

INTERNATIONAL STANDARD

NORME INTERNATIONALE

AMENDMENT 1
AMENDEMENT 1

**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**



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FOREWORD

This amendment has been prepared by subcommittee 17B: Low-voltage switchgear and controlgear of IEC technical committee 17: Switchgear and controlgear.

The text of this amendment is based on the following documents:

FDIS	Report on voting
17B/1769/FDIS	17B/1780/RVD

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

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

INTRODUCTION

This amendment includes the following significant technical changes with respect to the previous edition 3 (2009):

- introduction of the motor management starter;
- definitions and measurement method of the power consumption of the control circuit during holding and pick-up operations;
- measurement method of the pole impedance;
- requirements for screwless terminals;
- performance requirements for latched contactors;
- alignments to Amendment 1 of IEC 60947-1:2007;
- harmonisation with IEC 60947-2 of the operation tests of under-voltage relays and shunt releases;
- short-circuit tests harmonisation with North America;
- test requirements for utilisation AC-6b capacitor load;
- polarity for DC contactors;
- dielectric test method in presence of built-in varistor;
- addition of an extended function for electronic overload relay: control functions.

1.1.2 AC motor-starters

Add, in the first paragraph, the parenthesis "(including motor management starter)" between "AC motor-starters" and "intended to start".

1.1.2.1 Star-delta starters

Replace, in the first sentence of the existing note, "the current" by "the starting current".

1.1.2.3 Rheostatic rotor starters

Delete the existing second paragraph and the existing note.

2 Normative references

Add to the existing list the following normative reference:

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

3.2 Alphabetical index of terms

Delete from the existing list the following terms and references:

electronic overload relay with current imbalance detection.....	H.2.2
electronic overload relay with ground/earth fault function	H.2.1
electronic overload relay with phase reversal function.....	H.2.4
electronic overload relay with under power detection	H.2.6
inhibit current (I_{ic})	H.2.7

Add to the existing list the following new terms and references:

holding power	3.3.9
motor management starter	3.4.31
pick-up power	3.3.10

3.3.8 electronically energized coil of electromagnet

Replace the existing term and definition by the following new term and new definition:

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

Add, after the existing definition 3.3.8, the following new terms and definitions 3.3.9 and 3.3.10:

3.3.9 holding power (of a contactor)
 power needed to maintain the operation of the electromagnet

3.3.10 pick-up power (of a contactor)
 power needed to operate the contactor from the de-energized state to the energized state

Add, after the existing definition 3.4.30, the following new term and definition 3.4.31:

3.4.31 motor management starter
 starter including extended functions with communication ability

NOTE Interoperable device profiles for motor management starter are defined by IEC 61915-2.
<https://standards.iteh.ai/standards/iec/60947-4-1-2009-amd1-2012>

3.6 Symbols and abbreviations

Add to the existing list the following new symbols:

- P_c Nominal holding power of a d.c. controlled contactor
- P_p Pick-up power of a d.c. controlled contactor with separate pick-up and hold-on windings
- S_h Holding power of an a.c. controlled contactor
- S_p Pick-up power of an a.c. controlled contactor
- U_d Voltage drop of a contactor pole
- Z Pole impedance of a contactor (5.3.7)
- "r" Minimum short-circuit test current
- I_q Maximum conditional short-circuit test current

Delete from the existing list " I_{ic} Inhibit current (H.2.7)".

5.3.1.1.2 Rated rotor operational voltage (U_{er})

Add, after the second paragraph, the following new paragraph and new note:

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

NOTE Electrical stresses are lower and shorter in the rotor than in the stator.

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

Delete the existing note.

Add, after the existing Subclause 5.3.6, the following new Subclause 5.3.7:

5.3.7 Pole impedance of a contactor (Z)

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

5.5 Control circuits

Replace the entire existing text by the following new text:

Subclause 4.5 of IEC 60947-1:2007 applies.

5.7.3 Characteristic values

Replace the existing item c) by the following new item c):

- c) Release with residual current sensing relay:
- rated current;
 - operating current;
 - operating time or time-current characteristic according to Table T.1 of IEC 60947-1:2007, Amendment 1;
 - inhibit time (when applicable);
 - type designation (see Annex T of IEC 60947-1: 2007, Amendment 1).

