

LOVAG **TEST INSTRUCTION IEC 60947-2 Ed. 5.0**

CONDITIONS FOR TESTING LOW VOLTAGE SWITCHGEAR AND CONTROLGEAR **PART 2. SWITCHGEAR AND CONTROLGEAR**

This test instruction is based on the following standards:

General Rules:

IEC 60947-1 Edition 5.2 (2014-09)

Specific Requirements:

IEC 60947-2 Edition 5.0 (2016-06)

Valid from: 2016-11-30



Chairman of LOVAG Technical Committee

(Saverio MANGANARO)

General

It complies with this standard in all respects, and provides additional information ensuring a suitable degree of repeatability of the tests between the different test stations.

The tests shall be carried out after the reference standard(s) have been studied.

Test Instruction only provides the points as following referred to the previous standard and/or LTI edition:

-technical and/or structural change (text yellow highlighted)

-details on certain specific points giving clarification and/or technical interpretation

No points will be reported if clarification/interpretation don't need or no change was introduced in the standard.

For convenience in the use of this Test Instruction, the paragraphs are numbered according to the clauses in the standard IEC 60947-2.

All references to clauses of IEC 60947-1 are referred to the Edition 5.2 (2014-09) and are preceded with the letter G.

To better understand the entire standard text, some clauses are renumbered/renamed and many notes became standard text.

1.1 Scope and object

It's clearly stated that circuit-breakers rated above 1000V a.c. but not exceeding 1500V a.c. may also be tested to this standard

A dedicated part for circuit-breakers to use in photovoltaic system (Annex P) is included.

A dedicated part for residual current circuit-breakers with autoreclosing device (Annex R) is included.

1.2 Normatives references

Reviewed the references to all the IEC standard (including specific amendment)

2.17.4 Selectivity limit current (I_s)

Reviewed and clarified the definition with part of the existing text translated from a note

Deleted the "back-up protection" definition due to already present in IEC 60947-1

4.3.6.3 Standard relationship between short-circuit making and braking capacities and related power factor, for a.c. circuit-breakers Table 2

Value less than 4,5kA are included with related power factor required

4.4 Selectivity categories

Table is deleted and the existing note converted in text standard. It's clarified that is possible to declare value of I_{cw} less than 5kA for circuit-breakers in category A. In this case a Sequence IV is required.

4.5.1 Electrical control circuit

Note deleted in Table 5

4.7.3 Current setting of over-current release

In case of marking provided by a display, the current setting I_r (or range of current settings) shall be clearly displayed.

7.1.4 Clearances and creepages distances

Taking into account the new scope (Cl. 1.1), text is changed. Here the new text:

"For U_{imp} values exceeding the values given in Table 13 of IEC 60947-1:2007, clearances shall be obtained from Table F.2 of IEC 60664-1:2007."

7.1.6 List of construction breaks

List of construction breaks is extended with letters h and i.

h) difference in embedded software (firmware) in electronic trip units, which has no impact on the required performance, in particular the tripping function;

i) electronic trip unit hardware, due to omitted components on identical PCB layout (e.g. rotary knobs, display, etc.).

7.2.2.3 Main circuit

Text is changes deleting every reference to I_{th} and I_{the} . Here the new text:

“The main circuit of a circuit-breaker, including the over-current releases which may be associated with it, shall be capable of carrying its rated current I_n , under the conditions of Clause 8, without the temperature-rises exceeding the limits specified in Table 7.”

7.2.3.2 Impulse withstand voltage

Taking into account the new scope (Cl. 1.1), text is changed. Here the new text:

“For circuit-breakers rated above 1 000 V a.c., the impulse withstand voltage shall be agreed between the manufacturer and the user but shall not be less than the corresponding values for 1000 V a.c.”

8.1.2 Type tests

A d.c. critical test procedure and verification is included (see also 8.3.9 and P.8.3.9)

8.3.1 Test sequence

A certificate of conformity may be issued for each complete Sequence, Annex per performance requirements.

Compliance with the standard for the type of device shall include carrying out tests of the sequences in question.

The tests are defined in tables 9 and 9a, 9b, 9c and the number of samples in table 10, with the exception of sequence “I” which may require several samples.

8.3.1.3 Applicability of sequence according to the relationship between short-circuit ratings

Table “*alphabetical index of tests*” is implemented in the column “test” by the d.c. critical test procedure and verification is included (see also 8.3.9) At the same for Table 9 “*overall schema of test sequence*”

8.3.1.4 Alternative test programmes for a.c. circuit-breakers having a different number of poles

Tables 9b and 9c

In the last column of both table the title say “Applicability to 1-pole or 2-pole variants“ ; using “or” it seems not necessary to test both the variant but in the 1st paragraph is clearly stated :

A 2-pole circuit-breaker produced by removing the centre current path from a 3-pole circuit-breaker tested to programme 1 or programme 2 of this subclause need not be tested as it is considered to be covered by the tests on the 3-pole variant.

