

CONFIRMED
MAY 1998

Specification for

Low-voltage switchgear and controlgear —

Part 4: Contactors and motor-starters —

Section 1: Electromechanical
contactors and motor-starters

The European Standard EN 60947-4-1:1992 with the incorporation of amendments A1:1995 and A2:1997 has the status of a British Standard

ICS 29.120.60

NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

BSI
Documents

AVA

Document Sharing Hub

Cooperating organizations

The European Committee for Electrotechnical Standardization (CENELEC), under whose supervision this European Standard was prepared, comprises the national standards organizations of the following countries.

Austria	Italy
Belgium	Luxembourg
Denmark	Netherlands
Finland	Norway
France	Portugal
Germany	Spain
Greece	Sweden
Iceland	Switzerland
Ireland	United Kingdom

This British Standard, having been prepared under the direction of the Power Electrical Engineering Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 June 1992

© BSI 05-1999

The following BSI references relate to the work on this standard:
Committee reference PEL/10
Draft for comment 80/20856 DC

ISBN 0 580 20826 5

Amendments issued since publication

Amd. No.	Date	Comments
9816	May 1998	Indicated by a sideline in the margin

Contents

	Page
Cooperating organizations	Inside front cover
National foreword	ii
Foreword	2
Foreword to amendment A1	2
Foreword to amendment A2	2
Text of EN 60947-4-1	5
National annex NA (normative) Original IEC text amended by CENELEC	60
National annex NB (informative) Committees responsible	60
National annex NC (informative) Cross references	Inside back cover

National foreword

This British Standard has been prepared under the direction of the Power Electrical Engineering Standards Policy Committee and is the English language version of EN 60947-4-1, “*Low-voltage switchgear and controlgear*” — Part 4: “*Contactors and motor-starters*” — Section 1: “*Electromechanical contactors and motor-starters*”, plus corrigenda of December 1992, March 1993 and June 1997, and including amendments A1 and A2, published by the European Committee for Electrotechnical Standardization (CENELEC). It was derived by CENELEC from IEC 947-4-1:1990 and its corrigendum December 1991, published by the International Electrotechnical Commission (IEC). The corrigendum items have been indicated by a single sideline in the margin of this standard. For ease of production, some of the figures also include the French text.

In 8.3.1, note 1, line 3, for “(see page 107)” please read “(see page 28)”.

In 1995 the European Committee for Electrotechnical Standardization (CENELEC) accepted Amendment 1:1994 to IEC 947-4-1:1990 as Amendment A1:1995 to EN 60947-4-1:1992. In 1997 CENELEC accepted Amendment 2:1996 to IEC 947-4-1:1990 as Amendment A2:1997 to EN 60947-4-1:1992.

The CENELEC changes included in the introduction of the European Standard have been implemented at the appropriate places in the text and are indicated by a sideline in the margin. Parts of the original IEC text that have been modified by CENELEC have been quoted in National annex NA.

The foreword of the EN makes reference to date of withdrawal (dow) of conflicting national standards as 1997-10-01. In this case the relevant national standard is BS EN 60947-4-1:1992 but the date of withdrawal relates only to those parts of the British Standard subject to Amendment 5. Certificates and marks will not be awarded after this date with respect to the British Standard not incorporating Amendment 5. They will be awarded only to the amended British Standard. However, such certificates and marks already awarded with respect to the British Standard not incorporating Amendment 5 may continue to apply for production until 2000-12-01.

This British Standard supersedes BS 4941-1:1979, BS 4941-2:1997, BS 4941-3:1997, BS 4941-4:1997 and BS 5424-1:1977, which are withdrawn.

This British Standard is to be read in conjunction with BS EN 60947-1 which identifies the general requirements for equipment for low-voltage switchgear and controlgear. The BS EN 60947 series comprises the following publications.

- *Part 1: General rules;*
- *Part 2: Circuit breakers;*
- *Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units;*
- *Part 4: Contactors and motor-starters — Section 1: Electromechanical contactors and motor-starters;*
- *Part 5: Control circuit devices and switching elements — Section 1: Electromechanical control circuit devices — Section 2: Proximity switches;*
- *Part 6: Multiple function equipment — Section 1: Automatic transfer switching equipment;*
- *Part 7: Ancillary equipment — Section 1: Terminal blocks and copper conductors.*

From 1 January 1997, all IEC publications have the number 60000 added to the old number. For instance IEC 27-1 has been renumbered as IEC 60027-1. For a period of time during the change over from one numbering system to the other, publications may contain identifiers from both systems.

