q_2	O	O	O	C	
Q_3	O	O	C	C	

O: mechanical switching device open

C: mechanical switching device closed

Figure 4 – Example of three-phase diagram of a rheostatic rotor starter with three starting steps (see 3.2.16) and one direction of rotation (in the case when all the mechanical switching devices are contactors)



Contact sequence			
Contacts	Start	Transition	On
Q_1	C	O	O
Q_2	C	C	C
Q_3	O	O	C

C = contact closed

O = contact open

Contact sequence					
Contacts	Start	Transition Open	Transition Closed 1	Transition Closed 2	On
Q_1	C	O	O	O	O
Q_2	C	O	C	C	O
Q_3	O	O	O	C	C

For open transition, Q_1 and Q_2 may be contacts of the same mechanical switching device

Contact sequence			
Contacts	Start	Transition	On
Q_1	C	O	O
Q_2	C	O	O
Q_3	C	O	C

Q_1 and Q_2 may be contacts of the same mechanical switching device.

NOTE The graphical symbols utilized above correspond to the case where all the mechanical switching devices are contactors.

Figure 5 – Typical methods and diagrams of starting alternating-current induction motors by means of auto-transformers

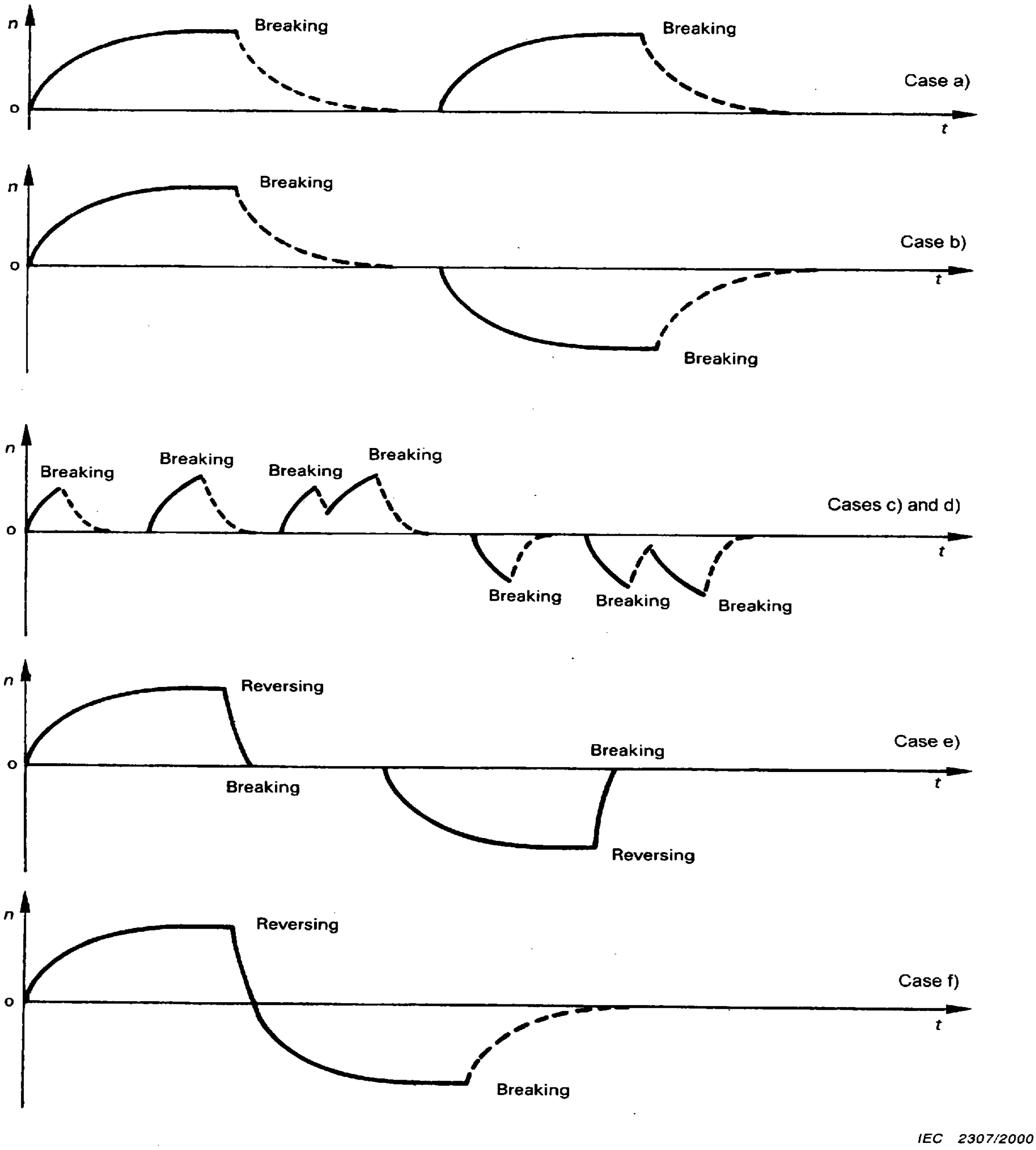


Figure 6 – Examples of speed/time curves corresponding to cases a), b), c), d), e) and f) of 5.3.5.5 (the dotted parts of the curves correspond to the periods when no current flows through the motor)

