



# INTERNATIONAL STANDARD



**Low-voltage switchgear and controlgear –  
Part 4-1: Contactors and motor-starters – Electromechanical contactors and  
motor-starters**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 29.120.99, 29.130.20

ISBN 978-2-8322-6208-5

**Warning! Make sure that you obtained this publication from an authorized distributor.**

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**IEC 60947-4-1**  
Edition 4.0 2018-10

**LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –**

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

**INTERPRETATION SHEET 1**

This interpretation sheet has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

The text of this interpretation sheet is based on the following documents:

DISH	Report on voting
121A/336/DISH	121A/342/RVDISH

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

**Interpretation of the first paragraph of 6.2**

The reference to 5.2 of IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010 is intended to cover the whole subclause where its first paragraph can be discarded.

In particular, the third paragraph of this Subclause 5.2 requiring the marking on the equipment of manufacturer's name or trademark and type designation or serial number is covering items a) and b) of 6.1.1 of IEC 60947-4-1:2018.

**Interpretation of footnotes <sup>n</sup> and <sup>o</sup> of Table 7**

The standard making conditions for the utilization category AC-3e are defined by the ratio  $I / I_e$  equal to 12 with the corresponding value of  $\text{Cos } \phi$  in footnote <sup>o</sup>.

Footnote <sup>n</sup> provides the possibility to select an alternate value of the ratio  $I / I_e$  between 12 and 13, and gives the corresponding equations to determine the value of  $\text{Cos } \phi$ .

### Interpretation of the rated operational current of Table 13 and Table 14

Tables 13 and 14 are intended to be used for contactors and starters specified for motor loads. If the contactor or starter is specified with more than one motor load utilization category (AC-2, AC-3, AC-3e or AC-4), the rated operational current  $I_e$  corresponding to the utilization category AC-3 is preferred for determining the prospective current “ $r$ ” for the test.

The utilization category AC-3 is considered as the most representative use case and is deemed to cover the other motor utilization categories.

Withdrawn

## CONTENTS

FOREWORD.....	10
INTRODUCTION.....	13
1 Scope <del>and object</del> .....	14
2 Normative references .....	17
3 Terms, definitions, symbols and abbreviated terms.....	20
3.1 General.....	20
3.2 Alphabetical index of terms.....	20
3.3 Terms and definitions concerning contactors .....	22
3.4 Terms and definitions concerning starters.....	24
3.5 Terms and definitions concerning characteristic quantities.....	29
3.6 Terms and definitions concerning safety aspects .....	30
3.7 Symbols and abbreviated terms .....	31
4 Classification.....	32
5 Characteristics of contactors and starters.....	32
5.1 Summary of characteristics.....	32
5.2 Type of equipment .....	33
5.2.1 Kind of equipment.....	33
5.2.2 Number of poles .....	33
5.2.3 Kind of current (AC or DC).....	33
5.2.4 Interrupting medium (air, oil, gas, vacuum, etc.) .....	33
5.2.5 Operating conditions of the equipment.....	33
5.3 Rated and limiting values for main circuits .....	33
5.3.1 Rated voltages .....	33
5.3.2 Currents or powers .....	35
5.3.3 Rated frequency .....	37
5.3.4 Rated duties .....	37
5.3.5 Normal load and overload characteristics .....	38
5.3.6 Short-circuit characteristics .....	40
5.3.7 Pole impedance of a contactor (Z) .....	40
5.4 Utilization category .....	40
5.4.1 General .....	40
5.4.2 Assignment of utilization categories based on the results of tests .....	41
5.5 Control circuits.....	43
5.6 Auxiliary circuits.....	44
5.7 Characteristics of relay and release of overload relays and motor protective switching device (MPSD) .....	44
5.7.1 Summary of characteristics.....	44
5.7.2 Types of relay or release .....	45
5.7.3 Characteristic values .....	45
5.7.4 Designation and current settings of overload relays .....	47
5.7.5 Time-current characteristics of overload relays .....	47
5.7.6 Influence of ambient air temperature.....	48
5.8 Co-ordination with short-circuit protective devices.....	48
5.9 Void .....	48
5.10 Types and characteristics of automatic change-over devices and automatic acceleration control devices.....	48

5.10.1	Types .....	48
5.10.2	Characteristics.....	48
5.11	Types and characteristics of auto-transformers for two-step auto-transformer starters .....	49
5.12	Types and characteristics of starting resistors for rheostatic rotor starters .....	49
6	Product information .....	49
6.1	Nature of information .....	49
6.1.1	Identification.....	49
6.1.2	Characteristics, basic rated values and utilization.....	50
6.2	Marking.....	51
6.3	Instructions for installation, operation, maintenance, decommissioning and dismantling.....	52
6.4	Environmental information .....	53
7	Normal service, mounting and transport conditions.....	53
8	Constructional and performance requirements.....	53
8.1	Constructional requirements .....	53
8.1.1	General .....	53
8.1.2	Materials .....	54
8.1.3	Current-carrying parts and their connections .....	54
8.1.4	Clearances and creepage distances .....	54
8.1.5	Actuator.....	55
8.1.6	Indication of the contact position .....	55
8.1.7	Additional requirements for equipment suitable for isolation.....	55
8.1.8	Terminals .....	55
8.1.9	Additional requirements for equipment provided with a neutral pole.....	56
8.1.10	Provisions for protective earthing.....	56
8.1.11	Enclosures for equipment.....	56
8.1.12	Degrees of protection of enclosed equipment .....	56
8.1.13	Conduit pull-out, torque and bending with metallic conduits .....	56
8.1.14	Limited energy source .....	56
8.1.15	Stored charge energy circuit.....	58
8.1.16	Fault and abnormal conditions.....	59
8.1.17	Short-circuit and overload protection of ports.....	59
8.2	Performance requirements.....	59
8.2.1	Operating conditions.....	59
8.2.2	Temperature-rise .....	67
8.2.3	Dielectric properties.....	69
8.2.4	Normal load and overload performance requirements .....	70
8.2.5	Co-ordination with short-circuit protective devices .....	80
	<del>Void.....</del>	
	<del>Additional requirements for combination starters and combination switching devices suitable for isolation .....</del>	
8.3	Electromagnetic compatibility (EMC).....	82
8.3.1	General .....	82
8.3.2	Immunity.....	83
8.3.3	Emission.....	83
9	Tests.....	84
9.1	Kinds of test.....	84
9.1.1	General .....	84

9.1.2	Type tests.....	84
9.1.3	Routine tests .....	84
9.1.4	Sampling tests.....	85
9.1.5	Special tests.....	85
9.2	Compliance with constructional requirements.....	86
9.2.1	General .....	86
9.2.2	Electrical performance of screwless-type clamping units.....	86
9.2.3	Ageing test for screwless-type clamping units.....	87
9.2.4	Limited energy source test.....	87
9.2.5	Breakdown of components.....	88
9.3	Compliance with performance requirements.....	88
9.3.1	Test sequences .....	88
9.3.2	General test conditions.....	89
9.3.3	Performance under no load, normal load and overload conditions.....	90
9.3.4	Performance under short-circuit conditions .....	101
9.3.5	Overload current withstand capability of contactors .....	106
9.3.6	Routine tests and sampling tests .....	107
9.4	EMC tests .....	108
9.4.1	General .....	108
9.4.2	Immunity.....	109
9.4.3	Emission.....	111
Annex A (normative) Marking and identification of terminals of contactors, starters and associated overload relays.....		113
A.1	General.....	113
A.2	Marking and identification of terminals of main circuits.....	113
A.3	Marking and identification of terminals of overload relays .....	113
Annex B (normative) Special tests .....		115
B.1	General.....	115
B.2	Mechanical durability .....	115
B.2.1	General .....	115
B.2.2	Verification of mechanical durability.....	115
B.3	Electrical durability .....	117
B.3.1	General .....	117
B.3.2	Results to be obtained .....	118
B.3.3	Statistical analysis of test results for contactors or starters.....	119
B.4	Coordination at the crossover current between the starter and associated SCPD .....	119
B.4.1	General and definitions.....	119
B.4.2	Condition for the test for the verification of co-ordination at the crossover current by a direct method .....	120
B.4.3	Test currents and test circuits.....	120
B.4.4	Test procedure and results to be obtained .....	120
B.4.5	Verification of co-ordination at the crossover current by an indirect method .....	121
Annex C <del>(Void)</del> (informative) Typical characteristics of starters.....		124
Annex D (informative) Items subject to agreement between manufacturer and user .....		131
Annex E <del>(informative) Examples of control circuit configurations</del> (Void) .....		131
Annex F (normative) Requirements for auxiliary contact linked with power contact (mirror contact) .....		133

F.1	Application and object.....	133
F.1.1	Application.....	133
F.1.2	Object.....	133
F.2	Terms and definitions.....	133
F.3	Characteristics.....	133
F.4	Product information.....	133
F.5	Normal service, mounting and transport conditions .....	134
F.6	Constructional and performance requirements .....	134
F.7	Tests .....	134
F.7.1	General .....	134
F.7.2	Tests on products in a new condition .....	134
F.7.3	Test after conventional operational performance (defined under Table 10).....	135
Annex G (informative)	Rated operational currents and rated operational powers of switching devices for electrical motors .....	136
G.1	General.....	136
G.2	Rated operational powers and rated operational currents.....	136
Annex H (normative)	Extended functions <del>within</del> to electronic overload relays.....	140
H.1	General.....	140
H.2	Terms and definitions.....	140
H.3	Limits of operation of control functions.....	140
H.3.1	General .....	140
H.3.2	Limits of electronic overload relay with main circuit under-voltage restarting function.....	140
H.4	Test of the control functions.....	141
Annex I (informative)	AC-1 contactors for use with semiconductor controlled motor load .....	142
Annex J (Void)	.....	143
Annex K (normative)	Procedure to determine data for electromechanical contactors used in functional safety applications.....	144
K.1	General.....	145
K.2	Test requirements.....	145
K.3	Characterization of a failure mode .....	145
K.4	Failure ratios of a contactor .....	146
Annex L (normative)	Assessment procedure for electromechanical overload protection used in safety applications and especially in explosive atmospheres .....	147
L.1	Application and object.....	147
L.1.1	Application.....	147
L.1.2	Object.....	147
L.2	Terms, definitions and symbols .....	147
L.2.1	Terms and definitions .....	147
L.2.2	Symbols and abbreviations .....	148
L.3	Procedure .....	149
L.3.1	General .....	149
L.3.2	Safety design process .....	149
L.4	Requirements .....	150
L.4.1	General .....	150
L.4.2	Safety plan .....	150
L.4.3	Design.....	151

