

BS EN 60947-4-1:2010+A1:2012



BSI Standards Publication

Low-voltage switchgear and controlgear

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

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National foreword

This British Standard is the UK implementation of EN 60947-4-1:2010+A1:2012. It is identical to IEC 60947-4-1:2009, incorporating amendment 1:2012. It supersedes BS EN 60947-4-1:2010, which will be withdrawn on 24 August 2015.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by A1 A1.

The UK participation in its preparation was entrusted by Technical Committee PEL/17, Switchgear, controlgear, and HV-LV co-ordination, to Subcommittee PEL/17/2, Low voltage switchgear and controlgear.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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ISBN 978 0 580 73588 2

ICS 29.120.99; 29.130.20

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2010

Amendments/corrigenda issued since publication

Date	Text affected
31 January 2013	Implementation of IEC amendment 1:2012 with CENELEC endorsement A1:2012

**Low-voltage switchgear and controlgear -
Part 4-1: Contactors and motor-starters -
Electromechanical contactors and motor-starters
(IEC 60947-4-1:2009)**

Appareillage à basse tension -
Partie 4-1: Contacteurs et démarreurs
de moteurs -
Contacteurs et démarreurs
électromécaniques
(CEI 60947-4-1:2009)

Niederspannungsschaltgeräte -
Teil 4-1: Schütze und Motorstarter -
Elektromechanische Schütze
und Motorstarter
(IEC 60947-4-1:2009)

This European Standard was approved by CENELEC on 2010-04-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 17B/1674/FDIS, future edition 3 of IEC 60947-4-1, prepared by SC 17B, Low-voltage switchgear and controlgear, of IEC TC 17, Switchgear and controlgear, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 60947-4-1 on 2010-04-01.

This standard is to be used in conjunction with EN 60947-1.

This European Standard supersedes EN 60947-4-1:2001 + A1:2002 + A2:2005.

This EN 60947-4-1 includes the following significant technical changes with respect to the EN 60947-4-1:2001 + A1:2002 + A2:2005:

- deletion of the test at –5 °C and +20 °C for thermal overload relays that are not compensated for ambient air temperature;
- addition of conditions of the tests according to Annex Q of EN 60947-1;
- EMC tests: clarification of acceptance criteria and alignment with EN 60947-1 for fast transient severity level;
- Annex B, test for Icd: modification of the duration of the dielectric test voltage from 5 s to 60 s;
- Annex B, electrical durability: improvement of the statistical aspects;
- Annex H: clarification and introduction of new extended functions within electronic overload relays;
- Annex K, procedure to determine data for electromechanical contactors used in functional safety applications: creation of this new annex.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

- | | | |
|--|-------|------------|
| – latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement | (dop) | 2011-01-01 |
| – latest date by which the national standards conflicting with the EN have to be withdrawn | (dow) | 2013-04-01 |

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and covers essential requirements of EC Directive 2004/108/EC. See Annex ZZ.

Annexes ZA and ZZ have been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 60947-4-1:2009 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60068-2-2:2007	NOTE	Harmonized as EN 60068-2-2:2007 (not modified).
IEC 60076-1:1993	NOTE	Harmonized as EN 60076-1:1997 (modified).
IEC 60269-1:2006	NOTE	Harmonized as EN 60269-1:2007 (not modified).
IEC 60269-2:2006	NOTE	Harmonized as EN 60269-2:2007 (modified).
IEC 60664-1:2007	NOTE	Harmonized as EN 60664-1:2007 (not modified).
IEC 61095:2009	NOTE	Harmonized as EN 61095:2009 (not modified).

Foreword to amendment A1

The text of document 17B/1769/FDIS, future edition 1 of IEC 60947-4-1:2009/A1, prepared by SC 17B, "Low-voltage switchgear and controlgear", of IEC TC 17, "Switchgear and controlgear" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 60947-4-1:2010/A1:2012.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2013-05-24
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2015-08-24

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60947-4-1:2009/A1:2012 was approved by CENELEC as a European Standard without any modification.