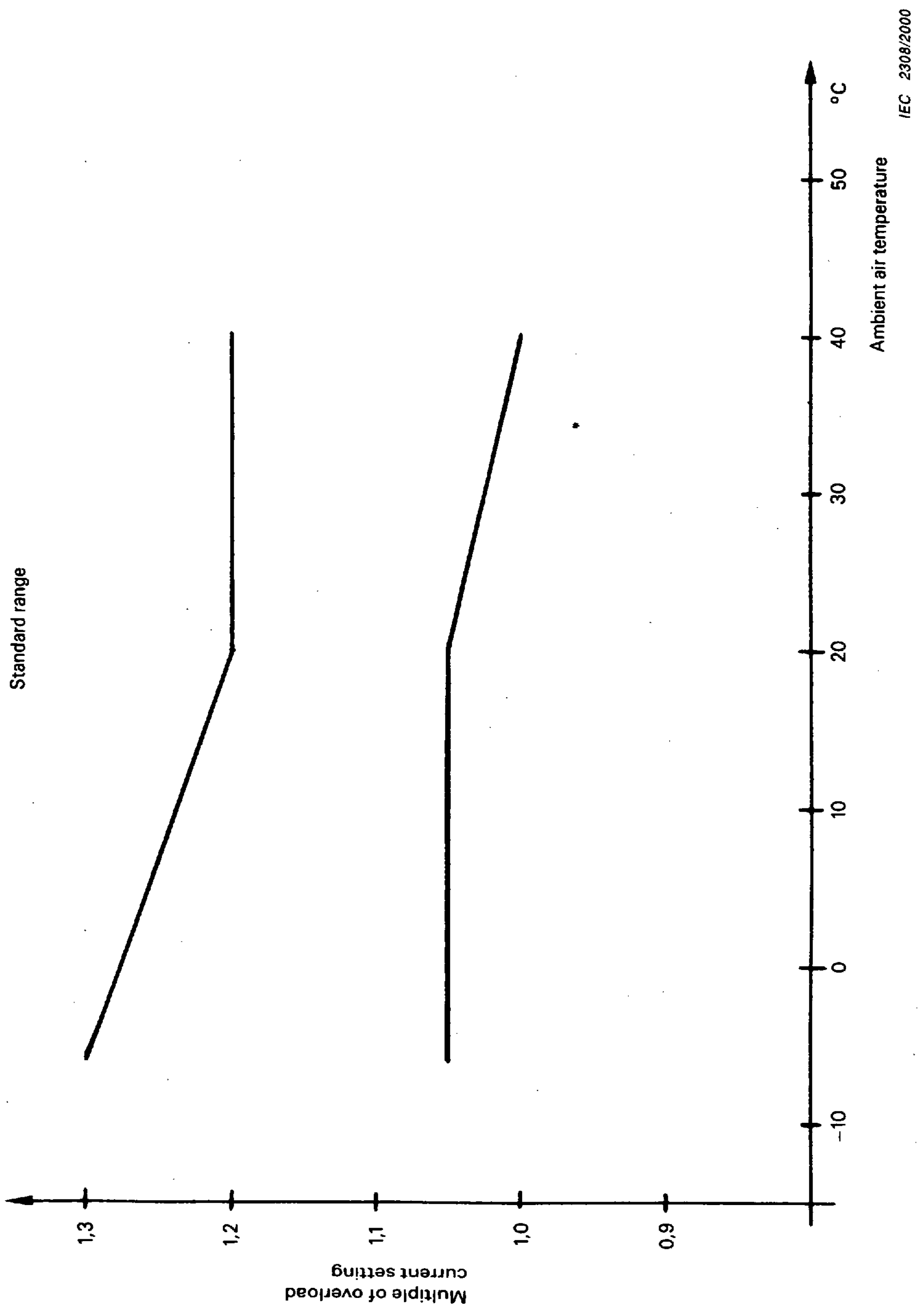


Figure 7 – Multiple of current setting limits for ambient air temperature compensated time-delay overload relays (see 8.2.1.5.1)

Annex A
(normative)

Marking and identification of terminals of contactors and associated overload relays

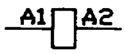
A.1 General

The purpose of identifying terminals of contactors and associated overload relays is to provide information regarding the function of each terminal or its location with respect to other terminals or for other use.

A.2 Marking and identification of terminals of contactors

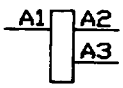
A.2.1 Marking and identification of terminals of coils

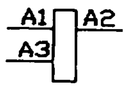
In the case of identification by alphanumeric markings, the terminals of a coil for an electromagnetic contactor shall be marked A1 and A2.



For a coil with tappings, the terminals of the tappings shall be marked in sequential order A3, A4, etc.

Examples:



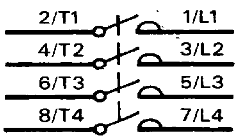


NOTE As a consequence of this, both incoming and outgoing terminals may have even or odd numbers.

For a coil having two windings, the terminals of the first winding will be marked A1, A2 and those of the second winding B1, B2.

A.2.2 Marking and identification of terminals of main circuits

The terminals of the main circuits shall be marked by single figure numbers and an alphanumeric system.



NOTE The present alternative methods of marking, i.e. 1-2 and L1-T1, will be progressively superseded by the new method above.

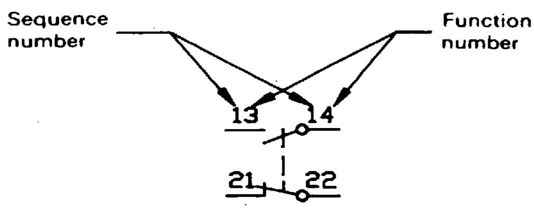
Alternatively, terminals may be identified on the wiring diagram supplied with the device.

A.2.3 Marking and identification of terminals of auxiliary circuits

The terminals of auxiliary circuits shall be marked or identified on the diagrams by two figure numbers:

– the unit number is a function number;
– the figure of the tens is a sequence number.

The following examples illustrate such a marking system:

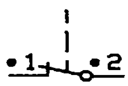


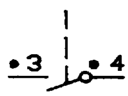
A.2.3.1 Function number

Function numbers 1, 2 are allocated to circuits with break contacts and function numbers 3, 4 to circuits with make contacts.