L.4.4	Failure mode and effects analysis of the safety function .....	151
L.4.5	Design plan .....	152
L.4.6	Verification .....	152
L.4.7	Function assessed.....	152
L.5	Documentation.....	152
L.5.1	Technical safety documentation.....	152
L.5.2	Safety instructions .....	152
L.6	Example.....	153
L.6.1	architecture description .....	153
L.6.2	FMEA .....	154
Annex M (normative)	DC contactors for use in photovoltaic (PV) applications .....	162
M.1	Application.....	162
M.2	Object.....	162
M.3	Terms and definitions.....	162
M.4	Classification .....	163
M.5	Characteristics.....	163
M.5.1	General .....	163
M.5.2	Rated impulse withstand voltage.....	163
M.5.3	Utilization category .....	163
M.6	Product information.....	164
M.7	Normal service, mounting and transport conditions .....	164
M.7.1	General .....	164
M.7.2	Ambient air temperature .....	164
M.7.3	Altitude .....	164
M.8	Constructional and performance requirements .....	165
M.8.1	Constructional requirements.....	165
M.8.2	Performance requirements.....	165
M.8.3	Electromagnetic compatibility (EMC) .....	166
M.9	Tests .....	166
M.9.1	General.....	166
M.9.2	Type tests.....	166
M.9.3	Making and breaking capacities and conventional operational performance .....	167
M.9.4	Thermal cycling test.....	167
M.9.5	Climatic test.....	167
M.9.6	Dielectric test .....	167
M.9.7	Critical load current test.....	168
M.9.8	Mechanical properties.....	169
M.9.9	Degree of protection of enclosed contactors .....	170
M.9.10	EMC .....	170
M.9.11	Clearance and creepage distances .....	170
Annex N (normative)	Additional requirements and tests for equipment with protective separation.....	171
N.1	General.....	171
N.2	Definitions.....	171
N.3	Requirements .....	171
N.3.1	Test method for implementing protective impedance.....	171
N.3.2	Touch current measurement .....	172
Annex O (informative)	Load monitoring indicators .....	174



O.1	General.....	174
O.2	Indicators list .....	174
O.3	Uncertainty .....	176
O.4	Tests .....	177
O.4.1	Routine tests .....	177
O.4.2	Type tests.....	177
Annex P	(normative) Short-circuit breaking tests of MPSD .....	179
P.1	General test conditions .....	179
P.2	Rated service short-circuit breaking capacity .....	179
P.2.1	General .....	179
P.2.2	Test of rated service short-circuit breaking capacity.....	180
P.2.3	Verification of operational performance capability .....	180
P.2.4	Verification of dielectric withstand.....	180
P.2.5	Verification of temperature-rise.....	181
P.2.6	Verification of overload releases .....	181
P.3	Rated ultimate short-circuit breaking capacity .....	181
P.3.1	General .....	181
P.3.2	Verification of overload releases .....	181
P.3.3	Test of rated ultimate short-circuit breaking capacity .....	182
P.3.4	Verification of dielectric withstand.....	182
P.3.5	Verification of overload releases.....	182
P.4	Test of MPSD for IT system .....	182
P.4.1	General .....	182
P.4.2	Individual pole short-circuit.....	182
P.4.3	Verification of dielectric withstand.....	183
P.4.4	Verification of overload releases.....	183
P.4.5	Marking .....	183
Annex Q	(normative) Co-ordination under short-circuit conditions between a MPSD and another short-circuit protective device associated in the same circuit.....	184
Q.1	Application.....	184
Q.2	Object.....	184
Q.3	General requirements for the co-ordination of a MPSD with another SCPD .....	185
Q.3.1	General considerations .....	185
Q.3.2	Behaviour of $C_1$ in association with another SCPD .....	185
Q.4	Type and characteristics of the associated SCPD .....	185
Q.5	Verification of selectivity .....	186
Q.5.1	General .....	186
Q.5.2	Consideration of selectivity by desk study.....	186
Q.5.3	Selectivity determined by test .....	187
Bibliography	.....	192
Figure 1	– Multiple of current setting limits for ambient air temperature compensated time-delay overload relays .....	64
Figure 2	– Thermal memory test .....	65
Figure 3	– Examples of co-ordination characteristics of a starter.....	81
Figure 4	– Voltage drop measurement at contact point of the clamping terminal .....	87
Figure 5	– Example of a pole impedance measurement for a 3 pole contactor .....	92
Figure A.1	– Main circuit .....	113

Figure A.2 – Overload relays .....	114
Figure B.1 – Examples of time-current withstand characteristic.....	123
Figure C.1 – Typical curves of currents and torques during a star-delta start (see 3.4.4.1) .....	124
Figure C.2 – Typical curves of currents and torques during an auto-transformer start (see 3.4.4.2) .....	125
Figure C.3 – Typical variants of protected starters, combination starters, protected switching devices and combination switching devices .....	126
Figure C.4 – Example of three-phase diagram of a rheostatic rotor starter with three starting steps and one direction of rotation (in the case when all the mechanical switching devices are contactors) .....	127
Figure C.5 – Typical methods and diagrams of starting alternating-current induction motors by means of auto-transformers .....	129
Figure C.6 – Examples of speed/time curves corresponding to cases a), b), c), d), e) and f) of 5.3.5.6.1 .....	130
Figure F.1 – Mirror contact.....	134
Figure L.1 – Safety design process .....	150
Figure L.2 – Typical structure of a thermal overload relay.....	153
Figure L.3 – typical structure of MPSD.....	154
Figure M.1 – Critical current.....	168
Figure N.1 – Protection by means of protective impedance .....	172
Figure N.2 – Measuring instrument .....	173
Figure O.1 – Example of quantification of a process change .....	176
Figure Q.1 – Over-current co-ordination between a MPSD and a fuse or back-up protection by a fuse: operating characteristics .....	189
Figure Q.2 – Total selectivity between MPSD and circuit-breakers – Case 1 .....	190
Figure Q.3 – Total selectivity between MPSD and circuit-breakers – Case 2.....	190
Figure Q.4 – Back-up protection by a circuit-breaker – Operating characteristics – Case 1 .....	191
Figure Q.5 – Back-up protection by a circuit-breaker – Operating characteristics – Case 2.....	191
Table 1 – Utilization categories .....	42
Table 2 – Trip classes of overload relays .....	46
Table 3 – Limits of operation of time-delay overload relays when energized on all poles.....	63
Table 4 – Limits of operation of three-pole time-delay overload relays when energized on two poles only.....	66
Table 5 – Temperature-rise limits for insulated coils in air and in oil .....	68
Table 6 – Intermittent duty test cycle data.....	69
Table 7 – Making and breaking capacities – Making and breaking conditions according to utilization category.....	71
Table 8 – Relationship between the test current <del>broken</del> $I_c$ and off-time for the verification of rated making and breaking capacities .....	75
Table 9 – Operational current determination for utilization categories AC-6a and AC-6b when derived from AC-3 ratings .....	76
Table 10 – Conventional operational performance – Making and breaking conditions according to utilization category.....	77

Table 11 – Overload current withstand requirements .....	79
Table 12 – Specific acceptance criteria for immunity tests .....	83
Table 13 – Value of the prospective test current according to the rated operational current .....	103
Table 14 – Value of the prospective test current according to the rated operational current (harmonized table) .....	104
Table 15 – Test conditions for $I_{cd}$ .....	82
Table 16 – EMC immunity tests .....	109
Table 17 – Terminal disturbance voltage limits for conducted radio-frequency emission <b>test limits</b> (for mains ports) .....	111
Table 18 – Radiated emission test limits .....	112
Table 19 – Limits for limited energy sources without an over-current protective device .....	57
Table 20 – Limits for limited energy sources with an over-current protective device .....	57
Table 21 – Limits for limited energy source with current limiting impedance .....	58
Table B.1 – Verification of the number of on-load operating cycles – Conditions for making and breaking corresponding to the several utilization categories .....	118
Table B.2 – Test conditions .....	121
Table F.1 – Test voltage according to altitude .....	135
Table G.1 – Rated operational powers and rated operational currents of motors .....	137
Table K.1 – Failure mode of contactors .....	146
Table K.2 – Typical failure ratios for normally open contactors .....	146
Table L.1 – Severity .....	154
Table L.2 – Occurrence .....	155
Table L.3 – Detection levels .....	155
Table L.4 – Conclusion .....	156
Table L.5 – Example of failure mode and effects analysis for thermal overload relay .....	157
Table M.1 – Rated impulse voltage levels for PV contactors .....	163
Table M.2 – Utilization categories .....	163
Table M.3 – Ambient air temperature conditions .....	164
Table M.4 – Verification of rated making and breaking capacities – Conditions for making and breaking corresponding to the DC-PV category .....	165
Table M.5 – Conventional operational performance – Making and breaking condition corresponding to the DC-PV category .....	166
Table M.6 – Overall scheme of test sequences .....	167
Table M.7 – Number of operating cycles corresponding to the critical load current .....	169
Table M.8 – Critical load current performance .....	169
Table O.1 – AC monitoring indicators list .....	175
Table O.2 – Different possibilities authorized for verification of indicators .....	177
Table O.3 – Reference for verification conditions .....	178
Table O.4 – Harmonic levels .....	178

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

#### FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

**This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.**

International Standard IEC 60947-4-1 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

This fourth edition cancels and replaces the third edition published in 2009 and its Amendment 1:2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- Scope structure and exclusions
- Editorial correction of notes and hanging paragraphs
- Reference to IEC 62683-1
- Motor protective switching device (MPSD) with its requirements
- Safety aspects related to:
  - General aspects;
  - Limited energy circuits;
  - Electronic circuits;
  - Assessment procedure for electromechanical overload protection used in safety - applications (new Annex L)
- Introduction of provisions covering the impact of higher locked rotor current to achieve high efficiency class
- Mention of dedicated wiring accessories
- Pickup power measurement
- Alignment to IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010, and IEC 60947-1:2007/AMD2:2014
- Direct current requirements for covering photovoltaic application (new Annex M)
- Load monitoring indicators (new Annex O)
- Short-circuit breaking tests of MPSD (new Annex P)
- Co-ordination under short-circuit conditions between a MPSD and another short-circuit protective device associated in the same circuit (new Annex Q)

The text of this International Standard is based on the following documents:

FDIS	Report on voting
121A/224/FDIS	121A/233/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60947 series can be found, under the general title *Low-voltage switchgear and controlgear*, on the IEC website.

This document shall be read in conjunction with IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010, IEC 60947-1:2007/AMD2:2014, *Low voltage switchgear and controlgear – Part 1: General rules*. The provisions of the general rules are applicable to this document, where specifically called for.

The provisions of the general rules dealt with IEC 60947-1 are applicable to this part of IEC 60947 series where specifically called for. Clauses and subclauses, tables, figures and annexes of the general rules thus applicable are identified by reference to IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010, and IEC 60947-1:2007/AMD2:2014. For example, 4.3.4.1 of IEC 60947-1:2007, Table 4 of IEC 60947-1:2007, or Annex A of IEC 60947-1:2007.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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

The contents of the interpretation sheet of March 2020 have been included in this copy.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

The contents of the corrigenda 1 (2020-04) and 2 (2021-04) have been included in this copy.

Withdrawn

## INTRODUCTION

This document introduces the requirements for motor protection switching devices (MPSD).