LOVAG intend not to leave bad interpretation so accepte the test on paragraph but impose the test on 2-pole variant except as in the case of the notes e of the tables 9b and 9c.

8.3.2.1 General requirements

A speed for the handle during the mechanical operation in case of circuit-breakers with dependent manual operation it's specified. Speed value was fixed in 0,1m/s $\pm 25\%$.

For circuit-breakers may be used in individual enclosure (if declared by manufacturer) and has been tested in free hair, further temperature-rise is required as at following

b) A temperature rise test according to the general conditions of 8.3.2.5 on a circuit-breaker having a maximum I_{th} , at the conventional enclosed thermal rating I_{the} (see 4.3.3.2). The temperature rises shall meet the requirements of 7.2.2 except that the temperature rise of the terminals shall not exceed 70 K.”

Clarification are implemented in Table 10 in regards of short-circuit relationship I_{cu} and I_{cw}

8.3.2.2.2 Tolerances on test quantities

Refer also to General Instruction LTI G2.

During three-phase short-circuit tests, the difference between the individual values of the voltages on each phase, and the average voltage on all three phases shall not exceed 10 %.

8.3.2.2.4 Power factor of the test circuit

LOVAG accepts power factor is checked on only one phase, bearing in mind that the additional condition accepted in 8.3.2.2.2 of this Test Instruction is sufficient.

8.3.2.2.7 Ripple of test current for d.c.

Since the new test (critical current), wave specification in regards of ripple are defined (IEC 62475)

8.3.2.4 Test reports

Refer also to General Instruction LTI G1 and OD 01-01

8.3.2.6.1 General requirements

The frame, with the polyethylene sheet, shall be centered on the opening of the enclosure around the operating mean.

Where tests by successive energization in both directions are required, it is acceptable to reverse the position of the circuit-breaker with the manufacturer's approval.

8.3.2.6.2 Test circuit

Remark concerning four-pole devices:

If the test station cannot carry out the test using a star supply with the neutral pole separated according to IEC 60947-1 Figure 12, the manufacturer's agreement may be obtained in order to test a four-pole device in 3-phase mode using a delta supply with an artificial neutral pole. The supply side and load side terminals of the fourth pole shall, in this case, be connected to the chassis of the device.

Where an artificial neutral is utilized the test station shall hold on record a test made to determine the prospective earth fault current. Calculation may be used with a direct connection to the neutral of the supply. An additional single-phase test is to be carried out as per paragraph 8.3.2.6.4.

8.3.2.6.3 Calibration of the test circuit

The standard requires the calibration to be carried out for a period of 0.1 s.

A shorter period is acceptable, provided that it is equal to at least twice the period during which the current passes during the test, and that it is sufficient to enable the power factor of the circuit to be measured.

For platforms supplied by a generator, it is acceptable for the calibration to be carried out at a voltage less than the test voltage. This proposal allows prospective current tests to be made repeatedly without undue stress to the generator supply. However, as some short-circuit generators do not exhibit a linear relationship, care should be exercised in application of this procedure to ensure that the rated prospective current is available for the test. In any case, the prospective current test shall not be made at a value less than 75 % of the test voltage relative to the rated value, the linearity characteristic having been predetermined by test at periodic intervals.

The instant of making should be chosen in that way that the maximum current value in one phase achieves the necessary value corresponding to the power factor and Table 2, clause 4.3.5.3.

8.3.2.6.5 Behaviour of the circuit-breaker during short-circuit making and breaking tests

To check that there is no re-ignition and to have the maximum value of I^2t recovery voltage is maintained, and recorded for at least 50 ms after the current's return to zero in all phases.

8.3.2.6.6 Interpretation of records

It is recalled that the phase-to-phase recovery voltage (or the average between the three voltages in the case of a 3-phase circuit) must be equal to 105 % of the operational voltage, with the tolerance of 0,+ 5 % specified in clause G 8.3.2.2.2.

According to Figures G9, G10, G11 and G12, the recovery voltage and the applied voltage are expressed and measured phase-to-phase, between the supply terminals.

Alternatively, they can also be measured phase to neutral.

Additional voltages may be measured across the poles of the device under test.

8.3.2.6.4.3 Test on four pole circuit-breakers

It's clarified that an additional sequence of operations on fourth pole is requested also if sequence III is replaced by sequence II ($I_{cs}=I_{cu}$)

8.3.3.2.1 General

For the verification of tripping characteristics and in case of releases independent of the temperature, the tests the terminal connections may be different from those required in 8.3.3.3.4 of IEC 60947-1, compatible with test current

8.3.3.2.2 short-circuit releases

Text is clarified to better explain the tests required

8.3.3.2.3 Overload releases

Text is clarified to better explain the tests required

8.3.3.3 Test of dielectric properties

List of additions tests is enlarged at following:

- “(v) *circuit-breakers having a rated insulation voltage greater than 1 000 V a.c. shall be tested at a voltage of $U_i + 1\,200$ V a.c. r.m.s. or $2 U_i$ whichever is the greater;*
- “(vi) *withdrawable circuit-breakers (see 7.1.2) shall be subject to verification of impulse withstand voltage, as per 8.3.3.4.1, item 2) b) of IEC 60947-1:2007. The test voltage shall be selected from Table 14 of IEC 60947-1:2007, and shall be applied between the withdrawable unit's main contacts and their associated fixed contacts, in the disconnected position. Acceptance criteria are as per 8.3.3.4.1, item 2) d) of IEC 60947-1:2007.”*

8.3.3.4.4 Operational performance capability without current

Standard prescribe how to carry out the trip operation for circuit-breakers which can be fitted with UVR or ST. For circuit breakers which can be fitted with both (UVR and ST), LOVAG recommends to use different

trip coil when samples are tested in alternative test programme (3 or 4 pole variant) In any case all the 10% of the trip operation shall to be tested with the same trip coil.

8.3.3.5 Overload performance

Notes became standard text:

"If the testing means do not withstand the let-through energy occurring during the automatic operation, the test may be performed as follows, with the agreement of the manufacturer:

- 12 manual operations;
- three additional operations with automatic opening, made at any convenient voltage.

8.3.3.6 Verification of dielectric withstand

LOVAG admits a maximum time of 30 minutes to carry out this tests after the preceding taking into account to ensure no influence to the test results

8.3.9 Critical d.c. load current

A dedicated procedure and verification was included regarding the possibility to detect a critical current in case of d.c. system supply.

8.4.6 Dielectric tests

It's clearly stated the three methods are available for the test:

- a) or b) or c)

Circuit-breakers having a rated insulation voltage greater than 1 000 V a.c. 2412 shall be tested at a voltage of $U_i + 1\,200$ V a.c. r.m.s. or $2 U_i$ whichever is the greater.

8.3.6.3 rated short-time withstand current

If a momentary separation of the contacts occurs the test must be repeated at the operational voltage. LOVAG defines this "momentary separation" a separation longer than 2ms.

The current and voltages of each pole of the device shall be recorded simultaneously, with a sufficient level of sensitivity to detect a momentary separation of the contacts.

Annex A

Coordination under short-circuit conditions between a circuit-breaker and another short-circuit protective device associated in the same circuit

A.5.2 Verification of discrimination by desk study

- A.5.2.1 Selectivity in overload zone
- A.5.2.2 Determination of selectivity in the fault current (short-circuit) zone
- A.5.2.3 Determination of selectivity limit current for specific installation conditions
- A.5.3 Selectivity determined by test

A.6.1 Determination of the take-over current

The standard does not provide test but a maximum value only ($I_B \leq I_{cu}$ of C1 alone) and the method of verification by comparison of the operating characteristics of C1 and SCPD associated for all setting of C1 and, if applicable, for all setting of C2.

A.6.2 Verification of the back-up protection

The standard indicates that it is possible to carry out this verification by comparing the characteristics or by tests in accordance with the paragraph A.6.3.

Annex B

Circuit-breakers incorporating residual current protection

B.5 Marking

The setting of residual operating current, when applicable, (fourth line of the paragraph a)), means $I_{\Delta R}$ (see figure K1 of the standard)

The instruments for the measurements of the residual current shall be in compliance with LTI G2 requirements

Annex J

Electromagnetic compatibility (EMC)

J.2.3 Radiated radio-frequency electromagnetic fields

For step 1 and 2, frequency sweep range was been respectively extended up to 2700MHz and 2450MHz.

Annex K

Glossary of symbols and graphical representation of characteristics

Rated automatic re-closing residual current is included with symbol $I_{\Delta ar}$

Annex P

D.C. circuit-breakers for use in photovoltaic (PV) applications

For circuit-breakers dedicated to these specific application shall to be in compliance with this new normative annex. Main points:

P.5 Product information

A PV circuit-breaker shall be marked "IEC 60947-2 Annex P" under the condition of item 5.2 b)

- method of poles connection and polarity shall be marked
- operational characteristic between -25°C and +70°C shall be declared

P.8.3.2 General test conditions

Time constant (L/R) is fixed in 1ms for all the tests

P.8.3.3÷8 Test sequence I ÷ VI

All the test sequences have to be performed considering the specifics differences for PV using

P.8.3.9 Critical load current

A specific critical load current detection and verification has to carried out (see also 8.3.9)

P.8.3.10 Thermal cycling test

According to IEC 60068-2-14 and verification test 8.3.3.1.3 after the cycles

P.8.3.11 Climatic test

According to IEC 60947-1 Annex Q Category B

Annex R

Circuit-breakers incorporating residual current protection with automatic re-closing functions

For circuit-breakers dedicated to these specific application shall to be in compliance with this new normative annex. Main points:

R.5 Product information

A circuit-breaker incorporating residual current protection with automatic re-closing device shall be marked under the condition of Clause 5 and B.5 with additional requirements clearly stated in this annex

Table R.1 Test sequences for independent type automatic re-closing devices

Five test sequences defined as "#1" to "#5" has to be performed considering Annex B tests also