

This is a preview - click here to buy the full publication



IEC 60947-4-1

Edition 4.0 2018-10
REDLINE VERSION

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 ⁿ and ^o 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 ^o.

Footnote ⁿ 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.

CONTENTS

FOREWORD.....	10
INTRODUCTION.....	13
1 Scope and object	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 (<i>Z</i>)	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
	Void.....	
	Additional requirements for combination starters and combination switching devices suitable for isolation	
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 (Void) (informative) Typical characteristics of starters.....		124
Annex D (informative) Items subject to agreement between manufacturer and user		131
Annex E (informative) Examples of control circuit configurations (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 within 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 broken 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 test limits (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.

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.

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 motors¹;
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 drive¹;
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 rules¹;
- 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

¹ 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*

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**

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 ⁿ and ^o 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 $\cos \phi$ in footnote ^o.

Footnote ⁿ 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 $\cos \phi$.

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.

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.

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.

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 motors¹;
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 drive¹;
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 rules¹;
- 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,

¹ 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*

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 ⁿ et ^o 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 ^o.

La note de bas de tableau ⁿ 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.

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

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.

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.

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 continu¹;

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 variable¹;

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 intégrés¹;
- 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,

¹ 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*