# LOVAG
# TEST INSTRUCTION IEC/EN 60947-2 Ed. 4.0

## CONDITIONS FOR TESTING LOW VOLTAGE SWITCHGEAR AND CONTROLGEAR
## PART 2. CIRCUIT BREAKERS

This test instruction is based on the following standards:

General Rules:

| | |
|---|---|
| IEC 60947-1 Edition 4.0 (2004) | EN 60947-1: (2004) |

Specific Requirements:

| | |
|---|---|
| IEC 60947-2 Edition 4.0 (2006) | EN 60947-2: (2006) |

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.

S. MANGANARO

Chairman of LOVAG Technical Committee

Edition 4.0
1st October 2009

Valid from: 2009-12-05

Author: ACAE

## 0. PREAMBLE

The tests shall be carried out after the reference standard(s) have been studied, since this Test Instruction only provides details on certain specific points.

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

All references to clauses of IEC 60947-1: (2004) are preceded with the letter G.

Modifications made since the preceding updated version are yellow headlight.

## 1. SCOPE

This standard applies to circuit-breakers, the main contacts of which 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.; it also contains additional requirements for integrally fused circuit-breakers.

## 2. DEFINITIONS

For the majority of the definitions required in connection with this standard, see Clause 2 of IEC 60947-1.

For the additional definitions refer to Standard.

## 3. CLASSIFICATION

Refer to Standard.

## 4. CHARACTERISTICS OF CIRCUIT BREAKERS

Refer to Standard.

## 5. PRODUCT INFORMATION

### 5.2. Marking

Refer to Standard.

Assessment is made by inspection

(Tests for checking compliance with requirements for indelibility and immovability of marking are under consideration.)

## 6. NORMAL SERVICE, MOUNTING AND TRANSPORT CONDITIONS

Refer to Standard.

## 7. CONSTRUCTIONAL AND PERFORMANCE REQUIREMENTS

### 7.1. Constructional requirements

Refer to Standard clauses 7.1.1; 7.1.2; 7.1.3; 7.1.4

### 7.1.5. List of construction breaks

Item d): The «external operating means» concern the supplementary means supplied to the laboratory with the device (e.g. extended actuator). This mean is then used for carrying out tests of sub-clause 8.2.5

**7.1.6. Additional requirements for circuit-breakers provided with a neutral pole**

Refer to Standard and to clause G 7.1.8

**7.2. Performance requirements**

Refer to Standard and to clause G 7.2

**7.3. Electromagnetic compatibility (EMC)**

Refer to Standard (Annex J) and to clause G 7.3

**8. TESTS**

**8.1. Kind of tests**

Refer to Standard and to clause G 8.1

**8.2. Compliance with construction requirements**

Refer to Standard and to clause G 8.2

**G 8.2.1 Materials**

**G 8.2.1.1 Test of resistance to abnormal heat and fire**

**G 8.2.1.1.1 Glow-wire test (on equipment)**

Refer to clauses 4 to 10 of IEC 60695-2-10 and IEC 60695-2-11, under the conditions specified in G 7.1.1.1. For the purpose of this test, a protective conductor is not considered as a current-carrying part.

**G 8.2.1.1.2 Flammability, hot wire ignition and arc ignition tests (on materials)**

Test a) Refer to the following paragraphs of IEC 60695-11-10:

- Test chamber: par. 6
- Test specimens: par. 7
- Conditioning: par. 8.1 and 9.1
- Method FH: par. 8.1 up to 8.5 (suitable for evaluating the burning rate)
- Method FV: par. 9.1 up to 9.5 (suitable for evaluating the extent of burning after extinction of the flame)

Test b) Refer to Standard

Test c) Refer to Standard

**G 8.2.2 Equipment**

Refer to Standard and to clause G 8.2.2

**G 8.2.3 Enclosures for equipment**

Refer to clause G 8.2.3 and annex C of the Standard IEC 60947-1 Ed. 4.0

**G 8.2.4 Mechanical properties of terminals**

Tests 8.2.4.1 to 8.2.4.5 inclusive are not part of a test sequence in IEC 947-2 and shall be carried out on a separate sample as indicated. They may be the object of a specific request.