6.1.2 Characteristics, basic rated values and utilization

Add, after the existing item d), the following new item aa):

- aa) polarity of terminals, if applicable;

Add, after the existing item h), the following Note 1:

NOTE 1 Other information such as the pole impedance could be given e.g. in the product literature.

Replace the existing Note 1 of item o) by the following new Note 2:

NOTE 2 Other information such as the holding or pick-up power could be given e.g. in the product literature.

Renumber the existing Note 2 and Note 3 as Note 3 and Note 4 respectively.

6.2 Marking

Replace, in the existing third paragraph, "items c) in 6.1.1, k), and s2) in 6.1.2" by " items c) in 6.1.1, aa), k), and s2) in 6.1.2".

Replace, at the end of the existing fourth paragraph, "and Annex E" by "and Annex U of IEC 60947-1:2007, Amendment 1".

8.2.1.2 Limits of operation of contactors and power-operated starters

Replace the existing Subclauses 8.2.1.2.1 to 8.2.1.2.4 by the following new text:

Subclause 7.2.1.2 of IEC 60947-1:2007 applies with following additions:

For latched contactors, the device shall drop out and open fully when a de-latching voltage between 85 % and 110 % of the rated de-latching voltage is applied.

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

Delete the existing table footnote ^c and its reference in the table.

Renumber the existing table footnote ^d and its four references in the table as ^c.

Renumber the existing table footnote ^e and its two references in the table as ^d.

Replace the text of the existing table footnote ^a by the following new text:

This test shall only be done at 20 °C for A, B and D multiples of current setting.

Delete, in column D, the existing reference to the table footnote ^a.

Add a new reference to the table footnote ^a at the end of "Electronic type".

8.2.2.7.1 Uninterrupted and eight-hour duty windings

Replace, in the first paragraph, "7.2.2.2" by "7.2.2.6".

8.2.3 Dielectric properties

Replace the entire existing text by the following new text:

Subclause 7.2.3 of IEC 60947-1:2007 applies with the following additions:

General requirements for device including voltage limiting components inserted between circuits not connected to the ground/earth to be tested according to the dielectric test are described as follows.

These voltage limiting components called varistors used in order to protect electronic parts from surges within the device shall comply with IEC 61051-2. In this clause, the intent is not to reduce the clearances. For the type test of the device the voltage limiting components may be disconnected.

IEC 61051-2 applies as follows:

a) Preferred climatic categories of the varistor:

- maximum lower temperature: -10 °C
- minimum upper temperature: +85 °C

The device manufacturer has to verify that the varistor is suitable for use in the extended ambient temperature if any.

- b) The minimum rated voltage of the varistor shall be 1,2 times the maximum peak voltage where the varistor is connected.
- c) When connected to the mains, varistors shall withstand the surge test according to 9.4.2.5.

NOTE 1 With the verification of the varistors above it is assumed that a fuse protecting the varistor is not necessary.

NOTE 2 The possibility given in 8.3.3.4.1 item 1) of IEC 60947-1:2007 of disconnecting circuits between poles may be not appropriate in the routine test, because the products are completed and it is not appropriate to reopen and manipulate them. The main purpose of this test is to identify the proper operation of the voltage limiting component.

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

Replace the existing Table 7 by the following new table:

Utilization category	Make and break conditions					
	I_c / I_e	U_r / U_e	$\text{Cos } \phi$	On-time ^b s	Off-time s	Number of operating cycles
AC-1	1,5	1,05	0,8	0,05	f	50
AC-2	4,0 ^h	1,05	0,65 ^h	0,05	f	50
AC-3 ⁱ	8,0	1,05	a	0,05	f	50
AC-4 ⁱ	10,0	1,05	a	0,05	f	50
AC-5a	3,0	1,05	0,45	0,05	f	50
AC-5b	1,5 ^c	1,05	c	0,05	60	50
AC-6a	j					
AC-6b	1,5 ^e	1,05		l	m	50
AC-8a ^k	6,0	1,05	a	0,05	f	50
AC-8b ^k	6,0	1,05	a	0,05	f	50
Utilization category	I_c / I_e	U_r / U_e	L / R ms	On-time ^b s	Off-time s	Number of operating cycles
DC-1	1,5	1,05	1,0	0,05	f	50 ^d
DC-3	4,0	1,05	2,5	0,05	f	50 ^d
DC-5	4,0	1,05	15,0	0,05	f	50 ^d
DC-6	1,5 ^c	1,05	c	0,05	60	50 ^d
Utilization category	Make conditions ⁱ					
	I / I_e	U / U_e	$\text{Cos } \phi$	On-time ^b s	Off-time s	Number of operating cycles
AC-3	10	1,05 ^g	a	0,05	10	50
AC-4	12	1,05 ^g	a	0,05	10	50
<p>I = current made. The making current is expressed in d.c. or a.c. r.m.s. symmetrical values but it is understood that, for a.c., the actual peak value during the making operation may assume a higher value than the symmetrical peak value.</p> <p>I_c = current made and broken, expressed in d.c. or a.c. r.m.s. symmetrical values</p> <p>I_e = rated operational current</p> <p>U = applied voltage</p> <p>U_r = power frequency or d.c. recovery voltage</p> <p>U_e = rated operational voltage</p> <p>$\text{Cos } \phi$ = power factor of test circuit</p> <p>L / R = time-constant of test circuit</p>						

Table 7 (continued)

a	$\cos \phi = 0,45$ for $I_e \leq 100$ A; $0,35$ for $I_e > 100$ A.
b	The time may be less than $0,05$ s, provided that contacts are allowed to become properly seated before re-opening.
c	Tests to be carried out with an incandescent light load.
d	If polarity not marked on the device, 25 operating cycles with one polarity and 25 operating cycles with reverse polarity.
e	The load shall consist of commercially available capacitor combinations to obtain a steady-state reactive current I_e calculated according to 9.3.3.3.4. Alternatively capacitive ratings may be derived by capacitor switching tests or assigned on the basis of established practice and experience. As a guide, reference may be made to the formula given in Table 9 which does not take into account the thermal effects due to harmonic currents. The available current capacity at the test terminals shall not be less than the prospective current "r". It can be determined by analytical evaluation.
f	See Table 8.
g	For U / U_e , a tolerance of ± 20 % is accepted.
h	The values shown are for stator contactors. For rotor contactors, the test shall be made with a current of four times the rated rotor operational current and a power factor of $0,95$.
i	The make conditions for utilization categories AC-3 and AC-4 shall also be verified. The verification may be made during the make and break test, but only with the manufacturer's agreement. In this case, the making current multiples shall be as shown for I / I_e and the breaking current as shown for I_c / I_e . 25 operating cycles shall be made at a control supply voltage equal to 110 % of the rated control supply voltage U_s and 25 operating cycles at 85 % of U_s . The off-times are to be determined from Table 8.
j	The manufacturer shall verify the AC-6a rating by testing with a transformer or may derive the rating from the values for AC-3 according to Table 9.
k	A lower ratio of I_c / I_e (locked rotor to full load current) may be used if specified by the manufacturer.
l	The on time shall be long enough in order to reach the stabilized current.
m	Off-time according to Table 8. The value of a discharge resistor shall be determined to reach less than 50 V at the end of off-time.

**Table 10 – Conventional operational performance –
Making and breaking conditions according to utilization category**

Replace the existing Table 10 by the following new table:

Utilization category	Make and break test conditions					
	I_c / I_e	U_r / U_e	$\text{Cos } \phi$	On-time s	Off-time s	Number of operating cycles
AC-1	1,0	1,05	0,80	0,05 ^b	c	6 000 ⁱ
AC-2	2,0	1,05	0,65	0,05 ^b	c	6 000 ⁱ
AC-3	2,0	1,05	a	0,05 ^b	c	6 000 ⁱ
AC-4	6,0	1,05	a	0,05 ^b	c	6 000 ⁱ
AC-5a	2,0	1,05	0,45	0,05 ^b	c	6 000 ⁱ
AC-5b	1,0 ^e	1,05	e	0,05 ^b	60	6 000 ⁱ
AC-6a	g	g	g	g	g	g
AC-6b	1 ^k	1,05		i	m	6 000
AC-8a	1,0	1,05	0,80	0,05 ^b	c	30 000
AC-8b ^{h,j}	6,0	1,05	a	1 10	g 90 ^d	5 900 100
Utilization category	I_c / I_e	U_r / U_e	L / R ms	On-time s	Off-time s	Number of operating cycles
DC-1	1,0	1,05	1,0	0,05 ^b	c	6 000 ^f
DC-3	2,5	1,05	2,0	0,05 ^b	c	6 000 ^f
DC-5	2,5	1,05	7,5	0,05 ^b	c	6 000 ^f
DC-6	1,0 ^e	1,05	e	0,05 ^b	60	6 000 ^f

I_c = current made or broken. Except for AC-5b, AC-6 or DC-6 categories, the making current is expressed in d.c. or a.c. r.m.s. symmetrical values but it is understood that for a.c. the actual peak value during the making operation may assume a higher value than the symmetrical peak value.
 I_e = rated operational current
 U_r = power frequency or d.c. recovery voltage
 U_e = rated operational voltage
 $\text{Cos } \phi$ = power factor of test circuit
 L / R = time-constant of test circuit

Table 10 (continued)

^a	$\cos \phi = 0,45$ for $I_e \leq 100$ A; $0,35$ for $I_e > 100$ A.
^b	The time may be less than 0,05 s, provided that contacts are allowed to become properly seated before re-opening.
^c	These off-times shall be not greater than the values specified in Table 8.
^d	The manufacturer may choose any value for the Off-time up to 200 s.
^e	Tests to be carried out with an incandescent light load.
^f	If polarity not marked on the device, 3 000 operating cycles with one polarity and 3 000 operating cycles with reverse polarity.
^g	The manufacturer shall verify the AC-6a rating by testing with a transformer or may derive the rating from the values for AC-3 according to Table 9.
^h	Tests for category AC-8b shall be accompanied by tests for category AC-8a. The tests may be made on different samples.
ⁱ	For manually operated switching devices, the number of operating cycles shall be 1 000 on-load, followed by 5 000 off-load.
^j	A lower ratio of I_c / I_e (locked rotor to full load current) may be used if specified by the manufacturer.
^k	The load shall consist of commercially available capacitor combinations to obtain a steady-state reactive current I_e calculated according to 9.3.3.3.4. Alternatively capacitive ratings may be derived by capacitor switching tests or assigned on the basis of established practice and experience. As a guide, reference may be made to the formula given in Table 9 which does not take into account the thermal effects due to harmonic currents. The available current capacity at the test terminals shall not be less than the prospective current "r". It can be determined by analytical evaluation.
^l	The on time shall be long enough in order to reach the stabilized current.
^m	Off-time according to Table 8. The value of a discharge resistor shall be determined to reach less than 50 V at the end of off-time.

Add, after the existing Subclause 8.2.4.4, the following new Subclauses 8.2.4.5 and 8.2.4.6:

8.2.4.5 Coil power consumption

Where the power consumption of the coil is given, it shall be tested according to 9.3.3.2.1.2.

8.2.4.6 Pole impedance

Where the pole impedance is given, it shall be tested according to 9.3.3.2.2.2.

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

Add, at the end of this subclause, the following new text:

These tests are applicable to AC motor ratings only.

Delete the existing Subclauses 8.2.6 and 8.2.7.

9.2 Compliance with constructional requirements

Replace the existing text by the following new text and new Subclauses 9.2.1, 9.2.2 and 9.2.3:

9.2.1 General

Subclause 8.2 of IEC 60947-1:2007 applies with the following additions:

9.2.2 Electrical performance of screwless-type clamping units

Subclause 8.2.4.7 of IEC 60947-1:2007, Amendment 1 applies with the following changes:

The number of specimens shall be at least 4.

The insertion and disconnection of the conductors shall be made in accordance with the manufacturer's instructions.