Add to the Bibliography of EN 60947-4-1:2010, the following note for the standard indicated:

IEC 61915-2:2011	NOTE	Harmonized as EN 61915-2:2012 (not modified).
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Annex ZA (normative)

Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60034-1	2004	Rotating electrical machines - Part 1: Rating and performance	EN 60034-1	2004
IEC 60085	2007	Electrical insulation - Thermal evaluation and designation	EN 60085	2008
IEC 60300-3-5	2001	Dependability management - Part 3-5: Application guide - Reliability test conditions and statistical test principles	-	-
IEC 60410	1973	Sampling plans and procedures for inspection - by attributes	-	-
IEC 60947-1	2007	Low-voltage switchgear and controlgear - Part 1: General rules	EN 60947-1	2007
IEC 60947-2	2006	Low-voltage switchgear and controlgear - Part 2: Circuit-breakers	EN 60947-2	2006
IEC 60947-3	2008	Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units	EN 60947-3	2009
IEC 60947-5-1	2003	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices	EN 60947-5-1 + corr. July	2004 2005
IEC 61000-4-2	2008	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	2009
IEC 61000-4-3	2006	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3	2006
IEC 61000-4-4	2004	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	EN 61000-4-4	2004
IEC 61000-4-5	2005	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	EN 61000-4-5	2006

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 61000-4-6	2008	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	EN 61000-4-6	2009
IEC 61051-2	1991	Varistors for use in electronic equipment - Part 2: Sectional specification for surge suppression varistors	-	-
IEC 61439-1 (mod)	2009	Low-voltage switchgear and controlgear assemblies - Part 1: General rules	EN 61439-1	2009
IEC 61508	Series	Functional safety of electrical/electronic/programmable electronic safety-related systems	EN 61508	Series
IEC 61511	Series	Functional safety - Safety instrumented systems for the process industry sector	EN 61511	Series
IEC 61513	2001	Nuclear power plants - Instrumentation and control for systems important to safety - General requirements for systems	-	-
IEC 61649	2008	Weibull analysis	EN 61649	2008
IEC 61810-1	2008	Electromechanical elementary relays - Part 1: General requirements	EN 61810-1	2008
IEC 62061	2005	Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems	EN 62061	2005
CISPR 11 (mod)	2003	Industrial scientific and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics - Limits and methods of measurement	EN 55011	2007
+ A1	2004		-	-
+ A2	2006		+ A2 ^{1) 2)}	2007
ISO 13849-1	2006	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design	-	-

¹⁾ EN 55011 includes A1 to CISPR 11 (mod).

²⁾ EN 55011 is superseded by prEN 55011(fragment 1), which is based on CISPR 11:200X (fragment 1)(CISPR/B/440/CDV).

Annex ZZ (informative)

Coverage of Essential Requirements of EC Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope the standard covers all relevant essential requirements as given in Article 1 of Annex I of the Directive 2004/108/EC.

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directives concerned.

WARNING: Other requirements and other EC Directives may be applicable to the products falling within the scope of this standard.

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LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

1 Scope and object

1.1 Scope

This part of IEC 60947 applies to the types of equipment listed in 1.1.1 and 1.1.2 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) forms 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 or protected starters are rated as units.

For circuit-breakers and fuse-combination units used as short-circuit protective devices in combination starters and in protected starters, the requirements of IEC 60947-2 and IEC 60947-3 respectively apply.

Equipment covered by this standard is as follows.

1.1.1 AC and DC contactors

AC and DC contactors intended for closing and opening electric circuits and, if combined with suitable relays (see 1.1.2), for protecting these circuits against operating overloads which may occur therein.

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

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

Contactors or starters with an electronically controlled electromagnet are also covered by this standard.

1.1.2 AC motor-starters

AC motor-starters  (including motor management starter)  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.

For overload relays for starters, including those based on electronic technology with or without extended functions according to Annex H, the requirements of this standard apply.

1.1.2.1 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.

1.1.2.2 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).

1.1.2.2.1 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, I_{A1} the starting current I_{A1} 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.

1.1.2.2.2 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.

1.1.2.3 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.

 Text deleted 

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 are 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.

1.2 Exclusions

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.

1.3 Object

The object of this standard is to state:

- a) the characteristics of contactors and starters and associated equipment;
- b) the conditions applicable to contactors and starters 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 referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1:2004, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60085:2007, *Electrical insulation – Thermal evaluation and designation*

IEC 60300-3-5:2001, *Dependability management – Part 3-5: Application guide – Reliability test conditions and statistical test principles*

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

IEC 60947-1:2007, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-2:2006, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 60947-3:2008, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 60947-5-1:2003, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61000-4-2:2008, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
Amendment 1 (2007)

IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-4-5:2005, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61000-4-6:2008, *Electromagnetic compatibility (EMC) – Part 4-6: Testing and measurement techniques – Immunity to conducted disturbances, induced by radio-frequency fields*

[A] IEC 61051-2:1991, *Varistors for use in electronic equipment – Part 2: Sectional specification for surge suppression varistors***[A1]**

IEC 61439-1:2009, *Low-voltage switchgear and controlgear assemblies – Part 1: General rules*

IEC 61508 (all parts), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

IEC 61511 (all parts), *Functional safety – Safety instrumented systems for the process industry sector*

IEC 61513:2001, *Nuclear power plants – Instrumentation and control for systems important to safety – General requirements for systems*

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CISPR 11:2003, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*
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Amendment 2 (2006)

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3 Terms, definitions, symbols and abbreviations

3.1 General

For the purposes of this document, the terms and definitions of Clause 2 of IEC 60947-1, as well as the following terms, definitions, symbol and abbreviations apply.