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

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, the EN title page, pages 2 to 60, an inside back cover and a back cover.

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

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 60947-4-1

January 1992

+ A1

January 1995

+ A2

June 1997

UDC 621.316.5.027.2

Supersedes HD 419.1 S1:1982 and HD 421 S1:1982

Incorporates corrigendum June 1997

Descriptors: Electrical switchgear and controlgear, low-voltage switchgear and controlgear, control equipment, contactor, starter, short-circuit protection, overload protection, characteristics, test

English version

Low-voltage switchgear and controlgear Part 4: Contactors and motor-starters Section 1 — Electromechanical contactors and motor-starters

(including amendments A1:1995 and A2:1997)
(IEC 947-4-1:1990, modified + A1:1994 + A2:1996)

Appareillage à basse tension Quatrième
partie: Contacteurs et démarreurs de moteurs
Section 1 — Contacteurs et démarreurs
électromécaniques
(inclut les amendements A1:1995 et A2 1997)
(CEI 947-4-1:1990, modifiée + A1:1994
+ A2:1996)

Niederspannung-Schaltgeräte
Teil 4: Schütze und Motorstarter
Hauptabschnitt 1: Elektromechanische Schütze
und Motorstarter
(enthält Änderungen A1:1995 und A2:1997)
(IEC 947-4-1:1990, modifiziert + A1:1994
+ A2:1996)

This European Standard was approved by CENELEC on 1991-12-10; amendment A1 was approved by CENELEC on 1994-12-06; amendment A2 was approved by CENELEC on 1996-07-02. 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, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

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

Central Secretariat: rue de Stassart 35, B-1050 Brussels

© 1997 CENELEC — All rights of exploitation in any form and by any means reserved worldwide for CENELEC members.

Ref. No. EN 60947-4-1:1992 + A1:1995 + A2:1997 E
 **Documents**
Document Sharing Hub

Foreword

The CENELEC questionnaire procedure, performed for finding out whether or not the International Standard IEC 947-4-1:1990 could be accepted without textual changes, has shown that no CENELEC common modifications were necessary for the acceptance as European Standard. The reference document was submitted to the CENELEC members for formal vote and was approved by CENELEC as EN 60947-4-1 on 10 December 1991.

This European Standard supersedes HD 419.1 S1:1982 and HD 421 S1:1982.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1992-12-01
- latest date of withdrawal of conflicting national standards (dow) 1997-10-01

For products which have complied with HD 419.1 S1:1982 or HD 421 S1:1982 before 1992-12-01, as shown by the manufacture or by a certification body, this previous standard may continue to apply for production until 1997-12-01.

Annexes designated “normative” are part of the body of the standard. In this standard, Annex ZA is normative.

Foreword to amendment A1

The text of document 17B(C)224, future amendment 1 to IEC 947-4-1:1990, 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 amendment A1 to EN 60947-4-1:1992 on 1994-12-06.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1995-12-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1997-10-01

For products which have complied with EN 60947-4-1:1992 before 1997-10-01, as shown by the manufacturer or by a certification body, this previous standard may continue to apply for production until 2000-12-01.

Annexes designated “normative” are part of the body of the standard. In this standard, Annex ZA is normative. Annex ZA has been added by CENELEC.

Foreword to amendment A2

The text of document 17B/731/FDIS, future amendment 2 to IEC 947-4-1:1990, 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 amendment A2 to EN 60947-4-1:1992 on 1996-07-02.

The following dates were fixed:

- latest date by which the amendment has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1997-10-01
- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 1997-10-01

Annexes designated “normative” are part of the body of the standard. In this standard, Annex ZA is normative. Annex ZA has been added by CENELEC.