NOTE The definitions for make contacts and break contacts are given in 2.3.12 and 2.3.13 of part 1.

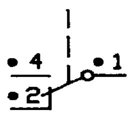
Examples:





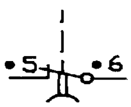
NOTE The dots in the above examples take the place of the sequence numbers which should be added appropriately to the application.

The terminals of circuits with change-over contact elements shall be marked by the function numbers 1, 2 and 4.

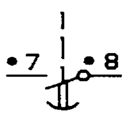


Function numbers 5 and 6 (for break contacts) and 7 and 8 (for make contacts) are allocated to terminals of auxiliary circuits containing auxiliary contacts with special functions.

Examples:



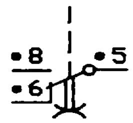
Break contact delayed on closing



Make contact delayed on closing

The terminals of circuits with change-over contact elements with special functions shall be marked by function numbers 5, 6 and 8.

Example:



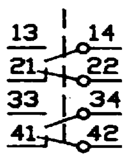
Change-over contact
delayed in both directions

A.2.3.2 Sequence number

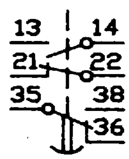
Terminals belonging to the same contact element shall be marked by the same sequence number.

All contact elements having the same function shall have different sequence numbers.

Examples:

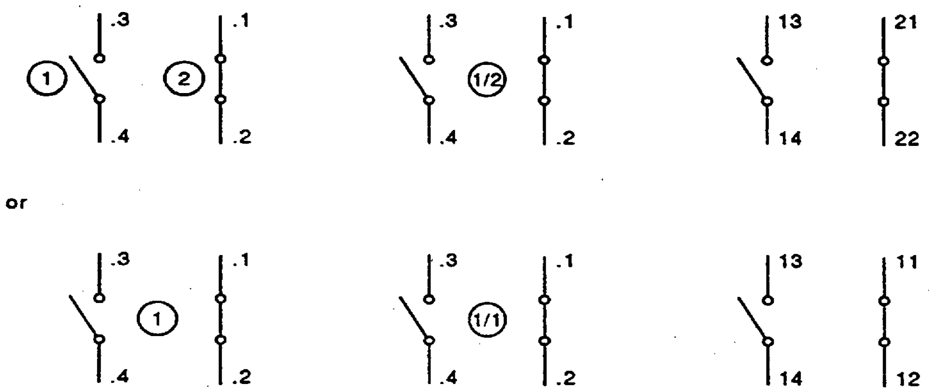


Four contact elements



Three contact elements

The sequence number may be omitted from the terminals only if additional information provided by the manufacturer or the user clearly gives such a number.



Device Device Diagram

NOTE The dots shown in the above examples are merely used to show the relationship and do not need to be used in practice.

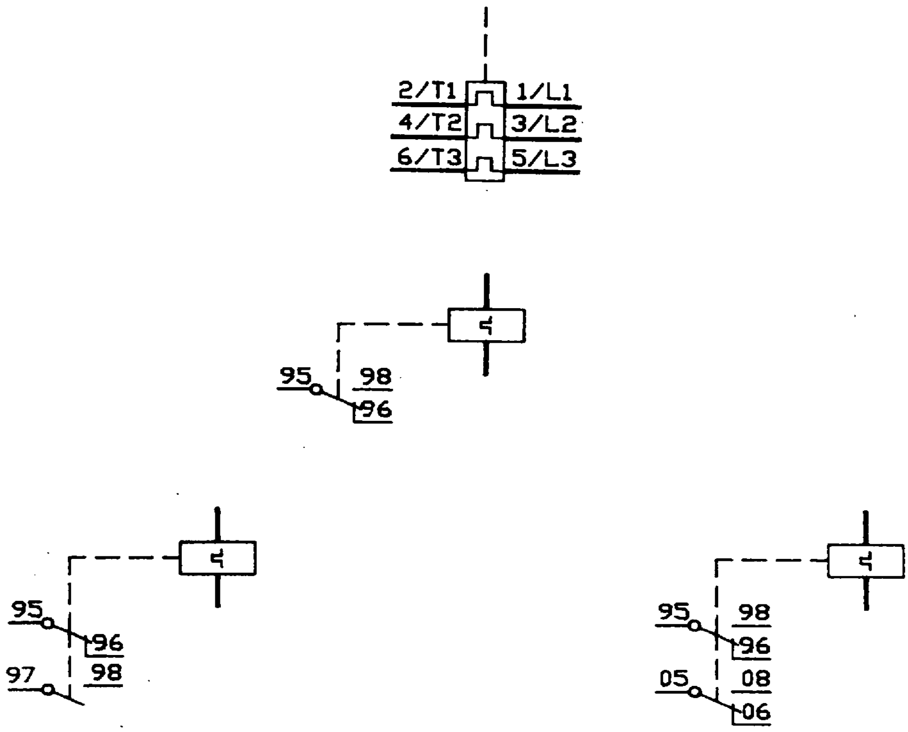
A.3 Marking and identification of terminals of overload relays

The terminals of the main circuits of overload relays shall be marked in the same manner as the terminals of the main circuits of contactors (see A.2.2).

The terminals of the auxiliary circuits of overload relays shall be marked in the same manner as the terminals of the auxiliary circuits of contactors with specified functions (see A.2.3).

The sequence number shall be 9; if a second sequence number is required, it shall be 0.

Examples:



Alternatively, terminals may be identified on the wiring diagram supplied with the device.

Annex B
(normative)

Special tests

B.1 General

Special tests are done at the discretion of the manufacturer.

B.2 Mechanical durability

B.2.1 General

By convention, the mechanical durability of a design of contactor or starter is defined as the number of no-load operating cycles which would be attained or exceeded by 90 % of all the apparatus of this design before it becomes necessary to service or replace any mechanical parts; however, normal maintenance including replacement of contacts as specified in B.2.2.1 and B.2.2.3 is permitted.