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3.3 Terms and definitions concerning contactors

3.3.1

(mechanical) contactor

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

[IEV 441-14-33]

NOTE 2 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 3 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 4 A contactor is usually intended to operate frequently.

3.3.2

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

NOTE The electromagnet may be electronically controlled.

3.3.3

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

3.3.4

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

3.3.5

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]

3.3.6

vacuum contactor (or starter)

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

3.3.7

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]

A1

3.3.8.

electronically controlled electromagnet

electromagnet in which the coil is controlled by a circuit with active electronic elements

3.3.9

holding power (of a contactor)

power needed to maintain the operation of the electromagnet

3.3.10

pick-up power (of a contactor)

power needed to operate the contactor from the de-energized state to the energized state ^{A1}

3.4 Terms and definitions concerning starters

3.4.1 starter

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

[IEV 441-14-38, modified]

3.4.2 direct-on-line starter

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

[IEV 441-14-40]

3.4.3 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

3.4.4 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

3.4.5 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

3.4.5.1 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]

3.4.5.2 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 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."

3.4.6 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 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.

3.4.6.1

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

3.4.6.2

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]

3.4.7

protected starter

equipment consisting of a starter, a manually-operated switching device and a short-circuit protective device, rated as a unit by the manufacturer

NOTE 1 The protected starter may or may not be enclosed.

NOTE 2 In the context of this standard, the term "manufacturer" means any person, company or organization with ultimate responsibility as follows:

- to verify compliance with the appropriate standard;
- to provide the product information according to Clause 6.

NOTE 3 The manually operated switching device and the short-circuit protective device may be just one device and may also incorporate the starter overload protection.

3.4.8

combination starter (see Figure 3)

equipment consisting of a protected starter incorporating an isolating function

NOTE Also called "combination motor controller".

3.4.9

manual starter

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

[IEV 441-14-39]

3.4.10

electromagnetic starter

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

3.4.11

motor-operated starter

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

3.4.12

pneumatic starter

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

3.4.13

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

3.4.14

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.

3.4.15

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.

3.4.16

***n*-step starter** (see Figure 4)

starter in which there are (*n*-1) intermediate accelerating positions between the OFF and ON positions

[IEV 441-14-41]

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

3.4.17

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

3.4.18

under-current relay or release

measuring relay or release which operates automatically when the current through it is reduced below a predetermined value

3.4.19

under-voltage relay or release

measuring relay or release which operates automatically when the voltage applied to it is reduced below a predetermined value

3.4.20

starting time (of a rheostatic starter)

period of time during which the starting resistors or parts of them carry current

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

3.4.21

starting time (of an auto-transformer starter)

period of time during which the auto-transformer carries current

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

3.4.22

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 as an additional step.

3.4.23

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 as an additional step.

3.4.24

inching (jogging)

energizing a motor or solenoid repeatedly for short periods to obtain small movements of the driven mechanism

3.4.25

plugging

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

3.4.26

protected switching device

equipment (for non motor loads) consisting of a contactor or a semiconductor controller, overload protection, a manually operated switching device and a short-circuit protective device, rated as a unit by the manufacturer

NOTE 1 The protected switching device may or may not be enclosed.

NOTE 2 In the context of this standard, the term “manufacturer” means any person, company or organization with ultimate responsibility as follows:

- to verify compliance with the appropriate standard;
- to provide the product information according to Clause 6.

NOTE 3 The manually operated switching device and the short-circuit protective device may be just one device and may incorporate the overload protection as well.

3.4.27

combination switching device

equipment consisting of a protected switching device incorporating an isolating function

3.4.28

stall sensitive (electronic overload) relay

electronic overload relay which operates when the current has not decreased below a predetermined value for a specific period of time during start-up or when the relay receives the input indicating there is no rotation of the motor after a predetermined time in accordance with specified requirements

NOTE 1 Explanation of stall: rotor locked during start.

NOTE 2 With appropriate adjustment of the current and starting time settings, such relay can be used to detect overtime starts.