MPSDs have been available on the market for many years. They are introduced in this document for covering the minimum safety and performance requirements of a manual motor starter with integral electromechanical or electronic short-circuit protection. This device fulfils all requirements of a starter and specific requirements of a circuit-breaker according to IEC 60947-2, mainly  $I_{CU}$  and  $I_{CS}$ , for protecting the motor and its circuit with control devices e.g. a contactor. An MPSD is not intended to support neutral pole, DC ratings, rated uninterrupted current  $I_U$ , backup protection, short-circuit tripping time-delay, selectivity category, withdrawable capability, RCD, recloser, EMC requirements of IEC 60947-2, etc.

Circuit-breakers according to Annex O of IEC 60947-2:2016 with motor overload protection characteristic according to this document but without starter ratings e.g. AC-3 are also available on the market. These devices are not covered by this document.

Withdrawal

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

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

~~NOTE This requirement is based on the fact that the electric stresses are less severe in the rotor than in the stator and are of short duration.~~

~~This standard applies also to starters for two directions of rotation when reversal of connections is made with the motor stopped (see 5.3.5.5). Operations including inching and plugging necessitate additional requirements and 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.~~

This part of IEC 60947 is applicable to the following equipment:

- electromechanical contactors and starters including motor protective switching device (MPSD);
- actuators of contactor relays;
- contacts dedicated exclusively to the coil circuit of this contactor or this contactor relay;
- dedicated accessories (e.g. dedicated wiring, dedicated latch accessory);

intended to be connected to distribution circuits, motors circuits and other load circuits, the rated voltage of which does not exceed 1 000 V AC or 1 500 V DC.

This document covers also the assessment procedure for electromechanical overload protection used in safety applications such as protecting a motor located in explosive atmosphere from the outside atmosphere: See Annex L.

This document does not apply to:

- starters for DC motors<sup>1</sup>;  
NOTE 1 The requirements for DC motor starters are under consideration for the next maintenance cycle.
- auxiliary contacts of contactors and contacts of contactor relays. These are covered by IEC 60947-5-1;
- starter used downstream to frequency drive<sup>1</sup>;  
NOTE 2 Additional requirements for starter used downstream to frequency drive are under consideration for the next maintenance cycle.
- short-circuit protective device integrated within starters other than MPSDs. This is covered by IEC 60947-2 and IEC 60947-3;
- the use of the product with additional measure within explosive atmospheres. These are given in IEC 60079 series;
- embedded software design rules<sup>1</sup>;
- cyber security aspects. These are covered by IEC 62443 series.

The objective of this document is to state:

- a) the characteristics of the equipment;
- b) the conditions applicable to the equipment with reference to:
  - 1) its operation and behaviour,
  - 2) its dielectric properties,
  - 3) its degree of protection,
  - 4) its construction including safety measures against electric shock, fire hazard and mechanical hazard;
- 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 documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition

<sup>1</sup> For this subject the manufacturer is responsible for taking additional safety measures.

cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60034-1:2004 2017, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-12:2016, *Rotating electrical machines – Part 12: Starting performance of single-speed three-phase cage induction motors*

IEC 60034-30-1, *Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)*

IEC 60038, *IEC standard voltages*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60079-14, *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

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 60364-1:2005, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-7-712, *Low voltage electrical installations – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems*

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

IEC 60715:2017, *Dimensions of low-voltage switchgear and controlgear – Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories*

IEC 60730-1, *Automatic electrical controls – Part 1: General requirements*

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

IEC 60947-1:2007/AMD1:2010

IEC 60947-1:2007/AMD2:2014

IEC 60947-2:2006 2016, *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 2016, *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~~

IEC 61000-6-2, Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments

IEC 61051-2, Varistors for use in electronic equipment – Part 2: Sectional specification for surge suppression varistors

IEC 61140:2016, Protection against electric shock – Common aspects for installation and equipment

IEC 61439 (all parts), Low-voltage switchgear and controlgear assemblies

~~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~~

~~IEC 61649:2008, Weibull analysis~~

~~IEC 61810-1:2008, Electromechanical elementary relays – Part 1: General and safety requirements (available in English only)~~

~~IEC 62061:2005, Safety of machinery – Functional safety of safety-related electrical, electronic and programmable electronic control systems~~

~~CISPR 11:2003, Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement – Amendment 1 (2004) – Amendment 2 (2006)~~

CISPR 11:2015, Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement  
CISPR 11:2015/AMD1:2016

~~ISO 13849-1:2006, Safety of machinery – Safety-related parts of control systems – Part 1: General principles for design~~

ISO 2859-1:1999, Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection

ISO 3864-2, *Graphical symbols – Safety colours and safety signs – Part 2: Design principles for product safety labels*

Withdrawn

# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Low-voltage switchgear and controlgear –  
Part 4-1: Contactors and motor-starters – Electromechanical contactors and  
motor-starters**

**Appareillage à basse tension –  
Partie 4-1: Contacteurs et démarreurs de moteurs – Contacteurs et démarreurs  
électromécaniques**

WITKOLOAN

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**IEC 60947-4-1**  
Edition 4.0 2018-10

**LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –**

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

**INTERPRETATION SHEET 1**

This interpretation sheet has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

The text of this interpretation sheet is based on the following documents:

DISH	Report on voting
121A/336/DISH	121A/342/RVDISH

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

**Interpretation of the first paragraph of 6.2**

The reference to 5.2 of IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010 is intended to cover the whole subclause where its first paragraph can be discarded.

In particular, the third paragraph of this Subclause 5.2 requiring the marking on the equipment of manufacturer's name or trademark and type designation or serial number is covering items a) and b) of 6.1.1 of IEC 60947-4-1:2018.

**Interpretation of footnotes <sup>n</sup> and <sup>o</sup> of Table 7**

The standard making conditions for the utilization category AC-3e are defined by the ratio  $I / I_e$  equal to 12 with the corresponding value of  $\text{Cos } \phi$  in footnote <sup>o</sup>.

Footnote <sup>n</sup> provides the possibility to select an alternate value of the ratio  $I / I_e$  between 12 and 13, and gives the corresponding equations to determine the value of  $\text{Cos } \phi$ .



### Interpretation of the rated operational current of Table 13 and Table 14

Tables 13 and 14 are intended to be used for contactors and starters specified for motor loads. If the contactor or starter is specified with more than one motor load utilization category (AC-2, AC-3, AC-3e or AC-4), the rated operational current  $I_e$  corresponding to the utilization category AC-3 is preferred for determining the prospective current “ $r$ ” for the test.

The utilization category AC-3 is considered as the most representative use case and is deemed to cover the other motor utilization categories.

Withdrawn

## CONTENTS

FOREWORD.....	10
INTRODUCTION.....	13
1 Scope.....	14
2 Normative references .....	15
3 Terms, definitions, symbols and abbreviated terms.....	16
3.1 General.....	16
3.2 Alphabetical index of terms .....	16
3.3 Terms and definitions concerning contactors .....	18
3.4 Terms and definitions concerning starters.....	19
3.5 Terms and definitions concerning characteristic quantities.....	25
3.6 Terms and definitions concerning safety aspects .....	26
3.7 Symbols and abbreviated terms .....	27
4 Classification.....	28
5 Characteristics of contactors and starters .....	28
5.1 Summary of characteristics.....	28
5.2 Type of equipment .....	29
5.2.1 Kind of equipment.....	29
5.2.2 Number of poles .....	29
5.2.3 Kind of current (AC or DC).....	29
5.2.4 Interrupting medium (air, oil, gas, vacuum, etc.) .....	29
5.2.5 Operating conditions of the equipment.....	29
5.3 Rated and limiting values for main circuits .....	29
5.3.1 Rated voltages .....	29
5.3.2 Currents or powers .....	31
5.3.3 Rated frequency .....	32
5.3.4 Rated duties .....	32
5.3.5 Normal load and overload characteristics .....	33
5.3.6 Short-circuit characteristics .....	35
5.3.7 Pole impedance of a contactor ( $Z$ ) .....	36
5.4 Utilization category .....	36
5.4.1 General .....	36
5.4.2 Assignment of utilization categories based on the results of tests .....	36
5.5 Control circuits.....	38
5.6 Auxiliary circuits.....	39
5.7 Characteristics of relay and release of overload relays and motor protective switching device (MPSD) .....	39
5.7.1 Summary of characteristics.....	39
5.7.2 Types of relay or release .....	39
5.7.3 Characteristic values .....	39
5.7.4 Designation and current settings of overload relays .....	41
5.7.5 Time-current characteristics of overload relays .....	41
5.7.6 Influence of ambient air temperature.....	42
5.8 Co-ordination with short-circuit protective devices.....	42
5.9 Void .....	42
5.10 Types and characteristics of automatic change-over devices and automatic acceleration control devices.....	42

5.10.1	Types .....	42
5.10.2	Characteristics.....	42
5.11	Types and characteristics of auto-transformers for two-step auto-transformer starters .....	43
5.12	Types and characteristics of starting resistors for rheostatic rotor starters .....	43
6	Product information .....	43
6.1	Nature of information .....	43
6.1.1	Identification.....	43
6.1.2	Characteristics, basic rated values and utilization.....	43
6.2	Marking.....	44
6.3	Instructions for installation, operation, maintenance, decommissioning and dismantling .....	46
6.4	Environmental information .....	46
7	Normal service, mounting and transport conditions.....	46
8	Constructional and performance requirements.....	47
8.1	Constructional requirements .....	47
8.1.1	General .....	47
8.1.2	Materials .....	47
8.1.3	Current-carrying parts and their connections .....	48
8.1.4	Clearances and creepage distances .....	48
8.1.5	Actuator.....	48
8.1.6	Indication of the contact position .....	49
8.1.7	Additional requirements for equipment suitable for isolation.....	49
8.1.8	Terminals .....	49
8.1.9	Additional requirements for equipment provided with a neutral pole .....	49
8.1.10	Provisions for protective earthing.....	49
8.1.11	Enclosures for equipment.....	49
8.1.12	Degrees of protection of enclosed equipment .....	50
8.1.13	Conduit pull-out, torque and bending with metallic conduits .....	50
8.1.14	Limited energy source .....	50
8.1.15	Stored charge energy circuit.....	52
8.1.16	Fault and abnormal conditions .....	52
8.1.17	Short-circuit and overload protection of ports.....	53
8.2	Performance requirements.....	53
8.2.1	Operating conditions.....	53
8.2.2	Temperature-rise .....	59
8.2.3	Dielectric properties.....	61
8.2.4	Normal load and overload performance requirements .....	62
8.2.5	Co-ordination with short-circuit protective devices .....	68
8.3	Electromagnetic compatibility (EMC).....	71
8.3.1	General .....	71
8.3.2	Immunity.....	71
8.3.3	Emission.....	72
9	Tests .....	72
9.1	Kinds of test.....	72
9.1.1	General .....	72
9.1.2	Type tests.....	73
9.1.3	Routine tests .....	73