The tests should be done as agreed with the manufacturer.

Their results shall be recorded in the test report, and the torque values used shall

be fully specified

The measurement facilities (dimensions, torque) shall be linked to international units and standards, and their inspection shall be included in the platform quality plan. The measurement results shall be mentioned in the test report, with the values of the torques used clearly specified.

The sentence ”aluminium terminals” means also ”aluminium alloy terminals”.

The sentence ”aluminium conductors” means ”aluminium conductors complying with the publication: IEC 60228”.

**G 8.2.4.2 Test of mechanical strength of terminals**

Refer to G8.2.4.2

**G 8.2.4.3 Testing for damage to and accidental loosening of conductors (flexion test)**

In this case, the word "sample" means a sample of a terminal, and not a sample of the complete device; this means that several tests can be carried out on the same device, according to the number of similar terminals.

**G 8.2.4.5 Test for insert ability of unprepared round copper conductors having the maximum specified cross-section**

**G 8.2.4.5.1 Test procedure**

Refer to G 8.2.4.5.1

The device shall be fixed in such a way that the direction of penetration is vertically downwards.

**G 8.2.4.5.2 Construction of gauges**

Refer to G 8.2.4.5.2.

In addition the length of the part of the gauge, intended to keep in handle, shall be 25 mm in length and diameter 6,3 mm for gauges form B.

**G 8.2.5 Verification of the effectiveness of indication of the main contact position of equipment suitable for isolation**

**G 8.2.5.2 Condition of equipment for the tests**

Taking into account that at the end of the sequence 1 is requested the" Verification of main contact position (where applicable)" the sample used for this test shall be the one of the sample which has performed the above mentioned sequence.

**G 8.2.5.2.1 Dependent and independent manual operation**

Using a torque measurement device for determination of the normal operation force necessary to open the contacts the value of the force F is calculated taking in to account the application point and it is acceptable to remove the handle so the torque measurement can be done directly on the shaft of the device under test. The measured force (F) shall be taken to be equal to the average value obtained from three consecutive tests.

In accordance with the standard, the contacts of the pole for which the test is deemed to be the most severe shall be kept closed. This pole shall be determined by evaluation of the construction. If this is not possible it is necessary to carry out a quick preliminary test on a separate sample to determine which one causes the most unfavorable distortion under the action of force (3F). For practical reasons, it is acceptable to slightly change the point of application of the force, with respect to Figure 16 - Actuator test force - provided that the same application point is used for the measurement of F and for the application of the test force defined in table 17.It is also acceptable to add an intermediate support part (a screw for example) or a handle extension. The operator should follow the manufacturers' instructions, if any, for application of table 17 and, only if there are not, makes himself the choice.

The choice of the line in table 17, which corresponds, to operation with one or two fingers, or with one or two hands, shall be carried out by the operator according to the true practical possibility of operation, during normal utilization, which is materialized by the space available on the actuator. If there are several possibilities, the most unfavorable condition shall be used. Mention of this fact is made in the test report.

**G 8.2.5.3 Condition of equipment during and after test**

**G 8.2.5.3.1 Dependent and independent manual operation**

The indication of the open position shall not be wrongly given. In particular, if the system concerned has colored ranges, the color corresponding to the not-opening position shall not become invisible.

It is acceptable for the actuator mechanism to be distorted or broken, provided that:

- the manufacturer's locking mechanism cannot be operated while the strain is being applied,
- the position indicator does not show the open position when the strain is released.

## 8.3 TYPE TESTS

### 8.3.1 Test sequence

Refer to Standard and to clause G 8.1.1

All the tests intended for verifying compliance of the type of device are called "type tests" in the standard.

A certificate of conformity to a sequence may be issued for each sequence.