The preferred numbers of no-load operating cycles, expressed in millions, are:

0,001 – 0,003 – 0,01 – 0,03 – 0,1 – 0,3 – 1 – 3 and 10.

B.2.2 Verification of mechanical durability

B.2.2.1 Condition of the contactor or starter for tests

The contactor or starter shall be installed as for normal service; in particular, the conductors shall be connected in the same manner as for normal use.

During the test, there shall be no voltage or current in the main circuit. The contactor or starter may be lubricated before the test if lubrication is prescribed in normal service.

B.2.2.2 Operating conditions

The coils of the control electromagnets shall be supplied at their rated voltage and, if applicable, at their rated frequency.

If a resistance or an impedance is provided in series with the coils, whether short-circuited during the operation or not, the tests shall be carried out with these elements connected as in normal operation.

Pneumatic and electro-pneumatic contactors or starters shall be supplied with compressed air at the rated pressure.

Manual starters shall be operated as in normal service.

B.2.2.3 Test procedure

a) The tests are carried out at the frequency of operations corresponding to the class of intermittent duty. However, if the manufacturer considers that the contactor or starter can satisfy the required conditions when using a higher frequency of operations, he may do so.

b) In the case of electromagnetic and electro-pneumatic contactors or starters, the duration of energization of the control coil shall be greater than the time of operation of the contactor or starter and the time for which the coil is not energized shall be of such a duration that the contactor or starter can come to rest at both extreme positions.

   The number of operating cycles to be carried out shall be not less than the number of no-load operating cycles stated by the manufacturer.

   The verification of mechanical durability may be made separately on the various components of the starter which are not mechanically linked together, unless a mechanical interlock not previously tested with its contactor is involved.

c) For contactors or starters fitted with releases with shunt coils or undervoltage releases, at least 10 % of the total number of opening operations shall be performed by these releases.

d) After each tenth of the total number of operating cycles given in B.2.1 has been carried out, it is permissible before carrying on with the test:
   - to clean the whole contactor or 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 contactor or starter enables this to be done.

e) This maintenance work shall not include any replacement of parts.

f) In the case of star-delta starters, the built-in device causing time-delay between closing on star connection and closing on delta connection, if adjustable, may be set at its lowest value.

g) In the case of rheostatic starters, the built-in device causing time-delay between closing of the rotor switching devices, if adjustable, may be set at its lowest value.

h) In the case of auto-transformer starters, the built-in device causing time-delay between closing on the starting position and closing on the ON position, if adjustable, may be set at its lowest value.

B.2.2.4 Results to be obtained

Following the tests of mechanical durability, the contactor or starter shall still be capable of complying with the operating conditions specified in 8.2.1.2 and 9.3.3.2 at room temperature. There shall be no loosening of the parts used for connecting the conductors.

Any timing relays or other devices for the automatic control shall still be operating.

B.2.2.5 Statistical analysis of test results for contactors or starters

The mechanical durability of a design of a contactor or starter is assigned by the manufacturer and verified by a statistical analysis of the results of the tests.

For contactors or starters which are produced in small quantities, the tests described in B.2.2.6 and B.2.2.7 do not apply.

However, for contactors or starters which are produced in small quantities and which also differ from a basic design only by detailed variations (i.e. without any significant variation) without notable influence on characteristics, the manufacturer may assign mechanical durability on the basis of experience with similar designs, analysis, properties of materials, etc., and on the basis of the analysis of test results on large quantity production of the same basic design.

After this assignment, one of the two tests described below shall be performed. It should be selected by the manufacturer as being the most suitable in each case, for example according to the quantities of planned production or according to the conventional thermal current.

NOTE This test is not intended to be a lot-by-lot or production acceptance test for application by the user.

B.2.2.6 Single 8 test

Eight contactors or starters shall be tested to the assigned mechanical durability.

If the number of failures does not exceed two, the test is considered passed.

B.2.2.7 Double 3 test

Three contactors or starters shall be tested to the assigned mechanical durability.

The test is considered passed if there is no failure, and failed if there is more than one failure. Should there be one failure, then three additional contactors or starters are tested up to assigned mechanical durability and, providing there is no additional failure, the test is considered passed. The test is failed if at any time there is a total of two or more failures.

Explanatory note:

The single 8 test and the double 3 test are both given in IEC 60410 (see tables X-C-2 and X-D-2).

These two tests have been chosen with the objective of basing them on testing a limited number of contactors or starters on essentially the same statistical characteristics (acceptance quality level: 10 %).

B.3 Electrical durability

B.3.1 General

With respect to its resistance to electrical wear, a contactor or starter is by convention characterized by the number of on-load operating cycles corresponding to the different utilization categories given in table B.1 which can be made without repair or replacement.

Since, for star-delta, two-step auto-transformer and rheostatic rotor starters, the operation is subjected to large variations in the service conditions, it is deemed convenient not to give standard values for the test conditions. However, it is recommended that the manufacturer indicate the electrical durability of the starter for stated service conditions; this electrical durability may be estimated from the results of tests on the component parts of the starter.

For categories AC-3 and AC-4, the test circuit shall comprise inductors and resistors so arranged as to give the appropriate values of current, voltage and power factor given in table B.1; moreover, for AC-4, the test circuit testing the making and breaking capacity shall be used, see 9.3.3.5.2.

In all cases, the speed of operation shall be chosen by the manufacturer.

The tests shall be taken as valid if the values recorded in the test report differ from the values specified only within the following tolerances:

– current: ±5 %;
– voltage: ±5 %.

Tests shall be carried out with the contactor or the starter under the appropriate conditions of B.2.2.1 and B.2.2.2 using the test procedure, where applicable, of B.2.2.3, except that replacement of contacts is not permitted.