9.1.4	Sampling tests.....	73
9.1.5	Special tests.....	74
9.2	Compliance with constructional requirements.....	75
9.2.1	General.....	75
9.2.2	Electrical performance of screwless-type clamping units.....	75
9.2.3	Ageing test for screwless-type clamping units.....	75
9.2.4	Limited energy source test.....	76
9.2.5	Breakdown of components.....	76
9.3	Compliance with performance requirements.....	77
9.3.1	Test sequences.....	77
9.3.2	General test conditions.....	78
9.3.3	Performance under no load, normal load and overload conditions.....	78
9.3.4	Performance under short-circuit conditions.....	90
9.3.5	Overload current withstand capability of contactors.....	95
9.3.6	Routine tests and sampling tests.....	95
9.4	EMC tests.....	97
9.4.1	General.....	97
9.4.2	Immunity.....	97
9.4.3	Emission.....	99
Annex A (normative) Marking and identification of terminals of contactors, starters and associated overload relays.....		101
A.1	General.....	101
A.2	Marking and identification of terminals of main circuits.....	101
A.3	Marking and identification of terminals of overload relays.....	101
Annex B (normative) Special tests.....		103
B.1	General.....	103
B.2	Mechanical durability.....	103
B.2.1	General.....	103
B.2.2	Verification of mechanical durability.....	103
B.3	Electrical durability.....	105
B.3.1	General.....	105
B.3.2	Results to be obtained.....	106
B.3.3	Statistical analysis of test results for contactors or starters.....	106
B.4	Coordination at the crossover current between the starter and associated SCPD.....	107
B.4.1	General and definitions.....	107
B.4.2	Condition for the test for the verification of co-ordination at the crossover current by a direct method.....	108
B.4.3	Test currents and test circuits.....	108
B.4.4	Test procedure and results to be obtained.....	108
B.4.5	Verification of co-ordination at the crossover current by an indirect method.....	108
Annex C (informative) Typical characteristics of starters.....		111
Annex D (informative) Items subject to agreement between manufacturer and user.....		118
Annex E (Void).....		119
Annex F (normative) Requirements for auxiliary contact linked with power contact (mirror contact).....		120
F.1	Application and object.....	120
F.1.1	Application.....	120

F.1.2	Object.....	120
F.2	Terms and definitions.....	120
F.3	Characteristics.....	120
F.4	Product information.....	120
F.5	Normal service, mounting and transport conditions .....	121
F.6	Constructional and performance requirements .....	121
F.7	Tests .....	121
F.7.1	General .....	121
F.7.2	Tests on products in a new condition .....	121
F.7.3	Test after conventional operational performance (defined under Table 13).....	122
Annex G (informative)	Rated operational currents and rated operational powers of switching devices for electrical motors .....	123
G.1	General.....	123
G.2	Rated operational powers and rated operational currents.....	123
Annex H (normative)	Extended functions to electronic overload relays.....	127
H.1	General.....	127
H.2	Terms and definitions.....	127
H.3	Limits of operation of control functions.....	127
H.3.1	General .....	127
H.3.2	Limits of electronic overload relay with main circuit under-voltage restarting function.....	127
H.4	Test of the control functions .....	128
Annex I (informative)	AC-1 contactors for use with semiconductor controlled motor load .....	129
Annex J (Void)	.....	130
Annex K (normative)	Procedure to determine data for electromechanical contactors used in functional safety applications.....	131
K.1	General.....	131
K.2	Test requirements .....	131
K.3	Characterization of a failure mode .....	131
K.4	Failure ratios of a contactor .....	131
Annex L (normative)	Assessment procedure for electromechanical overload protection used in safety applications and especially in explosive atmospheres .....	133
L.1	Application and object.....	133
L.1.1	Application.....	133
L.1.2	Object.....	133
L.2	Terms, definitions and symbols .....	133
L.2.1	Terms and definitions .....	133
L.2.2	Symbols and abbreviations .....	134
L.3	Procedure .....	135
L.3.1	General .....	135
L.3.2	Safety design process .....	135
L.4	Requirements .....	136
L.4.1	General .....	136
L.4.2	Safety plan .....	136
L.4.3	Design .....	137
L.4.4	Failure mode and effects analysis of the safety function .....	137
L.4.5	Design plan .....	138

L.4.6	Verification .....	138
L.4.7	Function assessed.....	138
L.5	Documentation.....	138
L.5.1	Technical safety documentation.....	138
L.5.2	Safety instructions .....	138
L.6	Example.....	139
L.6.1	architecture description .....	139
L.6.2	FMEA .....	140
Annex M (normative)	DC contactors for use in photovoltaic (PV) applications .....	148
M.1	Application.....	148
M.2	Object.....	148
M.3	Terms and definitions.....	148
M.4	Classification .....	149
M.5	Characteristics.....	149
M.5.1	General .....	149
M.5.2	Rated impulse withstand voltage.....	149
M.5.3	Utilization category .....	149
M.6	Product information.....	150
M.7	Normal service, mounting and transport conditions.....	150
M.7.1	General .....	150
M.7.2	Ambient air temperature.....	150
M.7.3	Altitude .....	150
M.8	Constructional and performance requirements .....	151
M.8.1	Constructional requirements.....	151
M.8.2	Performance requirements.....	151
M.8.3	Electromagnetic compatibility (EMC) .....	152
M.9	Tests .....	152
M.9.1	General .....	152
M.9.2	Type tests.....	152
M.9.3	Making and breaking capacities and conventional operational performance .....	153
M.9.4	Thermal cycling test.....	153
M.9.5	Climatic test.....	153
M.9.6	Dielectric test .....	153
M.9.7	Critical load current test.....	154
M.9.8	Mechanical properties.....	155
M.9.9	Degree of protection of enclosed contactors .....	156
M.9.10	EMC .....	156
M.9.11	Clearance and creepage distances .....	156
Annex N (normative)	Additional requirements and tests for equipment with protective separation.....	157
N.1	General.....	157
N.2	Definitions.....	157
N.3	Requirements .....	157
N.3.1	Test method for implementing protective impedance.....	157
N.3.2	Touch current measurement .....	158
Annex O (informative)	Load monitoring indicators .....	160
O.1	General.....	160
O.2	Indicators list .....	160

O.3	Uncertainty .....	162
O.4	Tests .....	163
O.4.1	Routine tests .....	163
O.4.2	Type tests.....	163
Annex P (normative)	Short-circuit breaking tests of MPSD .....	165
P.1	General test conditions .....	165
P.2	Rated service short-circuit breaking capacity .....	165
P.2.1	General .....	165
P.2.2	Test of rated service short-circuit breaking capacity.....	166
P.2.3	Verification of operational performance capability .....	166
P.2.4	Verification of dielectric withstand.....	166
P.2.5	Verification of temperature-rise.....	167
P.2.6	Verification of overload releases .....	167
P.3	Rated ultimate short-circuit breaking capacity .....	167
P.3.1	General .....	167
P.3.2	Verification of overload releases .....	167
P.3.3	Test of rated ultimate short-circuit breaking capacity.....	168
P.3.4	Verification of dielectric withstand.....	168
P.3.5	Verification of overload releases.....	168
P.4	Test of MPSD for IT system.....	168
P.4.1	General .....	168
P.4.2	Individual pole short-circuit.....	168
P.4.3	Verification of dielectric withstand.....	169
P.4.4	Verification of overload releases.....	169
P.4.5	Marking.....	169
Annex Q (normative)	Co-ordination under short-circuit conditions between a MPSD and another short-circuit protective device associated in the same circuit.....	170
Q.1	Application .....	170
Q.2	Object.....	170
Q.3	General requirements for the co-ordination of a MPSD with another SCPD .....	171
Q.3.1	General considerations .....	171
Q.3.2	Behaviour of $C_1$ in association with another SCPD .....	171
Q.4	Type and characteristics of the associated SCPD .....	171
Q.5	Verification of selectivity .....	172
Q.5.1	General .....	172
Q.5.2	Consideration of selectivity by desk study.....	172
Q.5.3	Selectivity determined by test .....	173
Bibliography.....		178
Figure 1	– Multiple of current setting limits for ambient air temperature compensated time-delay overload relays .....	56
Figure 2	– Thermal memory test .....	57
Figure 3	– Examples of co-ordination characteristics of a starter.....	70
Figure 4	– Voltage drop measurement at contact point of the clamping terminal .....	75
Figure 5	– Example of a pole impedance measurement for a 3 pole contactor .....	81
Figure A.1	– Main circuit .....	101
Figure A.2	– Overload relays .....	102

Figure B.1 – Examples of time-current withstand characteristic.....	110
Figure C.1 – Typical curves of currents and torques during a star-delta start (see 3.4.4.1) .....	111
Figure C.2 – Typical curves of currents and torques during an auto-transformer start (see 3.4.4.2) .....	112
Figure C.3 – Typical variants of protected starters, combination starters, protected switching devices and combination switching devices .....	113
Figure C.4 – Example of three-phase diagram of a rheostatic rotor starter with three starting steps and one direction of rotation (in the case when all the mechanical switching devices are contactors) .....	114
Figure C.5 – Typical methods and diagrams of starting alternating-current induction motors by means of auto-transformers .....	116
Figure C.6 – Examples of speed/time curves corresponding to cases a), b), c), d), e) and f) of 5.3.5.6.1 .....	117
Figure F.1 – Mirror contact.....	121
Figure L.1 – Safety design process .....	136
Figure L.2 – Typical structure of a thermal overload relay .....	139
Figure L.3 – typical structure of MPSD .....	140
Figure M.1 – Critical current.....	154
Figure N.1 – Protection by means of protective impedance .....	158
Figure N.2 – Measuring instrument .....	159
Figure O.1 – Example of quantification of a process change .....	162
Figure Q.1 – Over-current co-ordination between a MPSD and a fuse or back-up protection by a fuse: operating characteristics .....	175
Figure Q.2 – Total selectivity between MPSD and circuit-breakers – Case 1 .....	176
Figure Q.3 – Total selectivity between MPSD and circuit-breakers – Case 2 .....	176
Figure Q.4 – Back-up protection by a circuit-breaker – Operating characteristics – Case 1 .....	177
Figure Q.5 – Back-up protection by a circuit-breaker – Operating characteristics – Case 2 .....	177
Table 1 – Utilization categories .....	38
Table 2 – Trip classes of overload relays .....	41
Table 3 – Limits of operation of time-delay overload relays when energized on all poles.....	55
Table 4 – Limits of operation of three-pole time-delay overload relays when energized on two poles only .....	58
Table 5 – Temperature-rise limits for insulated coils in air and in oil .....	60
Table 6 – Intermittent duty test cycle data.....	61
Table 7 – Making and breaking capacities – Making and breaking conditions according to utilization category .....	63
Table 8 – Relationship between the test current and off-time for the verification of rated making and breaking capacities .....	65
Table 9 – Operational current determination for utilization categories AC-6a and AC-6b when derived from AC-3 ratings .....	65
Table 10 – Conventional operational performance – Making and breaking conditions according to utilization category .....	66
Table 11 – Overload current withstand requirements .....	68