Contents

	Page	Page
Foreword	2	
Introduction	5	
1 General	5	
1.1 Scope	5	
1.2 Object	6	
2 Definitions	7	
2.1 Definitions concerning contactors	7	
2.2 Definitions concerning starters	7	
2.3 Characteristic quantities	9	
3 Classification	9	
4 Characteristics of contactors and starters	9	
4.1 Summary of characteristics	9	
4.2 Type of equipment	9	
4.3 Rated and limiting values for main circuits	10	
4.4 Utilization category	14	
4.5 Control circuits	15	
4.6 Auxiliary circuits	15	
4.7 Characteristics of relays and releases (overload relays)	15	
4.8 Co-ordination with short-circuit protective devices	17	
4.9 Switching overvoltages	17	
4.10 Types and characteristics of automatic change-over devices and automatic acceleration control devices	17	
4.11 Types and characteristics of auto-transformers for two-step auto-transformer starters	17	
4.12 Types and characteristics of starting resistors for rheostatic rotor starters	17	
5 Product information	18	
5.1 Nature of information	18	
5.2 Marking	18	
5.3 Instructions for installation, operation and maintenance	19	
6 Normal service, mounting and transport conditions	19	
7 Constructional and performance requirements	19	
7.1 Constructional requirements	19	
7.2 Performance requirements	20	
7.3 Electromagnetic compatibility (EMC)	26	
8 Tests	28	
8.1 Kinds of test	28	
8.2 Compliance with constructional requirements		28
8.3 Compliance with performance requirements		28
8.4 EMC tests		38
Appendix A Marking and identification of terminals of contactors and associated overload relays		48
Appendix B Special tests		51
Appendix C Clearances and creepage distances for low-voltage contactors and starters		54
Appendix D Items subject to agreement between manufacturer and user		57
Annex ZA (normative) Other international publications quoted in this standard with references of the relevant European publications		58
Figure 1 — Typical curves of currents and torques during a star-delta start		41
Figure 2 — Typical curves of currents and torques during an auto-transformer start		42
Figure 3 — Typical variants of combination starters (Sub-clause 2.2.7).and protected starters		43
Figure 4 — Example of three-phase diagram of a rheostatic rotor starter with three starting steps (Sub-clause 2.2.16) and one direction of rotation (in the case when all the mechanical switching devices are contactors)		44
Figure 5 — Typical methods and diagrams of starting alternating-current induction motors by means of auto-transformers		45
Figure 6 — Examples of speed/time curves corresponding to cases a), b), c), d), e), and f) of Sub-clause 4.3.5.5 (the dotted parts of the curves correspond to the periods when no current flows through the motor)		46
Figure 7 — Multiple of current setting limits for ambient air temperature compensated time-delay overload relays		47
Table I — Utilization categories		15
Table II — Trip classes of thermal, time-delay magnetic or solid state overload relays		16
Table III — Limits of operation of time-delay overload relays when energized on all poles		21
Table IV — Limits of operation of three-pole thermal overload relays when energized on two poles only		21

	Page
Table V — Temperature-rise limits for insulated coils in air and in oil	22
Table VI — Intermittent duty test cycle data	22
Table VII — Making and breaking capacities. Making and breaking conditions according to utilization category	23
Table VIIa — Relationship between current broken I_c and off-time for the verification of rated making and breaking capacities	24
Table VIIb — Operational current determination for utilization categories AC-6a and AC-6b when derived from AC-3 ratings	24
Table VIII — Conventional operational performance. Making and breaking conditions according to utilization category	25
Table IX — Overload current withstand requirements	26
Table X — Dielectric test voltage according to rated insulation voltage	32
Table XI — Value of the prospective test current according to the rated operational current	36
Table XII — Specific acceptance criteria for immunity tests	27
Table XIII — EMC immunity tests	38
Table XIV — Conducted radio-frequency emission test limits	39
Table XV — Radiated emission test limits	40
Table B1 — Verification of the number of on-load operating cycles. Conditions for making and breaking corresponding to the several utilization categories	53
Table C1	56

Introduction

All subjects left “under consideration” in IEC 947-4-1:1990 are not part of this European Standard.

This means that:

— for the following clauses the title and text are to be replaced by “Vacant”:

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

8.1.4 Sampling tests

— in the following clauses the appropriate paragraphs or notes are to be deleted:

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

7.1 Constructional requirements

7.2.6 Switching overvoltages

8.3.3.5.4 Switching overvoltages

Up-to-date information concerning the subjects dealt with in these clauses can be obtained from the secretariat of CENELEC TC 17B.

1 General

The provisions of the general rules dealt with in Part 1 (IEC Publication 947-1) are applicable to this standard, where specifically called for. Clauses and sub-clauses, tables, figures and appendices of the general rules thus applicable are identified by reference to Part 1, e.g., Sub-clause 1.2.3 of Part 1, Table IV of Part 1, or Appendix A of Part 1.