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

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

### 8.3.2 General test conditions

Refer to Standard

Verification of switching over-voltages is under consideration.

All the tests in the following sequences are applicable for a given construction in a given frame size

#### 8.3.2.1 General requirements

Except the Test Sequence I the short-circuit releases shall be set at maximum (time and current) for all tests or at the maximum values of the frame size.

Cabling characteristics:

1) for In ≤ 630 A

***Conductor cross-sections***

For all tests, cross-section of the power supply conductors is selected from tables G 9, G 10 and G 11 on the basis of the current In attributed to the adjustable overload release, which is the maximum current setting as per paragraphs 4.7.2 and 4.7.3.

***Length of the conductors***

- Temperature-rise: refer to paragraph G 8.3.3.3.4.
- Tripping limits and characteristics: refer to paragraph 8.3.3.1.1.
- Short-circuit breaking capacity and short-time withstand current: refer to paragraph 8.3.2.6.4.
- For all other tests, the lengths are not specified.

2) for In > 630 A

***Conductor cross-sections***

The content of the above paragraph applies with the addition of the following: for currents of 2 In or over, for practical reasons, different cross-sections may be used but they must not influence the test results.

***Length of the conductors***

- Temperature-rise, refer to paragraph G 8.3.3.3.4.

- Tripping limits and characteristics: refer to paragraph 8.3.3.1.1. For currents of 2 In or over, for practical reasons, different lengths may be used but they must not influence the test results.
- For all other tests, the lengths are not specified, but shall be suitable for the current. If they are longer than these of 8.3.2.6.4 they are included in the test circuit for calibration.

8.3.2.2 **Test quantities**

**8.3.2.2.1 Values of test quantities**

Refer to G 8.3.2.2.1..

**8.3.2.2.2 Tolerances on test quantities**

Refer to G 8.3.2.2.2 and also General Instruction LTI G2.

These tolerances are specified in Table 8 of paragraph G 8.3.2.2.2, more severe test quantities than those specified in Table 8 are taken as those exceeding the positive tolerance for current, voltage and time constant and the negative tolerance for power factor.

These tolerances are applicable to the "displayed" values, and do not take the precision of the readings into account.

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 %. For currents see the clauses G 8.3.4.1.8 and G 8.3.4.3

**8.3.2.2.3 Frequency of the test circuit for a.c.**

Refer to note 2 of Table 8 of G 8.3.2.2.2.

**8.3.2.2.4 Power factor of the test circuit**

Note that G 8.3.4.1.3 requires the power factor of each phase of a 3-phase circuit to be checked.

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.

**8.3.2.2.5 Time constant of the test circuit**

A method for measurement is specified in Appendix F, paragraph b of IEC 947-1.

**8.3.2.2.6 Power-frequency recovery voltage**

The average of the recovery voltages for all phases shall be equal to 105 % of the operational voltage (to within the tolerances on table G 8).

The test voltage may be increased with the approval of the manufacturer according to G 8.3.2.2.3, note 3.

For all other conditions, and for the method of determination, refer to G 8.3.4.1.8 a).

**8.3.2.3 Evaluation of test results**

Refer to standard

**8.3.2.4 Test reports**

Refer to G 8.3.2.4 and also General Instruction LTI G1.

**8.3.2.5 Test conditions for temperature-rise test**

During the course of the test, the ambient temperature shall not vary more than 3 K in the last quarter of the test. If a temperature-rise test is required as a type test, the modalities for execution shall be those defined in IEC 947-1 (see the temperature-rise limits given in tables G 2 and G 3).

The measurement points are defined by Table 7 of the standard, which specifies the acceptable temperature-rise values.

The test report shall specify whether the temperature-rise test has been carried out in single phase mode, with the poles connected in series, or in 3-phase mode.

For four-pole devices, the separate temperature-rise test on the neutral pole required in G 8.3.3.3.4 is to be carried out only if this neutral pole has been subjected to breaking tests during the sequence carried out. The value of the test current is given in paragraph G 7.1.8.