After the test, the contactor or the starter shall fulfil the operating conditions specified in 9.3.3.2 and withstand a dielectric test voltage of twice the rated operational voltage U_e, but not less than 900 V, applied only as in 9.3.3.4.2, item a)1).

In the case of starters, if the associated contactor has already satisfied an equivalent test, the test need not be repeated on the starter.

Table B.1 – Verification of the number of on-load operating cycles – Conditions for making and breaking corresponding to the several utilization categories

Utilization category	Value of the rated operational current	Make			Break		
		I/I_e	U/U_e	Cos ϕ [1]	I_c/I_e	U_r/U_e	Cos ϕ [1]
AC-1	All values	1	1	0,95	1	1	0,95
AC-2	All values	2,5	1	0,65	2,5	1	0,65
AC-3	$I_e \leq$ 17A	6	1	0,65	1	0,17	0,65
	$I_e >$ 17A	6	1	0,35	1	0,17	0,35
AC-4	$I_e \leq$ 17A	6	1	0,65	6	1	0,65
	$I_e >$ 17A	6	1	0,35	6	1	0,35
		I/I_e	U/U_e	L/R [2] ms	I_c/I_e	U_r/U_e	L/R [2] ms
DC-1	All values	1	1	1	1	1	1
DC-3	All values	2,5	1	2	2,5	1	2
DC-5	All values	2,5	1	7,5	2,5	1	7,5

I_e = rated operational current
U_e = rated operational voltage
I = current made
In a.c. the conditions for making are expressed in r.m.s. values but it is understood that the peak value of symmetrical current corresponding to the power factor of the circuit may assume a higher value.
U = applied voltage
U_r = power-frequency or d.c. recovery voltage
I_c = current broken

[1] Tolerance for cos ϕ: ±0,05
[2] Tolerance for L/R: ±15 %

B.4 Co-ordination at the crossover current between the starter and associated SCPD

B.4.1 General and definitions

B.4.1.1 General

This annex states different methods of verifying the performance of starters and the associated SCPD(s) at currents below and above the intersection I_{co} of their respective time-current characteristics, provided by the starter and SCPD manufacturer(s), and the corresponding types of co-ordination described in 8.2.5.1.

Co-ordination at the crossover current between the starter and the SCPD can be verified either by the direct method with the special test of B.4.4 or, for type "2" co-ordination, by the indirect method as in B.4.5.

B.4.1.2 Definitions

B.4.1.2.1
crossover current I_{co}
current corresponding to the crossover point of the mean or published curves representing the time-current characteristics of the overload relay and the SCPD respectively

NOTE The mean curves are the curves corresponding to the average values calculated from the tolerances on the time-current characteristics given by the manufacturer.

B.4.1.2.2
test current I_{cd}
test current greater than I_{co}, tolerances included, designated by the manufacturer and verified by the requirements given in table B.2

B.4.1.2.3
time-current withstand characteristic capability of contactors/starters
locus of the currents a contactor/starter can withstand as a function of time

B.4.2 Condition for the test for the verification of co-ordination at the crossover current by a direct method

The starter and its associated SCPD shall be mounted and connected as in normal use. All the tests shall be performed starting from the cold state.

B.4.3 Test currents and test circuits

The test circuit shall be according to 8.3.3.5.2 of part 1 except that the oscillatory transient voltage need not be adjusted. The currents for the tests shall be:

(i) $0{,}75\ I_c\ {}^{0}_{-5}$ % and

(ii) $1{,}25\ I_c\ {}^{+5}_{0}$ %

The power factor of the test circuit shall be in accordance with table 7. In the case of small relays having a high resistance, inductors should be mainly used in order to have a value of power factor as low as possible. The recovery voltage shall be 1,05 times the rated operational voltage.

The SCPD shall be as stated in 8.2.5.1 and of the same rating and characteristics as used in the tests of 9.3.4.2.

If the switching device is a contactor, its coil shall be energized from a separate source at the rated control supply voltage of the contactor coil and connected so that the contactor opens when the overload relay operates.

B.4.4 Test procedure and results to be obtained

B.4.4.1 Test procedure

With the starter and the SCPD closed, the test currents stated in B.4.3 shall be applied by a separate closing device. In each case the device tested shall be at room temperature.

After each test, it is necessary to inspect the SCPD, reset the overload relay and the release of the circuit-breaker, if necessary, or to replace all fuses if at least one of them has melted.

B.4.4.2 Results to be obtained

After the test at the lower current (i) in B.4.3, the SCPD shall not have operated and the overload relay or release shall have operated to open the starter. There shall be no damage to the starter.

After the test at the higher current (ii) in B.4.3, the SCPD shall have operated before the starter. The starter shall meet the conditions of 9.3.4.2.3 for the type of co-ordination stated by the manufacturer.

B.4.5 Verification of co-ordination at the crossover current by an indirect method

NOTE For type "1" co-ordination, the indirect method may be different from the method described in annex B and is under consideration. For this reason, the indirect method for the verification of co-ordination at the crossover point is only applicable for type "2" co-ordination.

The indirect method consists in verifying on a diagram (see figure B.1) that the following conditions for the verification of co-ordination at the crossover current are met:

- the time-current characteristic of the overload relay/release, starting from cold state, supplied by the manufacturer, shall indicate how the tripping time varies with the current up to a value of at least I_{co}; this curve has to lie below the time-current characteristic of the SCPD up to I_{co};
- I_{cd} of the starter, tested as in B.4.5.1, shall be higher than I_{co};
- the time-current withstand characteristic of the contactor, tested as in B.4.5.2, shall be above the time-current characteristic (starting from cold state) of the overload relay up to I_{co}.