1.1 Scope

This standard applies to the types of equipment listed in Sub-clauses 1.1.1 and 1.1.2 hereinafter 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 Sub-clause 8.3.4) 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 Sub-clause 2.2.7) or protected starters (see Sub-clause 2.2.8) 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 Publications 947-2 and 947-3, as the case may be.

Equipment covered by this standard is as follows:

1.1.1 A.C. and d.c. contactors

A.C. and d.c. contactors intended for closing and opening electric circuits and, if combined with suitable relays (see Sub-clause 1.1.2), 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 Publication 947-2).

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

1.1.2 A.C. motor-starters

A.C. 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 Publication 255-8, or motor incorporated thermal protective devices dealt with in IEC Publication 34-11 which 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.

1.1.2.1 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 Sub-clause 4.10).

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, 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.

1.1.2.2.2 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 designed for starting 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 Sub-clause 4.3.1.1.2).

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 Sub-clause 4.3.5.5). 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.

1.1.3 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 Publication 947-5-1.

1.2 Object

The object of this standard is to state:

- 1) the characteristics of contactors and starters and associated equipment;
- 2) the conditions with which contactors or starters shall comply with reference to

- a) their operation and behaviour,
 - b) their dielectric properties,
 - c) the degrees of protection provided by their enclosures, where applicable,
 - d) their construction;
- 3) the tests intended for confirming that these conditions have been met, and the methods to be adopted for these tests;
- 4) the information to be given with the equipment or in the manufacturer's literature.

2 Definitions

Clause 2 of Part 1 applies with the following additional definitions:

2.1 Definitions concerning contactors

2.1.1

contactor (mechanical) (IEV 441-14-33)

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

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

NOTE (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.

2.1.2

electromagnetic contactor

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

2.1.3

pneumatic contactor

a 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

2.1.4

electro-pneumatic contactor

a 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

2.1.5

latched contactor (IEV 441-14-34)

a 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.

2.1.6

vacuum contactor (or starter)

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

2.1.7

position of rest (of a contactor) (IEV 441-16-24)

the position which the moving elements of the contactor take up when its electromagnet or its compressed-air device is not energized

2.2 Definitions concerning starters

2.2.1

starter (IEV 441-14-38)

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

2.2.2

direct-on-line starter (IEV 441-14-40)

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

2.2.3

reversing starter

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

2.2.4

two-direction starter

a 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

2.2.5 Reduced voltage starter

A 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.

2.2.5.1**star-delta starter** (IEV 441-14-44)

a 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

2.2.5.2**auto-transformer starter** (IEV 441-14-45)

a starter for an induction motor which uses for starting one or more reduced voltages derived from an auto-transformer

NOTE (not included in IEV 441-14-45).— An auto-transformer is defined as follows in Sub-clause 3.1.2 of IEC Publication 76-1: “A transformer in which at least two windings have a common part.”

2.2.6 Rheostatic starter (IEV 441-14-42)

A starter utilizing one or several resistors for obtaining, during starting, stated motor torque characteristics and for limiting the current.

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.

2.2.6.1**rheostatic stator starter**

a 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

2.2.6.2**rheostatic rotor starter** (IEV 441-14-43)

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

2.2.7**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.

2.2.8**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.

2.2.9**manual starter** (IEV 441-14-39)

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

2.2.10**electromagnetic starter**

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

2.2.11**motor-operated starter**

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

2.2.12**pneumatic starter**

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

2.2.13**electro-pneumatic starter**

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

2.2.14**single-step starter**

a starter in which there is no intermediate accelerating position between the OFF and ON positions

NOTE This is a direct-on-line starter (see Sub-clause 2.2.2).

2.2.15**two-step starter**

a 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.

2.2.16**n-step starter** (see Figure 4) (IEV 441-14-41)

a 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.

2.2.17**phase loss sensitive thermal overload relay or release**

a 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

2.2.18**under-current (under-voltage) relay or release**

a 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

2.2.19**starting time (of a rheostatic starter)**

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

2.2.20**starting time (of an auto-transformer starter)**

the period of time during which the auto-transformer carries current

NOTE to Sub-clauses 2.2.19 and 2.2.20.— 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.

2.2.21**open transition (with an auto-transformer starter or star-delta starter)**

a 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.

2.2.22**closed transition (with an auto-transformer Starter or star-delta starter)**

a 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.

2.2.23**inching (jogging)**

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

2.2.24**plugging**

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

2.3 Characteristic quantities**2.3.1****transient recovery voltage (abbrev. T.R.V.) (IEV 441-17-26)**

sub-clause 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 other than the first pole to clear.