3.4.29

jam sensitive (electronic overload) relay

electronic overload relay which operates in the case of overload and also when the current has increased above a predetermined value for a specific period of time during operation, in accordance with specified requirements

NOTE Explanation of jam: high overload occurring after the completion of starting which causes the current to reach the locked rotor current value of the motor being controlled.

3.4.30

inhibit time

time-delay period during which the tripping function of the relay is inhibited (may be adjustable)



3.4.31

motor management starter

starter including extended functions with communication ability

NOTE Interoperable device profiles for motor management starter are defined by IEC 61968-2-1



3.5 Terms and definitions concerning characteristic quantities

3.5.1

transient recovery voltage

TRV

recovery voltage during the time in which it has a significant transient character

NOTE In a vacuum contactor or starter, the highest transient recovery voltage may occur on an other pole than the first pole to clear. n

[IEC 60947-1, 2.5.34, modified]

3.5.2

CO operation

breaking of the circuit by the SCPD resulting from closing the circuit by the equipment under test

3.5.3

O operation

breaking of the circuit by the SCPD resulting from closing the circuit on the equipment under test which is in the closed position

NOTE The SCPD is normally in the closed position prior closing the circuit; in some cases the SCPD has to close the circuit (see 9.3.4.2.2, item b).

3.6 Symbols and abbreviations

AQL Acceptable quality level

EMC Electromagnetic compatibility

SCPD Short-circuit protective device

I_c Current made and broken (Table 7)

I_e Rated operational current (5.3.2.5)

I_{er} Rated rotor operational current (5.3.2.7)

I_{es} Rated stator operational current (5.3.2.6)

I_q Maximum conditional short-circuit test current I_{A1}

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

I_{the} Conventional enclosed thermal current (5.3.2.2)

I_{thr} Conventional rotor thermal current (5.3.2.4)

I_{ths} Conventional stator thermal current (5.3.2.3)

I_u Rated uninterrupted current (5.3.2.8)

P_c Nominal holding power of a d.c. controlled contactor I_{A1}

P_p Pick-up power of a d.c. controlled contactor with separate pick-up and hold-on windings

S_h Holding power of an a.c. controlled contactor

S_p Pick-up power of an a.c. controlled contactor I_{A1}

T_p Tripping time (Table 2)

U_c Rated control circuit voltage (5.5)

U_d Voltage drop of a contactor pole I_{A1}

U_e Rated operational voltage (5.3.1.1)

U_{er} Rated rotor operational voltage (5.3.1.1.2)

U_{es} Rated stator operational voltage (5.3.1.1.1)

U_i Rated insulation voltage (5.3.1.2)

U_{imp} Rated impulse withstand voltage (5.3.1.3)

U_{ir} Rated rotor insulation voltage (5.3.1.2.2)

U_{is} Rated stator insulation voltage (5.3.1.2.1)

U_r Power frequency or d.c. recovery voltage (Table 7)

U_s Rated control supply voltage (5.5)

Z Pole impedance of a contactor (5.3.7) I_{A1}

"r" Minimum short-circuit test current I_{A1}

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);
- 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 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 IEC 60947-1 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 rotor 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.

[A1] The rated insulation voltage of the switching devices inserted in the rotor circuit shall be at least 50 % the highest voltage between open slip-rings.

NOTE Electrical stresses are lower and shorter in the rotor than in the stator. **[A1]**

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 IEC 60947-1 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 IEC 60947-1 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 IEC 60947-1 applies.

5.3.2.2 Conventional enclosed thermal current (I_{the})

Subclause 4.3.2.2 of IEC 60947-1 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, precisely 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

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

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.

NOTE Annex G gives values concerning the relationship between rated operational currents and rated operational powers.

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 IEC 60947-1 applies.

5.3.3 Rated frequency

Subclause 4.3.3 of IEC 60947-1 applies.

5.3.4 Rated duties

Subclause 4.3.4 of IEC 60947-1 applies.

5.3.4.1 Eight-hour duty (continuous duty)

Subclause 4.3.4.1 of IEC 60947-1 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 IEC 60947-1 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 IEC 60947-1 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 IEC 60947-1 applies.

5.3.4.5 Periodic duty

Subclause 4.3.4.5 of IEC 60947-1 applies.

5.3.5 Normal load and overload characteristics

Subclause 4.3.5 of IEC 60947-1 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} is the rated rotor operational voltage;

I_{er} is the rated rotor operational current;

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

where

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

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;

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.)

A1 Text deleted **A1**

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 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 IEC 60947-1 applies.