**8.3.2.6 General test conditions for short-circuit tests**

**8.3.2.6.1 General requirements**

Refer to standard.

The position of the device shall be specified in the test report (vertical, horizontal, flat down, etc...).

If the music wire can be inserted, according to the length of insertion, it will be examined on drawings, or by any other means, the internal parts which can be reached.

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**

Refer to G 8.3.4.1.2, G 8.3.4.1.3 and G 8.3.4.1.4.

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 947-1 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**

Refer to G 8.3.4.1.5.

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.

**8.3.2.6.4 Test procedure**

For the cabling characteristics see paragraph 8.3.2.1. (c) of the Test Instruction and the dimensions shall be specified in the test report.

After calibration, without modifying the platform settings the temporary connections are replaced by the circuit-breaker under test.

If the submitter requires the value of $I^2t$ to be determined, this shall be determined on all phases, and the maximum value obtained shall be recorded in the test report. In accordance with paragraph 7.2.1.2.4. (a), this value is recorded only for devices in utilization category A, and, if necessary, B, if the requesting party so requires.

If the party requesting the test wishes to know the maximum value of the I2t constraint that the circuit-breaker can allow to pass, the appropriate detailed test program shall be established in agreement with the party.

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

Refer to G 8.3.4.1.7.

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**

Refer to G 8.3.4.1.8.

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.

### 8.3.3 Test sequence I: General performance characteristics

The Standard indicates (subclause 8.3.1) that the tests in sequence 1 may be carried out on different samples; (note that the last sentence of 8.3.3 is in opposition to 8.3.1).

Dielectric strength tests:

when the manufacturer declares a Uimp this test in fact requires not only the distances in the air to be checked (1,2/50 ms) but also the creepage distance. It is therefore necessary to strip down the device.

Cabling characteristics:

Refer to 8.3.2.1 (c) of the Test Instruction.

### 8.3.3.1 Test of tripping limits and characteristics

For the test of 8.3.3.1. the setting of adjustable releases shall be made at the minimum and maximum current setting and not according to table 10.

#### 8.3.3.1.1 General

Refer to the standard which specifies in particular that the tests may be carried out at any suitable voltage.

It is considered that for devices comprising two types of releases, one shall be considered to be intended for protection against overloads, and the other for protection against short-circuits.

Hereafter, $I_R$ will be used to designate the setting current of the short-circuit release, and Ir the setting current of the overload release.

#### 8.3.3.1.2 Opening under short-circuit conditions

As far as the duration of the current pulse is concerned, LOVAG accepts that the duration of the pulse may be longer than specified; in this case, the check is carried out by measuring the tripping time. In practice, rather than seeking to precisely set current values on 0.8 and 1.2 x $I_R$, it is also acceptable to determine the maximum no-trip current and the minimum tripping current, and to check that the two values obtained are not outside the 0.8 – 1.2 x $I_R$ range.

It should be recalled that:

- for multi-pole devices, the tests are carried out on two poles in series, by successive permutation.
- in addition, the operation of short-circuit releases shall be verified on each pole individually at 1.2 times the value of the tripping current declared by the manufacturer (this value may be different from the multi-pole value). This does not apply to circuit-breakers incorporating residual current protection (CBR) of Annex B.
- in case of adjustable releases, the tests are carried out in the two extreme adjustment positions,
- for definite time-delay releases, an additional test is specified in 8.3.3.1.4. at 1.5 x $I_R$.

**8.3.3.1.3 Opening under overload conditions**

**8.3.3.1.3 a) Instantaneous or definite time -delay releases**

Refer to standard.