3 Classification

Sub-clause 4.2 gives all the data which may be used as criteria for classification.

4 Characteristics of contactors and starters**4.1 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 (Sub-clause 4.2);
- rated and limiting values for main circuits (Sub-clause 4.3);
- utilization category (Sub-clause 4.4);
- control circuits (Sub-clause 4.5);
- auxiliary circuits (Sub-clause 4.6);
- types and characteristics of relays and releases (Sub-clause 4.7);
- co-ordination with short-circuit protective devices (Sub-clause 4.8);
- switching overvoltages (Sub-clause 4.9);
- types and characteristics of automatic change-over devices and automatic acceleration control devices (Sub-clause 4.10);
- types and characteristics of auto-transformers for two-step auto-transformer starters (Sub-clause 4.11);
- types and characteristics of starting resistors for rheostatic rotor starters (Sub-clause 4.12).

4.2 Type of equipment

The following shall be stated (see also Clause 5).

4.2.1 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.

4.2.2 Number of poles

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

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

4.2.5 Operating conditions of the equipment

4.2.5.1 Method of operation

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

4.2.5.2 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).

4.2.5.3 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 Figure 4 and Figure 5).

4.2.5.4 Method of connecting for particular types of starters

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

4.3 Rated and limiting values for main circuits

The rated values established for a contactor or starter shall be stated in accordance with Sub-clauses 4.3.1 to 4.4 and 4.8 to 4.9, 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 Sub-clauses 4.3.1.2, 4.3.2.3, 4.3.2.4, 4.3.2.6, 4.3.2.7 and 4.3.5.5 but it is not necessary to specify all the values listed.

4.3.1 Rated voltages

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

4.3.1.1 Rated operational voltage (U_o)

Sub-clause 4.3.1.1 of Part 1 applies.

4.3.1.1.1 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 It is expressed as the voltage between phases.

4.3.1.1.2 Rated rotor operational voltage (U_{er})

For rheostatic rotor starters, its value 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.

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

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.

4.3.1.2 Rated Insulation voltage (U_i)

Sub-clause 4.3.1.2 of Part 1 applies.

4.3.1.2.1 Rated stator Insulation voltage (U_{is})

For rheostatic rotor starters, the rated stator insulation voltage is the value of voltage which is designated to 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.

4.3.1.2.2 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.

4.3.1.3 Rated impulse withstand voltage (U_{imp})

Sub-clause 4.3.1.3 of Part 1 applies.

4.3.1.4 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.

4.3.2 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.

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

Sub-clause 4.3.2.1 of Part 1 applies.

4.3.2.2 Conventional enclosed thermal current (I_{the})

Sub-clause 4.3.2.2 of Part 1 applies.

4.3.2.3 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 Sub-clauses 4.3.2.1 and 4.3.2.2.

For rheostatic rotor starters, the stator thermal current is the maximum current it can carry on eight-hour duty (see Sub-clause 4.3.4.1) without the temperature-rise of its several parts exceeding the limits specified in Sub-clause 7.2.2 when tested in accordance with Sub-clause 8.3.3.3.

4.3.2.4 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 Sub-clauses 4.3.2.1 and 4.3.2.2.

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 Sub-clause 4.3.4.1) without their temperature-rise exceeding the limits specified in Sub-clause 7.2.2 when tested in accordance with Sub-clause 8.3.3.3.

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 Sub-clause 4.3.4) 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 Sub-clause 7.2.2.

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

4.3.2.5 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 Sub-clause 4.3.1.1), the conventional free air or enclosed thermal current, the rated current of the overload relay, the rated frequency (see Sub-clause 4.3.3), the rated duty (see Sub-clause 4.3.4), the utilization category (see Sub-clause 4.4) 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.

4.3.2.6 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 Sub-clause 4.3.1.1.1), the conventional free air or enclosed thermal current, the rated frequency (see Sub-clause 4.3.3), the rated duty (see Sub-clause 4.3.4), the starting characteristics (see Sub-clause 4.3.5.5) 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.

4.3.2.7 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 Sub-clause 4.3.1.1.2), the conventional free air or enclosed rotor thermal current, the rated frequency (see Sub-clause 4.3.3), the rated duty (see Sub-clause 4.3.4) the starting characteristics (see Sub-clause 4.3.5.5) 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 Sub-clause 4.3.5.5).

4.3.2.8 Rated uninterrupted current (I_U)

Sub-clause 4.3.2.4 of Part 1 applies.