B.4.5.1 Test for I_{cd}

Subclause 9.3.4.1 applies with the following addition.

- Test procedure: the contactor or starter shall make and break the test current (I_{cd}) for the number of operating cycles given in table B.2 below. This is made without the SCPD in the circuit.

Table B.2 – Test conditions

	U_r/U_e	Cos ϕ	On-time (see note 2) s	Off-time s	Number of operations
I_{cd}	1,05	See note 1	0,05	See note 3	3

NOTE 1 Power factor to be selected according to table 16 of IEC 60947-1.

NOTE 2 Time may be less than 0,05 s provided that contacts are allowed to become properly seated before re-opening.

NOTE 3 See table 7a.

– Behaviour of contactors or starters during and after the I_{cd} test:

a) during the test, there shall be no permanent arcing, no flash-over between poles, no blowing of the fusible element in the earth circuit (see 9.3.4.1.2) and no welding of contacts;

b) after the test,

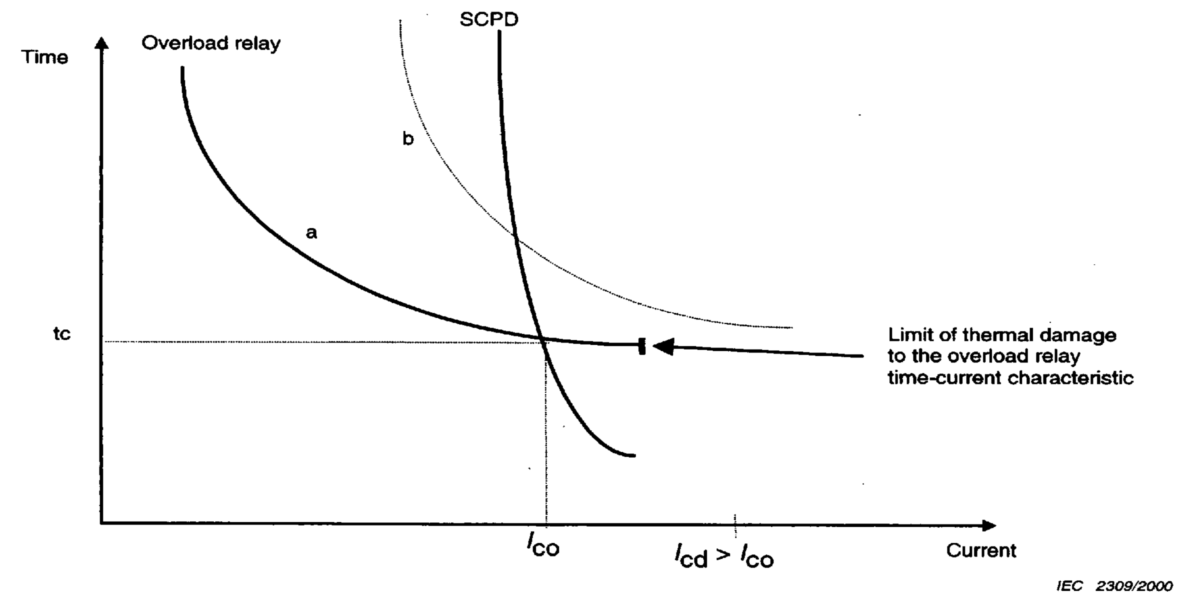
1) the contacts shall operate correctly when the contactor or starter is switched by the applicable method of control;

2) the dielectric properties of the contactors and starters shall be verified by a dielectric test on the contactor or starter using an essentially sinusoidal test voltage of twice the rated operational voltage U_e used for the I_{cd} test, with a minimum of 1 000 V. The test voltage shall be applied for 5 s, as specified in 9.3.3.4.2, item a)1).

B.4.5.2 Time-current characteristic withstand capability of contactors/starters

This characteristic is issued by the manufacturer and the values are obtained according to the test procedure specified in 9.3.5 but with combinations of overload currents and durations to establish the characteristic at least up to I_{co}, in addition to those stated in 8.2.4.4.

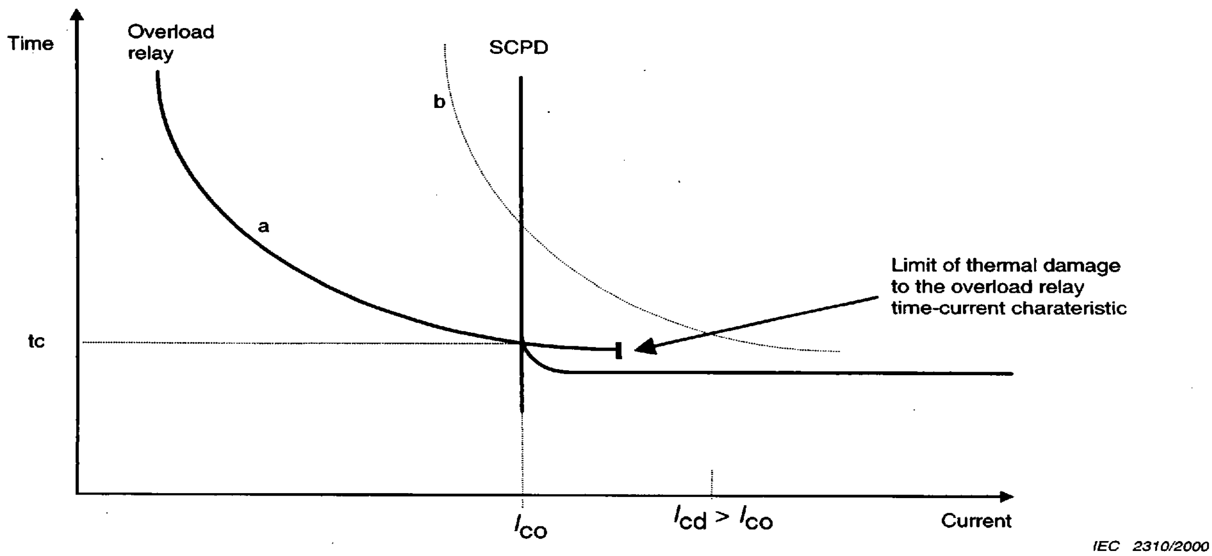
This characteristic is valid for overload currents, starting with the contactor at room temperature. The minimum cooling duration required by the contactor between two such overload tests should be stated by the manufacturer.