A suitable test arrangement is shown in Figure 10. If the measurement points cannot be positioned within the 10 mm to the point of contact, the voltage difference between the ideal and the actual measuring points shall be deducted from the voltage drop measured. This voltage difference within the part of the conductor shall be determined with a suitable measurement method on one specimen at a stabilised temperature. The measurement methods and the results shall be documented in the test report. The test current is I_{th} .

NOTE 1 Usually it is possible to equip a IEC 60947-4-1 product with many different types of wires (stranded, solid, flexible...) which results in a sufficient number of tests for the same terminal.

NOTE 2 Particular testing method with conductor cross sections larger than 10 mm² is under consideration.

NOTE 3 The device sample may be provided with holes or equivalent arrangements which provide measurement access points for the voltage drop on the terminal.

9.2.3 Ageing test for screwless-type clamping units

Subclause 8.2.4.8 of IEC 60947-1:2007, Amendment 1 applies with the following change:

The test shall be done on the device equipped with the clamping units.

The test current is I_{th} .

NOTE The device sample may be provided with holes or equivalent arrangements which provide measurement access points for the voltage drop on the terminal.

9.3.1 Test sequences

Replace, in the existing item e), the item 1) by the following:

- 1) verification of mechanical properties of terminals (see 8.2.4 of IEC 60947-1:2007, 9.2.1 and 9.2.2);

9.3.3.2.1 Power-operated equipment

Replace the existing text of this subclause, by the following new Subclauses 9.3.3.2.1.1, 9.3.3.2.1.2, 9.3.3.2.1.2.1, 9.3.3.2.1.2.2, 9.3.3.2.1.2.3, 9.3.3.2.1.2.4 and 9.3.3.2.1.3:

9.3.3.2.1.1 General

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

The drop out test requirements of 8.3.3.2.1 of IEC 60947-1:2007, Amendment 1 applies.

9.3.3.2.1.2 Coil power consumption

9.3.3.2.1.2.1 General

A contactor coil is evaluated for both holding power and pick-up power.

In the case where different coils cover a range of voltages, 5 coils shall be tested as follows:

The coil with the lowest rated control supply voltage U_s , the coil with the highest rated control supply voltage U_s , plus 3 coils deemed to be representative of the coils with the highest calculated hold power at the discretion of the manufacturer.

The test shall be performed at ambient temperature $+23\text{ °C} \pm 3\text{ °C}$. The test shall be made without any load in the main and auxiliary circuits. The coil shall be supplied with the rated control supply voltage U_s and at the rated frequency. For a given coil, where a voltage range is declared, the test shall be made at the highest voltage at the respective frequency.

The measured values shall be obtained with a r.m.s. measurement method covering at least a bandwidth from 0 Hz to 10 kHz and the resulting power values shall be given within a measurement uncertainty better than 5 %.

9.3.3.2.1.2.2 Holding power for conventional and electronically controlled electromagnet

The current measurement $I_{(i)}$ of the coil shall be performed after the coil has been energized and has reached a stable temperature.

The holding power consumption is defined as follows:

$$S_{h(i)} = U_{s(i)} \times I_{(i)} \text{ [VA] for a.c. controlled contactor;}$$

$$P_{c(i)} = U_{s(i)} \times I_{(i)} \text{ [W] for d.c. controlled contactor.}$$

The published value shall be equal to the average value of the 5 tested coils.

$$S_h = \sum (U_{s(i)} \times I_{(i)}) / 5 \text{ [VA] respectively } P_c = \sum (U_{s(i)} \times I_{(i)}) / 5 \text{ [W]}$$

NOTE The power dissipation for an a.c. controlled contactor can also be expressed in [W], taking into account the power factor.

9.3.3.2.1.2.3 Pick-up power for a.c. controlled contactor or d.c. controlled contactor with separate pick-up and hold-on windings

The pick-up measurement shall be performed directly after the measurement of the hold current (see 9.3.3.2.1.2.2).

The current measurement $I_{(i)}$ of the coil shall be performed immediately after the coil has been de-energized, the contactor has been held in the Off position and re-energized.

The pick-up power consumption is defined as follows:

$$S_{p(i)} = U_s \times I_{(i)} \text{ [VA] for a.c. controlled contactor;}$$