4.3.3 Rated frequency

Sub-clause 4.3.3 of Part 1 applies.

4.3.4 Rated duties

Sub-clause 4.3.4 of Part 1 applies.

4.3.4.1 Eight-hour duty (continuous duty)

Sub-clause 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, it 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.

4.3.4.2 Uninterrupted duty

Sub-clause 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, it 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).

4.3.4.3 Intermittent periodic duty or intermittent duty

Sub-clause 4.3.4.3 of Part 1 applies with the following addition:

For a reduced voltage starter, it 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.

4.3.4.4 Temporary duty

Sub-clause 4.3.4.4 of Part 1 applies.

4.3.4.5 Periodic duty

Sub-clause 4.3.4.5 of Part 1 applies.

4.3.5 Normal load and overload characteristics

Sub-clause 4.3.5 of Part 1 applies with the following additions:

4.3.5.1 Ability to withstand motor switching overload currents

Requirements to meet these conditions are given for contactors in Sub-clause 7.2.4.4.

4.3.5.2 Rated making capacity

Requirements for the various utilization categories (see Sub-clause 4.4) are given in Sub-clause 7.2.4.1. The rated making and breaking capacities are only valid when the contactor or the starter is operated in accordance with the requirements of Sub-clauses 7.2.1.1 and 7.2.1.2.

4.3.5.3 Rated breaking capacity

Requirements for the various utilization Categories (see Sub-clause 4.4) are given in Sub-clause 7.2.4.1. The rated making and breaking capacities are only valid when the contactor or the starter is operated in accordance with the requirements of Sub-clauses 7.2.1.1 and 7.2.1.2.

4.3.5.4 Conventional operational performance

This is specified as a series of making and breaking operations in Sub-clause 7.2.4.2.

4.3.5.5 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 paragraph 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 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 VII. 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 VII. 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.

4.3.5.5.1 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:

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

- I_1 = current in the rotor circuit immediately before shorting out a resistor section;
 I_2 = current in the rotor circuit immediately after shorting out a resistor section;
 I_m = $1/2 (I_1 + I_2)$;
 T_e = rated motor operational torque;
 t_s = starting time (see Sub-clause 2.2.19);
 k = 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 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.

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

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

The conditions for making and breaking as given in Table VII 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.

4.3.5.5.3 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 Sub-clause 2.2.20) for all classes of duty (see Sub-clause 4.3.4) 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.

4.3.6 Rated conditional short-circuit current

Sub-clause 4.3.6.4 of Part 1 applies.

4.4 Utilization category

Sub-clause 4.4 of Part 1 applies with the following additions:

For contactors and starters the utilization categories as given in Table I 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 VII and Table VIII 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 VII.

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.

4.4.1 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, the on and off times given in Table VII and Table VIII, 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:

2.5×10^{-3} s (DC-3) and:

15×10^{-3} s (DC-5)

and where $U = 1.05 U_e$, $I = 4 I_e$ and L = inductance of the test circuit.

(See Table VII of this standard.)

4.5 Control circuits

Sub-clause 4.5 of Part 1 applies.

4.6 Auxiliary circuits

Sub-clause 4.6 of Part 1 applies.

4.7 Characteristics of relays and releases (overload relays)

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

4.7.1 Summary of characteristics

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

- types of relay or release (see Sub-clause 4.7.2);
- characteristic values (see Sub-clause 4.7.3);
- designation and current settings of overload relays (see Sub-clause 4.7.4);

— time-current characteristics of overload relays (see Sub-clause 4.7.5);

— influence of ambient air temperature (see Sub-clause 4.7.6).

4.7.2 Types of relay or release

- 1) Release with shunt coil (shunt trip).
- 2) Under-voltage and under-current opening relay or release.
- 3) Overload time-delay relay, the time-lag of which is:
 - a) substantially independent of previous load (e.g.: time-delay magnetic overload relay);
 - b) dependent on previous load (e.g.: thermal overload relay);
 - c) dependent on previous load (e.g.: thermal overload relay) and also sensitive to phase loss (see Sub-clause 2.2.17).
- 4) Instantaneous over-current relay or release (when applicable).
- 5) 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 4) and 5) require consultation between manufacturer and user according to the particular application.

Table I — Utilization categories

Kind of current	Utilization categories	Typical applications
A.C.	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 ^a
	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 ^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
D.C.	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

^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 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 1095.