**8.3.3.1.3 b) Inverse time -delay releases**

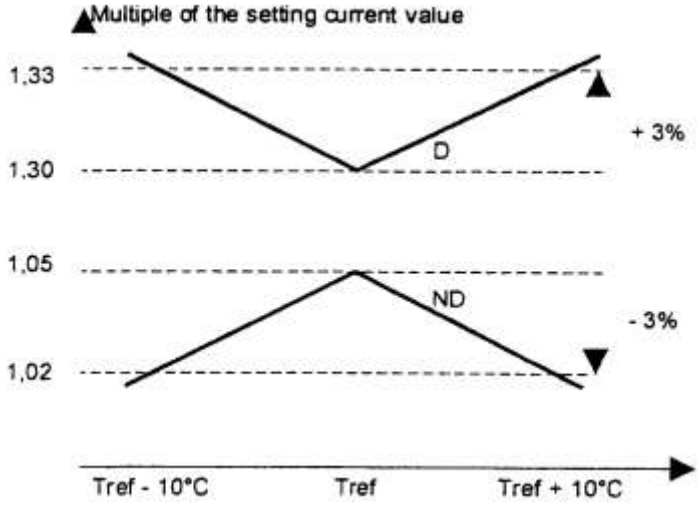
The test shall be carried out in still air and, in the case of long period tests, it shall be ensured that the ambient temperature does not vary by more than ± 2 °C during the test.

It is accepted that, for large circuit-breakers whose releases are supplied via current transformers, the test may be carried out on the release and transformer associated together, and separated from the circuit-breaker.

In the case of releases dependent on ambient temperature, the manufacturer may specify a reference temperature different from 30 °C, and the test may be carried out at a temperature different from the specified reference temperature, provided that the manufacturer supplies the correction coefficient for the test currents as a function of ambient temperature, before the tests are actually started; this coefficient, and the real currents applied during the tests, shall be recorded in the test report.

For releases declared to be independent of ambient temperature, it is recalled that it is necessary to take two readings, one at the reference temperature $T_{ref}$ (30 °C or the value indicated by the manufacturer), and the other at $T_{ref}$ + or - 10 °C. The choice of the latter temperature shall be made by agreement with the party requesting the tests.

The tests are carried out according to paragraph 7.2.1.2.4 b) 2), i.e. at 1.05 x $I_n$ and then at 1.30 x $I_n$ at $T_{ref}$,, with a conventional time of 1 hour for I ≤ 63 A and two hours above. For adjustable releases whose range includes the value of 63 A, i.e. whose $I_r$ max. > 63 A and $I_r$ min. < 63 A, the conventional time of 2 hours shall be retained for the tests at both settings. For the tests at $T_{ref}$ ± 10 °C, admissible variations of 0.3 %/K should be taken into account. The following diagram gives the different rated values. They should be observed, with their tolerance of ± 1 %, after the disappearance of the transitory variations.




D = tripping
ND = no-tripping

Tests on releases declared independent on ambient temperature, clause 8.3.3.1.3 b)

Unless otherwise stated by the agreement between manufacturer and user for the additional test, LOVAG requires a single test to be earned out with a cold start, at approximately 2. x $I_r$, i.e. approximately in the middle of the range of action of the inverse time-delay release, to verify that the time/current characteristic of the release is conformed (within the stated tolerances) to the curves provided by the manufacturer.

Unless otherwise stated by the agreement between manufacturer and user, this additional test is carried out at the reference temperature.

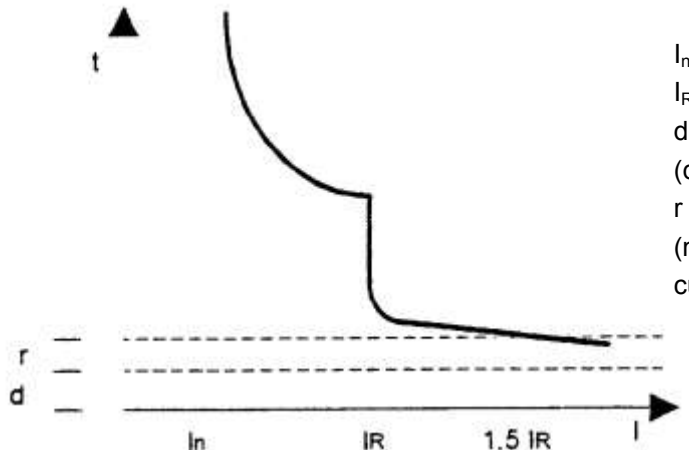
For devices comprising an adjustable release, this additional test is carried out in the two extreme setting positions.