Table 12 – Specific acceptance criteria for immunity tests .....	72
Table 13 – Value of the prospective test current according to the rated operational current .....	92
Table 14 – Value of the prospective test current according to the rated operational current (harmonized table) .....	92
Table 15 – Test conditions for $I_{cd}$ .....	70
Table 16 – EMC immunity tests .....	97
Table 17 – Terminal disturbance voltage limits for conducted radio-frequency emission (for mains ports) .....	99
Table 18 – Radiated emission test limits .....	100
Table 19 – Limits for limited energy sources without an over-current protective device .....	51
Table 20 – Limits for limited energy sources with an over-current protective device .....	51
Table 21 – Limits for limited energy source with current limiting impedance .....	52
Table B.1 – Verification of the number of on-load operating cycles – Conditions for making and breaking corresponding to the several utilization categories .....	106
Table B.2 – Test conditions .....	109
Table F.1 – Test voltage according to altitude .....	122
Table G.1 – Rated operational powers and rated operational currents of motors .....	124
Table K.1 – Failure mode of contactors .....	131
Table K.2 – Typical failure ratios for normally open contactors .....	132
Table L.1 – Severity .....	140
Table L.2 – Occurrence .....	141
Table L.3 – Detection levels .....	141
Table L.4 – Conclusion .....	142
Table L.5 – Example of failure mode and effects analysis for thermal overload relay .....	143
Table M.1 – Rated impulse voltage levels for PV contactors .....	149
Table M.2 – Utilization categories .....	149
Table M.3 – Ambient air temperature conditions .....	150
Table M.4 – Verification of rated making and breaking capacities – Conditions for making and breaking corresponding to the DC-PV category .....	151
Table M.5 – Conventional operational performance – Making and breaking condition corresponding to the DC-PV category .....	152
Table M.6 – Overall scheme of test sequences .....	153
Table M.7 – Number of operating cycles corresponding to the critical load current .....	155
Table M.8 – Critical load current performance .....	155
Table O.1 – AC monitoring indicators list .....	161
Table O.2 – Different possibilities authorized for verification of indicators .....	163
Table O.3 – Reference for verification conditions .....	164
Table O.4 – Harmonic levels .....	164

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

#### FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60947-4-1 has been prepared by subcommittee 121A: Low-voltage switchgear and controlgear, of IEC technical committee 121: Switchgear and controlgear and their assemblies for low voltage.

This fourth edition cancels and replaces the third edition published in 2009 and its Amendment 1:2012. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- Scope structure and exclusions
- Editorial correction of notes and hanging paragraphs
- Reference to IEC 62683-1
- Motor protective switching device (MPSD) with its requirements

- Safety aspects related to:
  - General aspects;
  - Limited energy circuits;
  - Electronic circuits;
  - Assessment procedure for electromechanical overload protection used in safety - applications (new Annex L)
- Introduction of provisions covering the impact of higher locked rotor current to achieve high efficiency class
- Mention of dedicated wiring accessories
- Pickup power measurement
- Alignment to IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010, and IEC 60947-1:2007/AMD2:2014
- Direct current requirements for covering photovoltaic application (new Annex M)
- Load monitoring indicators (new Annex O)
- Short-circuit breaking tests of MPSD (new Annex P)
- Co-ordination under short-circuit conditions between a MPSD and another short-circuit protective device associated in the same circuit (new Annex Q)

The text of this International Standard is based on the following documents:

FDIS	Report on voting
121A/224/FDIS	121A/233/RVD

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

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of the IEC 60947 series can be found, under the general title *Low-voltage switchgear and controlgear*, on the IEC website.

This document shall be read in conjunction with IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010, IEC 60947-1:2007/AMD2:2014, *Low voltage switchgear and controlgear – Part 1: General rules*. The provisions of the general rules are applicable to this document, where specifically called for.

The provisions of the general rules dealt with IEC 60947-1 are applicable to this part of IEC 60947 series where specifically called for. Clauses and subclauses, tables, figures and annexes of the general rules thus applicable are identified by reference to IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010, and IEC 60947-1:2007/AMD2:2014. For example, 4.3.4.1 of IEC 60947-1:2007, Table 4 of IEC 60947-1:2007, or Annex A of IEC 60947-1:2007.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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

The contents of the interpretation sheet of March 2020 have been included in this copy.

The contents of the corrigenda 1 (2020-04) and 2 (2021-04) have been included in this copy.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

Withdrawn

## INTRODUCTION

This document introduces the requirements for motor protection switching devices (MPSD).

MPSDs have been available on the market for many years. They are introduced in this document for covering the minimum safety and performance requirements of a manual motor starter with integral electromechanical or electronic short-circuit protection. This device fulfils all requirements of a starter and specific requirements of a circuit-breaker according to IEC 60947-2, mainly  $I_{CU}$  and  $I_{CS}$ , for protecting the motor and its circuit with control devices e.g. a contactor. An MPSD is not intended to support neutral pole, DC ratings, rated uninterrupted current  $I_U$ , backup protection, short-circuit tripping time-delay, selectivity category, withdrawable capability, RCD, recloser, EMC requirements of IEC 60947-2, etc.

Circuit-breakers according to Annex O of IEC 60947-2:2016 with motor overload protection characteristic according to this document but without starter ratings e.g. AC-3 are also available on the market. These devices are not covered by this document.

Withdrawal

## LOW-VOLTAGE SWITCHGEAR AND CONTROLGEAR –

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

#### 1 Scope

This part of IEC 60947 is applicable to the following equipment:

- electromechanical contactors and starters including motor protective switching device (MPSD);
- actuators of contactor relays;
- contacts dedicated exclusively to the coil circuit of this contactor or this contactor relay;
- dedicated accessories (e.g. dedicated wiring, dedicated latch accessory);

intended to be connected to distribution circuits, motors circuits and other load circuits, the rated voltage of which does not exceed 1 000 V AC or 1 500 V DC.

This document covers also the assessment procedure for electromechanical overload protection used in safety applications such as protecting a motor located in explosive atmosphere from the outside atmosphere: See Annex L.

This document does not apply to:

- starters for DC motors<sup>1</sup>;  
NOTE 1 The requirements for DC motor starters are under consideration for the next maintenance cycle.
- auxiliary contacts of contactors and contacts of contactor relays. These are covered by IEC 60947-5-1;
- starter used downstream to frequency drive<sup>1</sup>;  
NOTE 2 Additional requirements for starter used downstream to frequency drive are under consideration for the next maintenance cycle.
- short-circuit protective device integrated within starters other than MPSDs. This is covered by IEC 60947-2 and IEC 60947-3;
- the use of the product with additional measure within explosive atmospheres. These are given in IEC 60079 series;
- embedded software design rules<sup>1</sup>;
- cyber security aspects. These are covered by IEC 62443 series.

The objective of this document is to state:

- a) the characteristics of the equipment;
- b) the conditions applicable to the equipment with reference to:
  - 1) its operation and behaviour,
  - 2) its dielectric properties,
  - 3) its degree of protection,

---

<sup>1</sup> For this subject the manufacturer is responsible for taking additional safety measures.

- 4) its construction including safety measures against electric shock, fire hazard and mechanical hazard;
- 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 documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 60034-1:2017, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-12:2016, *Rotating electrical machines – Part 12: Starting performance of single-speed three-phase cage induction motors*

IEC 60034-30-1, *Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors (IE code)*

IEC 60038, *IEC standard voltages*

IEC 60068-2-14:2009, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60079-14, *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

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

IEC 60364-1:2005, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-7-712, *Low voltage electrical installations – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems*

IEC 60715:2017, *Dimensions of low-voltage switchgear and controlgear – Standardized mounting on rails for mechanical support of switchgear, controlgear and accessories*

IEC 60730-1, *Automatic electrical controls – Part 1: General requirements*

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

IEC 60947-1:2007/AMD1:2010

IEC 60947-1:2007/AMD2:2014

IEC 60947-2:2016, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 60947-5-1:2016, *Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices*

IEC 61000-6-2, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity standard for industrial environments*

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

IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

IEC 61439 (all parts), *Low-voltage switchgear and controlgear assemblies*

IEC 61810-1, *Electromechanical elementary relays – Part 1: General and safety requirements*

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CISPR 11:2015/AMD1:2016

ISO 2859-1:1999, *Sampling procedures for inspection by attributes – Part 1: Sampling schemes indexed by acceptance quality limit (AQL) for lot-by-lot inspection*

ISO 3864-2, *Graphical symbols – Safety colours and safety signs – Part 2: Design principles for product safety labels*

Withdrawn



COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

**IEC 60947-4-1**  
Edition 4.0 2018-10

**APPAREILLAGE A BASSE TENSION –**

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

**FEUILLE D'INTERPRÉTATION 1**

Cette feuille d'interprétation a été établie par le sous-comité 121A: Appareillage à basse tension, du comité d'études 121 de l'IEC: Appareillages et ensembles d'appareillages basse tension.

Le texte de cette feuille d'interprétation est issu des documents suivants:

DISH	Rapport de vote
121A/336/DISH	121A/342/RVDISH

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette feuille d'interprétation.

**Interprétation du premier alinéa de 6.2**

L'objectif de la référence à l'article 5.2 de l'IEC 60947-1:2007, IEC 60947-1:2007/AMD1:2010 est de s'appliquer à l'ensemble du paragraphe alors que son premier alinéa peut en être écarté.

Plus particulièrement, le troisième alinéa de ce Paragraphe 5.2 imposant le marquage sur l'équipement du nom du fabricant ou de sa marque et de la désignation du type ou du numéro de série satisfait aux exigences des points a) et b) de 6.1.1 de l'IEC 60947-4-1:2018.

**Interprétation des notes de bas de tableau <sup>n</sup> et <sup>o</sup> du Tableau 7**

Les conditions normales d'établissement du courant pour la catégorie d'utilisation AC-3e sont définies par un rapport  $I / I_e$  égal à 12, avec la valeur correspondante du  $\cos \phi$  telle que définie dans la note de bas de tableau <sup>o</sup>.

La note de bas de tableau <sup>n</sup> offre la possibilité de choisir une valeur du rapport  $I / I_e$  différente, comprise entre 12 et 13, et décrit l'équation associée permettant de déterminer la valeur de  $\cos \phi$ .

#### **Interprétation du courant assigné d'emploi du Tableau 13 et du Tableau 14**

Les Tableaux 13 et 14 sont applicables aux contacteurs et démarreurs pour les charges de type moteur. Si le contacteur ou le démarreur satisfait aux exigences de plusieurs catégories d'emploi (AC-2, AC-3, AC-3e ou AC-4), le courant assigné d'emploi  $I_e$  correspondant à la catégorie d'emploi AC-3 doit être choisi afin de déterminer la valeur présumée du courant "I" pour l'essai.