a: mean overload relay time-current characteristic from cold state

b: time-current characteristic withstand capability of contactor

Figure B.1a – Co-ordination with fuse



a: mean overload relay time-current characteristic from cold state

b: time-current characteristic withstand capability of contactor

Figure B.1b – Co-ordination with circuit-breaker

Figure B.1 – Examples of time-current withstand characteristic

Annex C
(informative)

Clearances and creepage distances for low-voltage contactors and starters

Introduction

It is not possible to lay down a simple set of rules relating to clearances and creepage distances which can be applied to equipment, because much depends on variable factors such as atmospheric conditions, the type of insulation employed, the disposition of the creepage paths and the conditions of the system on which the equipment is to be used.

This annex, therefore, is intended to serve as a guide to the values of minimum clearances and creepage distances to be used. The values given are based on those used in various national specifications and which are known to give satisfactory service under normal industrial conditions and under system conditions generally found in the majority of the countries in which these specifications are in use.

Further investigation is necessary to obtain a better understanding of the effects of the various factors and thus to determine a more comprehensive set of rules.

C.1 Scope

The recommendations of this annex apply to the low-voltage contactors and starters specified in this standard. They apply to equipment in air and to normal atmospheric conditions as defined in 7.1.3.2. When the atmospheric conditions differ from normal, this should be recognized either by the choice of enclosures or by larger creepage distances. Observation of these recommendations does not imply that the equipment will meet the test requirements of this standard.

The recommendations apply neither to devices for which a value of U_{imp} has been declared, nor to devices suitable for isolation, which shall comply with the requirements of 8.1.3 and 9.3.3.4.

C.2 Definitions

Vacant.

C.3 General

C.3.1 It is recommended that the surface of the insulating parts should be designed with ridges so arranged as to break the continuity of any conducting deposits which may form.

C.3.2 The recommended clearances and creepage distances apply to non-arcing parts. In the vicinity of arcs or in areas where ionized gases may be present, the normal atmospheric conditions defined in 7.1.3.2 do not exist and larger values may be necessary.

C.3.3 The recommended clearances do not apply to the gap between the separable contacts of the same pole when in the open position.

C.3.4 Conductive parts covered only with varnish or enamel, or protected only by oxidation or a similar process, should not be considered as being insulated.

C.3.5 The recommended clearances and creepage distances shall be maintained under the following circumstances:

a) on the one hand, without external electrical connections, on the other hand, when insulated or bare conductors of the type and of any dimensions specified for the equipment are installed according to the manufacturer's instructions, if any;
b) after interchangeable parts have been changed, taking into account maximum permissible manufacturing tolerances;
c) after taking into consideration possible deformations due to the effect of temperature, ageing, shocks, vibrations, or due to short-circuit conditions which the equipment is intended to endure.

C.4 Determination of clearances and creepage distances

In determining clearances and creepage distances, it is recommended that the following points should be considered.

C.4.1 If a clearance or a creepage distance is influenced by one or more metal parts, either one of the sections between these parts should have at least the prescribed minimum value, or the sum of the two largest sections should have at least 1,25 times the prescribed minimum value. Individual sections less than 2 mm in length should not be taken into consideration in the calculation of the total length of clearances and creepage distances.

C.4.2 In determining a creepage distance, grooves at least 2 mm wide and 2 mm deep should be measured along their contour. Grooves having any dimension less than these dimensions and any groove liable to be clogged with dirt should be neglected and only direct distance should be measured.

C.4.3 In determining a creepage distance, ridges less than 2 mm high should be disregarded. Those at least 2 mm high:

– are measured along their contour, if they are an integral part of a component in insulating material (for instance by moulding or welding);
– are measured along the shorter of two paths: length of joint or profile of ridge, if they are not an integral part of a component in insulating material.

C.4.4 The application of the foregoing recommendations is illustrated by examples 1 to 11 of annex G of part 1.

C.5 Minimum values of clearances and creepage distances

C.5.1 The values of clearances and creepage distances are given in table C.1 as a function of the rated insulation voltage and of the rated operational current I_e.

C.5.2 The values of clearances are given between two live parts (*L-L*), and between a live part and an exposed conductive part (*L-A*). The distance between a live part and an earthed part (which is not considered accidentally dangerous) may be that specified for *L-L* for the corresponding voltage.

C.5.3 The values of creepage distances also depend on the insulating material and the shape of the insulating piece.

Column a:

1) Ceramics (steatite, porcelain).
2) Other kinds of insulating materials designed with ridges or with approximately vertical surfaces, which experience has shown to be capable of giving satisfactory service with the creepage distances used for ceramics.

NOTE Such materials may be materials having a comparative tracking index of at least 140 V (see IEC 60112), e.g. phenolic mouldings.

Column b:

All other cases.

The values in the table are given only as a guide to what may be regarded as minimum values.