5.3.7 Pole impedance of a contactor (Z)

The pole impedance may be stated by the manufacturer and is determined by measuring the voltage drop resulting of the current flowing through the pole. 

5.4 Utilization category

5.4.1 General

Subclause 4.4 of IEC 60947-1 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 Table 7 and Table 10, 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.

5.4.2 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 Table 7 and Table 10, 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	$0,005\ 25 \times U_e \times I_e$
DC-5	$0,031\ 5 \times U_e \times I_e$

The values of the constants 0,005 25 and 0,031 5 are derived from:

$$J_c = 1/2 L I^2$$

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	Additional category designation	Typical applications
AC	AC-1	General use	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 ^a
	AC-4	Ballast Incandescent	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 ^c		Slightly inductive loads in household appliances and similar applications
	AC-7b ^c		Motor-loads for household applications
	AC-8a		Hermetic refrigerant compressor motor ^b control with manual resetting of overload releases
	AC-8b		Hermetic refrigerant compressor motor ^b control with automatic resetting of overload releases
DC	DC-1	Incandescent	Non-inductive or slightly inductive loads, resistance furnaces
	DC-3		Shunt-motors: starting, plugging, inching
	DC-5		Dynamic breaking of d.c. motors
			Series-motors: starting, plugging, inching
	DC-6		Dynamic breaking of d.c. motors
Switching of incandescent lamps			
a 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. b 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. c For AC-7a and AC-7b, see IEC 61095.			

5.5 Control circuits

A1 Subclause 4.5 of IEC 60947-1:2007 applies. **A1**

5.6 Auxiliary circuits

Subclause 4.6 of IEC 60947-1 applies.

Digital inputs and/or digital outputs contained in contactors and motor-starters, and intended to be compatible with PLCs shall fulfil the requirements of Annex S of IEC 60947-1.

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;
 - 2) dependent on previous load;
 - 3) dependent on previous load and also sensitive to phase loss.
- d) Instantaneous over-current relay or release (e.g. jam sensitive).
- e) Other relays or releases (e.g. control relay associated with devices for the thermal protection of the motor).
- f) Stall relay or release.

5.7.3 Characteristic values

- a) Release with shunt coil, under-voltage (under-current), over-voltage (instantaneous over current), current or voltage imbalance and phase reversal opening relay or release:
 - rated voltage (current);
 - rated frequency;
 - operating voltage (current);
 - operating time (when applicable);
 - inhibit time (when applicable).
- 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 40 s;
 - nature of the relay: thermal, magnetic, electronic or electronic without thermal memory (electronic relay not fulfilling the thermal memory test verification according 8.2.1.5.1.2 shall be marked ~~Thm~~);
 - nature of the reset: manual and/or automatic; in case of combination manual or automatic-reset, the set position shall be indicated;
 - tripping time of overload relays class 10A if longer than 2 min at –5 °C or below (see 8.2.1.5.1.1, item c).

A1 c) Release with residual current sensing relay:

- rated current;
- operating current;
- operating time or time-current characteristic according to Table T.1 of IEC 60947-1:2007, Amendment 1;
- inhibit time (when applicable);
- type designation (see Annex T of IEC 60947-1: 2007, Amendment 1).**A1**

Table 2 – Trip classes of overload relays

Trip class	Tripping time T_p under the conditions specified in 8.2.1.5.1, Table 3, column D ^a	Tripping time T_p under the conditions specified in 8.2.1.5.1, Table 3, column D for tighter tolerances (tolerance band E) ^a
	s	s
2	–	$T_p \leq 2$
3	–	$2 < T_p \leq 3$
5	$0,5 < T_p \leq 5$	$3 < T_p \leq 5$
10 A	$2 < T_p \leq 10$	–
10	$4 < T_p \leq 10$	$5 < T_p \leq 10$
20	$6 < T_p \leq 20$	$10 < T_p \leq 20$
30	$9 < T_p \leq 30$	$20 < T_p \leq 30$
40	–	$30 < T_p \leq 40$

^a The manufacturer shall add the letter E to trip classes to indicate compliance with the band E.

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 abscissa 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 and Figure 1 of IEC 60269-1 and in Figure 104, Figure 504 and Figure 505 of IEC 60269-2.

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 (i.e. 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

The co-ordination of contactors and starters is characterized by the type, ratings and characteristics of the short-circuit protective devices (SCPD) that provide protection of the contactor and starter against short-circuit currents. Requirements are given in 8.2.5.1 and 8.2.5.2 of this standard, and in 4.8 of IEC 60947-1.

5.9 Void

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.
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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.
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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;