La catégorie d'emploi AC-3 est considérée comme le cas d'utilisation le plus représentatif, et est considérée couvrir les exigences des autres catégories d'emploi des moteurs.

Withdrawal

## SOMMAIRE

AVANT-PROPOS.....	191
INTRODUCTION.....	194
1 Domaine d'application .....	195
2 Références normatives.....	196
3 Termes, définitions, symboles et abréviations.....	197
3.1 Généralités .....	197
3.2 Index alphabétique des termes .....	197
3.3 Termes et définitions relatifs aux contacteurs .....	199
3.4 Termes et définitions relatives aux démarreurs .....	200
3.5 Termes et définitions concernant les grandeurs caractéristiques.....	206
3.6 Termes et définitions relatifs aux aspects liés à la sécurité .....	207
3.7 Symboles et abréviations .....	208
4 Classification.....	209
5 Caractéristiques des contacteurs et des démarreurs.....	209
5.1 Énumération des caractéristiques .....	209
5.2 Type du matériel.....	210
5.2.1 Nature du matériel.....	210
5.2.2 Nombre de pôles .....	210
5.2.3 Nature du courant (alternatif ou continu).....	210
5.2.4 Milieu de coupure (air, huile, gaz, vide, etc.).....	210
5.2.5 Conditions de fonctionnement du matériel .....	210
5.3 Valeurs assignées et valeurs limites des circuits principaux.....	211
5.3.1 Tensions assignées .....	211
5.3.2 Courants ou puissances .....	212
5.3.3 Fréquence assignée .....	214
5.3.4 Services assignés.....	214
5.3.5 Caractéristiques en conditions normales de charge et de surcharge .....	215
5.3.6 Caractéristiques de court-circuit .....	217
5.3.7 Impédance de pôle d'un contacteur (Z) .....	218
5.4 Catégorie d'emploi.....	218
5.4.1 Généralités.....	218
5.4.2 Attribution des catégories d'emploi en fonction des résultats d'essais.....	218
5.5 Circuits de commande .....	220
5.6 Circuits auxiliaires.....	221
5.7 Caractéristiques du relais et du déclencheur des relais de surcharge et de l'appareil de connexion de protection des moteurs (ACPM).....	221
5.7.1 Énumération des caractéristiques .....	221
5.7.2 Types du relais ou du déclencheur .....	221
5.7.3 Valeurs caractéristiques .....	222
5.7.4 Désignation et courants de réglage des relais de surcharge .....	223
5.7.5 Caractéristiques temps-courant des relais de surcharge .....	223
5.7.6 Influence de la température de l'air ambiant .....	224
5.8 Coordination avec les dispositifs de protection contre les courts-circuits.....	224
5.9 Vide.....	224
5.10 Types et caractéristiques des appareils de commande automatique de commutation et des appareils de commande automatique d'accélération .....	224

5.10.1	Types .....	224
5.10.2	Caractéristiques .....	224
5.11	Types et caractéristiques des autotransformateurs des démarreurs par autotransformateur à deux étapes.....	225
5.12	Types et caractéristiques des résistances de démarrage des démarreurs rotoriques à résistances .....	225
6	Informations sur le matériel .....	226
6.1	Nature des informations .....	226
6.1.1	Identification.....	226
6.1.2	Caractéristiques, valeurs assignées fondamentales et utilisation .....	226
6.2	Marquage .....	226
6.3	Instructions d'installation, de fonctionnement, de maintenance, de mise hors service et de démontage.....	228
6.4	Informations relatives à l'environnement .....	229
7	Conditions normales de service, de montage et de transport .....	229
8	Exigences relatives à la construction et au fonctionnement .....	229
8.1	Exigences relatives à la construction .....	229
8.1.1	Généralités.....	229
8.1.2	Matériaux .....	230
8.1.3	Parties conductrices et leurs connexions .....	230
8.1.4	Distances d'isolement et lignes de fuite .....	230
8.1.5	Organe de commande .....	231
8.1.6	Indication de la position des contacts.....	231
8.1.7	Exigences supplémentaires pour les matériels aptes au sectionnement.....	231
8.1.8	Bornes.....	232
8.1.9	Exigences supplémentaires pour les matériels équipés d'un pôle neutre .....	232
8.1.10	Dispositions pour assurer la mise à la terre de protection .....	232
8.1.11	Enveloppes pour le matériel .....	232
8.1.12	Degrés de protection du matériel sous enveloppe.....	232
8.1.13	Traction, torsion et flexion avec des conduits métalliques.....	232
8.1.14	Source d'énergie limitée .....	232
8.1.15	Circuit d'énergie de charge emmagasinée .....	235
8.1.16	Conditions de défaut et conditions anormales .....	235
8.1.17	Protection des accès contre les courts-circuits et les surcharges.....	236
8.2	Exigences relatives au fonctionnement .....	236
8.2.1	Conditions de fonctionnement.....	236
8.2.2	Échauffement .....	242
8.2.3	Propriétés diélectriques .....	244
8.2.4	Exigences de fonctionnement dans des conditions normales de charge et de surcharge .....	245
8.2.5	Coordination avec les dispositifs de protection contre les courts-circuits .....	251
8.3	Compatibilité électromagnétique (CEM) .....	254
8.3.1	Généralités.....	254
8.3.2	Immunité .....	254
8.3.3	Émission.....	255
9	Essais .....	256
9.1	Nature des essais .....	256
9.1.1	Généralités.....	256
9.1.2	Essais de type.....	256

9.1.3	Essais individuels de série.....	256
9.1.4	Essais sur prélèvement.....	256
9.1.5	Essais spéciaux.....	257
9.2	Conformité aux exigences de construction .....	258
9.2.1	Généralités .....	258
9.2.2	Performance électrique des organes de serrage sans vis .....	258
9.2.3	Essai de vieillissement pour organes de serrage sans vis.....	259
9.2.4	Essai de la source d'énergie limitée.....	259
9.2.5	Défaillance de composants.....	260
9.3	Conformité aux exigences relatives au fonctionnement .....	261
9.3.1	Séquences d'essais .....	261
9.3.2	Conditions générales pour les essais.....	261
9.3.3	Fonctionnement à vide et dans les conditions normales de charge et de surcharge .....	262
9.3.4	Fonctionnement en court-circuit.....	275
9.3.5	Capacité de tenue des contacteurs aux courants de surcharge.....	280
9.3.6	Essais individuels de série et essais sur prélèvement.....	280
9.4	Essais CEM .....	282
9.4.1	Généralités.....	282
9.4.2	Immunité .....	283
9.4.3	Émission.....	285
Annexe A (normative) Marquage et identification des bornes des contacteurs, des démarreurs et des relais de surcharge associés .....		287
A.1	Généralités .....	287
A.2	Marquage et identification des bornes des circuits principaux .....	287
A.3	Marquage et identification des bornes des relais de surcharge .....	287
Annexe B (normative) Essais spéciaux .....		289
B.1	Généralités .....	289
B.2	Durabilité mécanique .....	289
B.2.1	Généralités.....	289
B.2.2	Vérification de la durabilité mécanique .....	289
B.3	Durabilité électrique.....	291
B.3.1	Généralités.....	291
B.3.2	Résultats à obtenir .....	292
B.3.3	Analyse statistique des résultats d'essais pour les contacteurs ou les démarreurs.....	293
B.4	Coordination au courant d'intersection entre démarreur et DPCC associé.....	293
B.4.1	Généralités et définitions .....	293
B.4.2	Condition pour l'essai de vérification de la coordination au courant d'intersection par une méthode directe .....	294
B.4.3	Courants d'essai et circuits d'essai .....	294
B.4.4	Procédure d'essai et résultats à obtenir .....	294
B.4.5	Vérification de la coordination au courant d'intersection par une méthode indirecte .....	295
Annexe C (informative) Caractéristiques types des démarreurs .....		298
Annexe D (informative) Points faisant l'objet d'un accord entre le fabricant et l'utilisateur .....		305
Annexe E (Vide).....		306

Annexe F (normative) Exigences pour un contact auxiliaire lié à un contact de puissance (contact miroir).....	307
F.1 Application et objet .....	307
F.1.1 Application.....	307
F.1.2 Objet .....	307
F.2 Termes et définitions .....	307
F.3 Caractéristiques.....	307
F.4 Informations sur le matériel.....	307
F.5 Conditions normales de service, de montage et de transport.....	308
F.6 Exigences relatives à la construction et au fonctionnement.....	308
F.7 Essais.....	308
F.7.1 Généralités .....	308
F.7.2 Essais sur produits à l'état neuf.....	308
F.7.3 Essai après le fonctionnement conventionnel en service (défini dans le Tableau 12) .....	309
Annexe G (informative) Courants assignés d'emploi et puissances assignées d'emploi des appareils de connexion pour moteurs électriques .....	310
G.1 Généralités .....	310
G.2 Puissances assignées d'emploi et courants assignés d'emploi.....	310
Annexe H (normative) Fonctions étendues des relais électroniques de surcharge.....	314
H.1 Généralités .....	314
H.2 Termes et définitions .....	314
H.3 Limites d'action des fonctions de commande.....	314
H.3.1 Généralités .....	314
H.3.2 Limites du relais électronique de surcharge avec fonction de redémarrage à minimum de tension du circuit principal.....	315
H.4 Essai des fonctions de commande.....	315
Annexe I (informative) Contacteurs AC-1 pour utilisation avec des moteurs commandés par des appareils à semiconducteurs .....	316
Annexe J (Vide) .....	317
Annexe K (normative) Procédure de détermination des données des contacteurs électromécaniques utilisés dans des applications de sécurité fonctionnelle.....	318
K.1 Généralités .....	318
K.2 Exigences d'essais .....	318
K.3 Caractérisation d'un mode de défaillance.....	318
K.4 Rapports de défaillance d'un contacteur.....	318
Annexe L (normative) Procédure d'évaluation de la protection électromécanique contre les surcharges utilisée dans des applications de sécurité, et plus particulièrement dans des atmosphères explosives.....	320
L.1 Application et objet .....	320
L.1.1 Application.....	320
L.1.2 Objet .....	320
L.2 Termes, définitions et symboles.....	320
L.2.1 Termes et définitions .....	320
L.2.2 Symboles et abréviations.....	322
L.3 Procédure .....	322
L.3.1 Généralités.....	322
L.3.2 Processus de conception de sécurité.....	322
L.4 Exigences .....	323