Table C.1 – Minimum values of clearances and creepage distances

Rated insulation voltage U_i V	Clearances mm				Creepage distances mm			
	$I_e \leq 63$ A		$I_e > 63$ A		$I_e \leq 63$ A		$I_e > 63$ A	
	L-L	*L-A*	*L-L*	*L-A*	a	b	a	b
$U_i \leq 60$	2	3	3	5	2	3	3	4
$60 < U_i \leq 250$	3	5	5	6	3	4	5	8
$250 < U_i \leq 400$	4	6	6	8	4	6	6	10
$400 < U_i \leq 500$	6	8	8	10	6	10	8	12
$500 < U_i \leq 690$	6	8	8	10	8	12	10	14
$690 < U_i \leq 750$ a.c. 800 d.c.	10	14	10	14	10	14	14	20
$750 < U_i \leq 1\,000$ a.c. $800 < U_i \leq 1\,500$ a.c.	14	20	14	20	14	20	20	28

NOTE 1 The values in table C.1 apply to the atmospheric conditions specified in 7.1.3.2. For more severe conditions and for marine service, creepage distances should be at least those in column b.

NOTE 2 When the clearance *L-A* is greater than the corresponding creepage distance specified in column a or column b, then the creepage distance from the live part to the exposed conductive part shall be not less than the clearance.

NOTE 3 The clearances and creepage distances for control and auxiliary circuits should be those given for $I_e \leq 63$ A.

Clearances and creepage distances between live parts of the main circuit and live parts of control or auxiliary circuits should be those given in column *L-L* corresponding to the rated operational current I_e of the contactor or starter.

Annex D
(informative)

Items subject to agreement between manufacturer and user

NOTE For the purpose of this annex:

– *agreement* is used in a very wide sense;

– *user* includes testing stations.

Annex J of part 1 applies, as far as covered by clauses and subclauses of this standard, with the following additions.

Clause or subclause number of this standard	Item
1.2.3	Additional requirements concerning two-direction starters and inching and plugging
5.3.4.3 – Note	Overload protection of starters for intermittent duty
5.3.5.5.3	Time interval between two successive starts of auto-transformer starters having a starting time exceeding 15 s
5.4	Types of utilization other than the utilization categories defined in table 1
5.7.2	Specific applications of instantaneous over-current relays or releases and of relays or releases of a type other than those defined in 5.7.2
5.7.3	Protection of the rotor circuit for a rheostatic rotor starter
5.7.3	Protection of the auto-transformer for an auto-transformer starter
5.7.5	Tolerances on time-current characteristics of overload relays (to be indicated by the manufacturer)
5.10.2	Characteristics of devices for automatic acceleration control
5.11; 5.12	Nature and dimensions of the connecting links: a) between an auto-transformer starter and the auto-transformer, if this is provided separately b) between a rheostatic rotor starter and the resistors, if these are provided separately Agreement for items a) and b) is to be concluded between the starter manufacturer and the manufacturer of the transformer, or of the resistors, as the case may be
8.2.2.6.3	Ratings of specially rated windings (to be stated by the manufacturer)
Table 7	Verification of the make conditions when this verification is carried out during the make and break test (manufacturer's agreement)
Table 12	Value of the prospective current "*r*" for the conditional short-circuit current test of devices of I_e > 1 600 A

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Q6 If you ticked NOT AT ALL in Question 5 the reason is: *(tick all that apply)*

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(1) unacceptable,
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(5) exceptional,
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- timeliness ....
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- other ....

Q8 I read/use the: *(tick one)*

- French text only ❑
- English text only ❑
- both English and French texts ❑

Q9 Please share any comment on any aspect of the IEC that you would like us to know:

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Q1 Veuillez ne mentionner qu'**UNE SEULE NORME** et indiquer son numéro exact: (*ex. 60601-1-1*)

....

Q2 En tant qu'acheteur de cette norme, quelle est votre fonction?
(cochez tout ce qui convient)
Je suis le/un:

- agent d'un service d'achat ❑
- bibliothécaire ❑
- chercheur ❑
- ingénieur concepteur ❑
- ingénieur sécurité ❑
- ingénieur d'essais ❑
- spécialiste en marketing ❑
- autre(s)...

Q3 Je travaille:
(cochez tout ce qui convient)

- dans l'industrie ❑
- comme consultant ❑
- pour un gouvernement ❑
- pour un organisme d'essais/ certification ❑
- dans un service public ❑
- dans l'enseignement ❑
- comme militaire ❑
- autre(s)...

Q4 Cette norme sera utilisée pour/comme
(cochez tout ce qui convient)

- ouvrage de référence ❑
- une recherche de produit ❑
- une étude/développement de produit ❑
- des spécifications ❑
- des soumissions ❑
- une évaluation de la qualité ❑
- une certification ❑
- une documentation technique ❑
- une thèse ❑
- la fabrication ❑
- autre(s)...

Q5 Cette norme répond-elle à vos besoins:
(une seule réponse)

- pas du tout ❑
- à peu près ❑
- assez bien ❑
- parfaitement ❑

Q6 Si vous avez répondu PAS DU TOUT à Q5, c'est pour la/les raison(s) suivantes:
(cochez tout ce qui convient)

- la norme a besoin d'être révisée ❑
- la norme est incomplète ❑
- la norme est trop théorique ❑
- la norme est trop superficielle ❑
- le titre est équivoque ❑
- je n'ai pas fait le bon choix ❑
- autre(s) ....

Q7 Veuillez évaluer chacun des critères ci-dessous en utilisant les chiffres
(1) inacceptable,
(2) au-dessous de la moyenne,
(3) moyen,
(4) au-dessus de la moyenne,
(5) exceptionnel,
(6) sans objet

- publication en temps opportun ....
- qualité de la rédaction..........................
- contenu technique ....
- disposition logique du contenu ....
- tableaux, diagrammes, graphiques, figures ....
- autre(s) ....

Q8 Je lis/utilise: *(une seule réponse)*

- uniquement le texte français ❑
- uniquement le texte anglais ❑
- les textes anglais et français ❑

Q9 Veuillez nous faire part de vos observations éventuelles sur la CEI:

....
....
....
....
....
....