L.4.1	Généralités .....	323
L.4.2	Plan de sécurité.....	324
L.4.3	Conception .....	324
L.4.4	Analyse des modes de défaillance et de leurs effets de la fonction de sécurité .....	325
L.4.5	Plan de conception .....	325
L.4.6	Vérification .....	325
L.4.7	Fonction évaluée .....	326
L.5	Documentation.....	326
L.5.1	Documentation de sécurité technique .....	326
L.5.2	Instructions de sécurité.....	326
L.6	Exemple.....	326
L.6.1	Description de l'architecture .....	326
L.6.2	AMDE .....	328
Annexe M (normative) Contacteurs à courant continu utilisés dans des applications photovoltaïques (PV) .....		338
M.1	Application.....	338
M.2	Objet.....	338
M.3	Termes et définitions .....	338
M.4	Classification .....	339
M.5	Caractéristiques.....	339
M.5.1	Généralités.....	339
M.5.2	Tension assignée de tenue aux chocs .....	339
M.5.3	Catégorie d'emploi.....	339
M.6	Informations sur le matériel.....	340
M.7	Conditions normales de service, de montage et de transport.....	340
M.7.1	Généralités.....	340
M.7.2	Température de l'air ambiant .....	340
M.7.3	Altitude.....	341
M.8	Exigences relatives à la construction et au fonctionnement.....	341
M.8.1	Exigences relatives à la construction .....	341
M.8.2	Exigences relatives au fonctionnement .....	341
M.8.3	Compatibilité électromagnétique (CEM) .....	342
M.9	Essais.....	343
M.9.1	Généralités.....	343
M.9.2	Essais de type .....	343
M.9.3	Pouvoirs de fermeture et de coupure et performance de fonctionnement conventionnel en service .....	343
M.9.4	Essai de cycles thermiques .....	343
M.9.5	Essai climatique .....	344
M.9.6	Essai diélectrique .....	344
M.9.7	Essai du courant critique de charge .....	344
M.9.8	Propriétés mécaniques .....	346
M.9.9	Degré de protection des contacteurs sous enveloppe .....	346
M.9.10	CEM .....	346
M.9.11	Distances d'isolement et lignes de fuite .....	346
Annexe N (normative) Exigences supplémentaires et essais pour le matériel avec séparation de protection .....		347
N.1	Généralités .....	347

N.2	Définitions.....	347
N.3	Exigences .....	347
N.3.1	Méthode d'essai de mise en œuvre de l'impédance de protection .....	347
N.3.2	Mesurage du courant de contact.....	348
Annexe O (informative)	Indicateurs de surveillance de charge .....	350
O.1	Généralités .....	350
O.2	Liste des indicateurs .....	350
O.3	Incertitude.....	352
O.4	Essais.....	353
O.4.1	Essais individuels de série.....	353
O.4.2	Essais de type .....	353
Annexe P (normative)	Essais de coupure en court-circuit de l'ACPM .....	355
P.1	Conditions générales d'essai .....	355
P.2	Pouvoir de coupure de service en court-circuit assigné.....	356
P.2.1	Généralités.....	356
P.2.2	Essai du pouvoir de coupure de service en court-circuit assigné.....	356
P.2.3	Vérification de l'aptitude au fonctionnement en service.....	356
P.2.4	Vérification de la rigidité diélectrique .....	356
P.2.5	Vérification de l'échauffement.....	357
P.2.6	Vérification des déclencheurs de surcharge.....	357
P.3	Pouvoir de coupure ultime en court-circuit assigné .....	357
P.3.1	Généralités.....	357
P.3.2	Vérification des déclencheurs de surcharge.....	357
P.3.3	Essai du pouvoir de coupure ultime en court-circuit assigné .....	358
P.3.4	Vérification de la rigidité diélectrique .....	358
P.3.5	Vérification des déclencheurs de surcharge.....	358
P.4	Essai de l'ACPM pour les schémas de mise à la terre de type IT .....	358
P.4.1	Généralités.....	358
P.4.2	Court-circuit du pôle individuel.....	359
P.4.3	Vérification de la rigidité diélectrique .....	359
P.4.4	Vérification des déclencheurs de surcharge.....	359
P.4.5	Marquage.....	359
Annexe Q (normative)	Coordination dans les conditions de court-circuit entre un ACPM et un autre dispositif de protection contre les courts-circuits associés dans le même circuit .....	361
Q.1	Application.....	361
Q.2	Objet.....	362
Q.3	Exigences générales relatives à la coordination d'un ACPM avec un autre DPCC .....	362
Q.3.1	Généralités.....	362
Q.3.2	Comportement de $C_1$ en association avec un autre DPCC.....	362
Q.4	Type et caractéristiques du DPCC associé.....	363
Q.5	Vérification de la sélectivité .....	363
Q.5.1	Généralités.....	363
Q.5.2	Prise en compte de la sélectivité par étude théorique .....	363
Q.5.3	Sélectivité déterminée par essai .....	365
Bibliographie.....		369



Figure 1 – Limites des multiples de la valeur du courant de réglage des relais de surcharge à fonctionnement différé compensés pour la température de l'air ambiant .....	239
Figure 2 – Essai de mémoire thermique .....	240
Figure 3 – Exemples de caractéristiques de coordination d'un démarreur .....	253
Figure 4 – Mesurage de chute de tension au point de contact de la borne de contact .....	259
Figure 5 – Exemple de mesurage d'impédance de pôles pour un contacteur tripolaire .....	265
Figure A.1 – Circuit principal.....	287
Figure A.2 – Relais de surcharge .....	288
Figure B.1 – Exemples de caractéristique de tenue temps-courant .....	297
Figure C.1 – Courbes types de courants et de couples au cours d'un démarrage étoile-triangle (voir 3.4.4.1) .....	298
Figure C.2 – Courbes types de courants et de couples au cours d'un démarrage par autotransformateur (voir 3.4.4.2).....	299
Figure C.3 – Variantes types de démarreurs protégés, de combinés de démarrage, d'appareils de connexion protégés et de combinés d'appareils de connexion.....	300
Figure C.4 – Exemple de schéma en triphasé d'un démarreur rotorique à résistances à trois étapes de démarrage et à un seul sens de marche (dans le cas dans lequel tous les appareils mécaniques de connexion sont des contacteurs).....	301
Figure C.5 – Méthodes et schémas types de démarrage, au moyen d'autotransformateurs, de moteurs à induction à courant alternatif.....	303
Figure C.6 – Exemples de courbes vitesses/temps correspondant aux cas a), b), c), d), e) et f) de 5.3.5.6.1 .....	304
Figure F.1 – Contact miroir .....	308
Figure L.1 – Processus de conception de sécurité .....	323
Figure L.2 – Structure type d'un relais thermique de surcharge .....	327
Figure L.3 – Structure type d'un ACPM .....	328
Figure M.1 – Courant critique.....	345
Figure N.1 – Protection au moyen de l'impédance de protection .....	348
Figure N.2 – Instrument de mesure .....	349
Figure O.1 – Exemple de quantification d'une modification de procédé .....	352
Figure Q.1 – Coordination à maximum de courant entre un ACPM et un fusible ou protection d'accompagnement par un fusible: caractéristiques de fonctionnement .....	366
Figure Q.2 – Sélectivité totale entre l'ACPM et les disjoncteurs – Cas 1 .....	367
Figure Q.3 – Sélectivité totale entre l'ACPM et les disjoncteurs – Cas 2 .....	367
Figure Q.4 – Protection d'accompagnement par un disjoncteur – Caractéristiques de fonctionnement – Cas 1 .....	368
Figure Q.5 – Protection d'accompagnement par un disjoncteur – Caractéristiques de fonctionnement – Cas 2 .....	368
Tableau 1 – Catégories d'emploi.....	220
Tableau 2 – Classes de déclenchement des relais de surcharge.....	223
Tableau 3 – Limites de fonctionnement des relais de surcharge à fonctionnement différé alimentés sur tous leurs pôles.....	238
Tableau 4 – Limites de fonctionnement des relais de surcharge tripolaires à fonctionnement différé alimentés sur deux pôles seulement.....	241
Tableau 5 – Limites d'échauffement pour les bobines isolées dans l'air et dans l'huile.....	243
Tableau 6 – Données pour les cycles d'essai de service intermittent .....	244

Tableau 7 – Pouvoirs de fermeture et de coupure – Conditions de fermeture et de coupure correspondant aux catégories d'emploi.....	246
Tableau 8 – Relation entre le courant d'essai et la durée à l'état non passant pour la vérification des pouvoirs assignés de fermeture et de coupure.....	248
Tableau 9 – Détermination du courant d'emploi pour les catégories d'emploi AC-6a et AC-6b à partir des caractéristiques assignées pour AC-3.....	248
Tableau 10 – Fonctionnement conventionnel en service – Conditions de fermeture et de coupure en fonction de la catégorie d'emploi.....	249
Tableau 11 – Exigences de tenue aux courants de surcharge.....	251
Tableau 12 – Critères d'acceptation spécifiques pour les essais d'immunité.....	255
Tableau 13 – Valeur du courant d'essai présumé en fonction du courant assigné d'emploi.....	277
Tableau 14 – Valeur du courant d'essai présumé en fonction du courant assigné d'emploi (tableau harmonisé).....	278
Tableau 15 – Procédure d'essai pour $I_{cd}$ .....	253
Tableau 16 – Essais d'immunité CEM.....	283
Tableau 17 – Limites de la tension perturbatrice aux bornes pour les émissions conduites aux fréquences radioélectriques (pour les accès principaux).....	285
Tableau 18– Limites d'essai d'émission rayonnée.....	286
Tableau 19 – Limites pour les sources d'énergie limitée sans dispositif de protection contre les surintensités.....	233
Tableau 20 – Limites pour les sources d'énergie limitée avec dispositif de protection contre les surintensités.....	234
Tableau 21 – Limites pour la source d'énergie limitée avec impédance de limitation de courant.....	235
Tableau B.1 – Vérification du nombre de cycles de manœuvres en charge – Conditions d'établissement et de coupure correspondant aux diverses catégories d'emploi.....	292
Tableau B.2 – Conditions d'essai.....	295
Tableau F.1 – Tension d'essai selon l'altitude.....	309
Tableau G.1 – Puissances assignées d'emploi et courants assignés d'emploi des moteurs.....	311
Tableau K.1 – Mode de défaillance des contacteurs.....	318
Tableau K.2 – Rapports types de défaillance pour les contacteurs normalement ouverts.....	319
Tableau L.1 – Sévérité.....	328
Tableau L.2 – Occurrence.....	329
Tableau L.3 – Niveaux de détection.....	329
Tableau L.4 – Conclusion.....	330
Tableau L.5 – Exemple d'analyse des modes de défaillance et de leurs effets pour relais thermique de surcharge.....	331
Tableau M.1 – Niveaux de tension de choc assignée des contacteurs PV.....	339
Tableau M.2 – Catégories d'emploi.....	339
Tableau M.3 – Conditions de température de l'air ambiant.....	341
Tableau M.4 – Vérification des pouvoirs assignés de fermeture et de coupure – Conditions de fermeture et de coupure correspondant à la catégorie d'emploi DC-PV.....	342
Tableau M.5 – Fonctionnement conventionnel en service – Conditions de fermeture et de coupure correspondant à la catégorie DC-PV.....	342
Tableau M.6 – Description générale des séquences d'essais.....	343

Tableau M.7 – Nombre de cycles de manœuvres correspondant au courant critique de charge .....	345
Tableau M.8 – Performances du courant critique de charge .....	346
Tableau O.1 – Liste des indicateurs de surveillance en courant alternatif.....	351
Tableau O.2 – Différentes possibilités admises pour vérifier les indicateurs.....	353
Tableau O.3 – Référence pour les conditions de vérification .....	354
Tableau O.4 – Niveaux d'harmoniques .....	354

Withdrawn

## COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

### APPAREILLAGE À BASSE TENSION –

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

##### AVANT-PROPOS

- 1) La Commission Électrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. À cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
- 2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
- 3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
- 4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
- 5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
- 6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
- 7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
- 8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
- 9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

La Norme internationale IEC 60947-4-1 a été établie par le sous-comité 121A: Appareillage à basse tension, du comité d'études 121 de l'IEC: Appareillages et ensembles d'appareillages basse tension.

Cette quatrième édition annule et remplace la troisième édition parue en 2009, ainsi que son Amendement 1:2012. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- Structure du domaine d'application et exclusions
- Corrections rédactionnelles des notes et des alinéas suspendus

- Référence à l'IEC 62683-1
- Appareil de connexion de protection des moteurs (ACPM) accompagné de ses exigences
- Aspects relatifs à la sécurité:
  - Aspects généraux;
  - Circuits limités en énergie;
  - Circuits électroniques;
  - Procédure d'évaluation de la protection électromécanique contre les surcharges utilisée dans des applications de sécurité (nouvelle Annexe L)
- Introduction des dispositions relatives à l'impact du courant rotor bloqué plus élevé afin d'atteindre une classe de rendement supérieure
- Mention des accessoires de câblage dédiés
- Mesurage de la puissance d'appel
- Alignement avec l'IEC 60947-1:2007, l'IEC 60947-1:2007/AMD1:2010, et l'IEC 60947-1:2007/AMD2:2014
- Exigences en matière de courant continu pour couvrir les applications photovoltaïques (nouvelle Annexe M)
- Indicateurs de surveillance de charge (nouvelle Annexe O)
- Essais de coupure en court-circuit de l'ACPM (nouvelle Annexe P)
- Coordination dans les conditions de court-circuit entre un ACPM et un autre dispositif de protection contre les courts-circuits associés dans le même circuit (nouvelle Annexe Q)

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
121A/224/FDIS	121A/233/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60947, publiées sous le titre général *Appareillage à basse tension*, peut être consultée sur le site web de l'IEC.

Le présent document doit être lu conjointement avec l'IEC 60947-1:2007, l'IEC 60947-1:2007/AMD1:2010, l'IEC 60947-1:2007/AMD2:2014, *Appareillage à basse tension – Partie 1: Règles générales*. Les dispositions des règles générales sont applicables au présent document, lorsque cela est spécifiquement mentionné.

Les dispositions des règles générales présentées dans l'IEC 60947-1 sont applicables à la présente partie de la série IEC 60947, lorsque cela est spécifiquement mentionné. Les articles et paragraphes, les tableaux, les figures et les annexes des règles générales qui sont donc applicables sont identifiés en référence à l'IEC 60947-1:2007, à l'IEC 60947-1:2007/AMD1:2010 et à l'IEC 60947-1:2007/AMD2:2014. Par exemple, 4.3.4.1 de l'IEC 60947-1:2007, Tableau 4 de l'IEC 60947-1:2007 ou Annexe A de l'IEC 60947-1:2007.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous «<http://webstore.iec.ch>» dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

Le contenu de la feuille d'interprétation de mars 2020 a été pris en considération dans cet exemplaire.

Le contenu des corrigenda 1 (2020-04) et 2 (2021-04) a été pris en considération dans cet exemplaire.

**IMPORTANT – Le logo «*colour inside*» qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.**

Withdrawn

## INTRODUCTION

Ce document introduit les exigences relatives aux appareils de connexion de protection des moteurs (ACPM).

Les ACPM sont disponibles sur le marché depuis de nombreuses années. Ils sont présentés dans ce document pour couvrir les exigences minimales de sécurité et de performances d'un démarreur moteur à main comportant une protection intégrale, électromécanique ou électronique, contre les courts-circuits. Cet appareil satisfait à toutes les exigences d'un démarreur et aux exigences spécifiques d'un disjoncteur conformément à l'IEC 60947-2 (plus particulièrement  $I_{cu}$  et  $I_{cs}$ ) pour la protection du moteur et de ses circuits avec des appareils de commande (un contacteur, par exemple). Un ACPM n'a pas vocation à prendre en charge les exigences en matière de pôle neutre, de courants continus assignés, de courant assigné ininterrompu  $I_u$ , de protection de secours, de retard de déclenchement de court-circuit, de catégorie de sélectivité, de capacité débrochable, de dispositif à courant différentiel résiduel, de disjoncteur à réenclenchement et de CEM de l'IEC 60947-2, etc.

Les disjoncteurs conformes à l'Annexe O de l'IEC 60947-2:2016 présentant des caractéristiques de protection du moteur contre les surcharges selon le présent document, mais sans caractéristiques assignées de démarreur (AC-3, par exemple), sont également disponibles sur le marché. Ces appareils ne sont pas couverts par le présent document.

Withdrawn

## APPAREILLAGE À BASSE TENSION –

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

#### 1 Domaine d'application

La présente partie de l'IEC 60947 s'applique aux équipements suivants:

- contacteurs électromécaniques et démarreurs, y compris les appareils de connexion de protection des moteurs (ACPM);
- organes de commande de contacteurs auxiliaires;
- contacts destinés exclusivement au circuit de la bobine de ce contacteur ou ce contacteur auxiliaire;
- accessoires dédiés (câblage dédié, accessoires d'accrochage dédié, par exemple);

destinés à être connectés à des circuits de distribution, des circuits de moteur et à d'autres circuits de charge, dont la tension assignée ne dépasse pas 1 000 V en courant alternatif ou 1 500 V en courant continu.

Le présent document couvre également la procédure d'évaluation de la protection électromécanique contre les surcharges utilisée dans des applications de sécurité, telle que la protection d'un moteur situé dans une atmosphère explosive provenant de l'atmosphère extérieure. Voir l'Annexe L.

Le présent document ne s'applique pas:

- aux démarreurs de moteurs en courant continu<sup>1</sup>;

NOTE 1 Des exigences relatives aux démarreurs moteurs en courant continu sont à l'étude pour le prochain cycle de maintenance.

- aux contacts auxiliaires des contacteurs et aux contacts des contacteurs auxiliaires. Ils sont couverts par l'IEC 60947-5-1;
- aux démarreurs utilisés en aval d'un entraînement à fréquence variable<sup>1</sup>;

NOTE 2 Des exigences supplémentaires relatives aux démarreurs utilisés en aval d'un entraînement à fréquence variable sont à l'étude pour le prochain cycle de maintenance.

- aux dispositifs de protection contre les courts-circuits intégrés dans les démarreurs autres que des ACPM. Ils sont couverts par l'IEC 60947-2 et l'IEC 60947-3;
- à l'utilisation du produit avec des dispositifs supplémentaires en atmosphères explosives. Elle est spécifiée par la série IEC 60079;
- aux règles de conception de logiciels intégrés<sup>1</sup>;
- aux aspects liés à la cybersécurité. Ils sont couverts par la série IEC 62443.

Le présent document a pour objet de fixer:

- a) les caractéristiques du matériel;
- b) les conditions applicables au matériel relativement:
  - 1) à son fonctionnement et son comportement,

<sup>1</sup> À ce sujet, le fabricant est chargé de prendre des mesures de sécurité supplémentaires.



- 2) à ses propriétés diélectriques,
  - 3) à son degré de protection,
  - 4) à sa construction, y compris les mesures de sécurité contre les chocs électriques, les dangers d'incendie et les dangers mécaniques;
- c) les essais destinés à vérifier si ces conditions sont réalisées, ainsi que les méthodes à adopter pour ces essais;
- d) les renseignements à fournir avec les matériels ou dans la documentation du fabricant.

## 2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60034-1:2017, *Machines électriques tournantes – Partie 1: Caractéristiques assignées et caractéristiques de fonctionnement*

IEC 60034-12:2016, *Machines électriques tournantes – Partie 12: Caractéristiques de démarrage des moteurs triphasés à induction à cage à une seule vitesse*

IEC 60034-30-1, *Machines électriques tournantes – Partie 30-1: Classes de rendement pour les moteurs à courant alternatif alimentés par le réseau (code IE)*

IEC 60038, *Tensions normales de la CEI*

IEC 60068-2-14:2009, *Essais d'environnement – Partie 2-14: Essais – Essai N: Variation de température*

IEC 60079-14, *Atmosphères explosives – Partie 14: Conception, sélection et construction des installations électriques*

IEC 60085:2007, *Isolation électrique – Evaluation et désignation thermiques*

IEC 60364-1:2005, *Installations électriques à basse tension – Partie 1: Principes fondamentaux, détermination des caractéristiques générales, définitions*

IEC 60364-7-712, *Installations électriques à basse tension – Partie 7-712: Exigences applicables aux installations ou emplacements spéciaux – Installations d'énergie solaire photovoltaïque (PV)*

IEC 60715:2017, *Dimensions de l'appareillage à basse tension – Montage normalisé sur profilés-supports pour le support mécanique des appareillages et de leurs accessoires*

IEC 60730-1, *Dispositifs de commande électrique automatiques – Partie 1: Exigences générales*

IEC 60947-1:2007, *Appareillage à basse tension – Partie 1: Règles générales*

IEC 60947-1:2007/AMD1:2010

IEC 60947-1:2007/AMD2:2014

IEC 60947-2:2016, *Appareillage à basse tension – Partie 2: Disjoncteurs*

IEC 60947-5-1:2016, *Appareillage à basse tension – Partie 5-1: Appareils et éléments de commutation pour circuits de commande – Appareils électromécaniques pour circuits de commande*

IEC 61000-6-2, *Compatibilité électromagnétique (CEM) – Partie 6-2: Normes génériques – Norme d'immunité pour les environnements industriels*

IEC 61051-2, *Varistances utilisées dans les équipements électroniques – Deuxième partie: Spécification intermédiaire pour varistances pour limitations de surtensions transitoires*

IEC 61140:2016, *Protection contre les chocs électriques – Aspects communs aux installations et aux matériels*

IEC 61439 (toutes les parties), *Ensembles d'appareillage à basse tension*

IEC 61810-1, *Relais électromécaniques élémentaires – Partie 1: Exigences générales et de sécurité*

CISPR 11:2015, *Appareils industriels, scientifiques et médicaux – Caractéristiques de perturbations radioélectriques – Limites et méthodes de mesure*  
CISPR 11:2015/AMD1:2016

ISO 2859-1:1999, *Règles d'échantillonnage pour les contrôles par attributs – Partie 1: Procédures d'échantillonnage pour les contrôles lot par lot, indexés d'après le niveau de qualité acceptable (NQA)*

ISO 3864-2, *Symboles graphiques – Couleurs de sécurité et signaux de sécurité – Partie 2: Principes de conception pour l'étiquetage de sécurité des produits*