**8.3.3.1.4 Additional test for definite time -delay releases**

Refer to 8.3.3.1.2 and 8.3.3.1.3 a) of the instruction.

The manufacturer shall declare:

- the current setting for the overload and/or short-circuit releases,
- the time-delay value (or the different values if it is adjustable),
- the non-tripping duration corresponding to each time-delay value.




$I_n$ = rated current
$I_R$ = current setting
d = non-operating time (determined by manufacturer)
r = release time-delay (mechanical functioning time + cut-off time)

The parameter displayed on the device - known as "time-delay" - represents the non-operating time (d) for the setting position chosen.

On the other hand, the reading taken - known as the "time-delay" in the standard - includes the non-operating time (d) and the release time-delay (r)

The standard a) and b) tests are performed for the maximum setting of each release.

**8.3.3.2 Test of dielectric properties**

Application of the test voltage:

- an Uimp is declared

  Refer to G 8.3.3.4.1 4) a), b). c) and, for equipment suitable for isolation G 8.3.3.4.1 4)d).

- an Uimp is not declared

  Refer to 8.3.3.2.2 a) 1) and 2) for the main circuit and 8.3.3.2.2 b) 1) and 2) for the control and auxiliary circuits.

**8.3.3.3 Test of mechanical operation and operational performance capability**

**8.3.3.3.1 General test conditions**

Refer to standard.

**8.3.3.3.2 Construction and mechanical operation**

a) Construction

   Refer to standard.

b) Mechanical operation

   Test modalities which must be adapted to the device, according to the design of its control and tripping mode, are described precisely in the test report.

   As an example, for an electrically controlled device, the checks are as follows:

   - with the closing command sustained (locally or by remote control), the opening order shall cause total tripping;
   - with the release command maintained, a dosing command remains ineffective;
   - with the device closed, a further closing command, does not cause any anomaly.

For a device with a mechanical control only, the first point above can be checked by causing electrical tripping by passing a current, when testing releases for example (clause 8.3.3.1).

For a device requiring an external source of power (paragraph 7.2.1.1.3), only checks of off load closures under 0.85 $U_S$ and 1.1 $U_S$ are carried out. Verification of the current closing corresponding to the rated making capacity Icm under 0.5 $U_S$ could be carried forward to sequences II/III if they are required. If this is not the case, this latter check shall be carried out in sequence I.

If the technical data sheet specifies the dosing and/or opening times, these "specified" values shall be recorded in the test report, and shall be verified by the tests.

c) Undervoltage releases

   iii) Performance under overvoltage condition:

   At the end of this test and after cooling down, the tests of item ii are repeated.

d) Shunt releases

   Refer to Standard.

#### 8.3.3.3.3 Operational performance capability without current

It is recalled that this test can be carried out without the individual enclosure.

In compliance with Note 1 of Table VIII, the number of cycles per hour may be increased with the manufacturer's agreement. This number, as well as the on load factor adopted (refer to paragraph G 4.3.4.3) shall therefore be specified by the manufacturer and given in the test report.

For devices requiring maintenance, the manufacturer shall specify a number of operations which is higher than that of table 8, and in this case (according to clause 8.3.3.3.1), the additional operations shall be carried out first, followed by the maintenance operations, and then the operations specified in table 8.

If the circuit-breaker is manually controlled, attention is drawn to those parameters which are liable to affect the test results: operating speed, travel, maximum effort, point of application of effort... These shall result in the circuit breaker being operated as in service and verified as being such.

#### 8.3.3.3.4 Operational performance capability with current

Refer to standard and to G 8.3.3.5.1 and G 8.3.3.5.2 for the test diagram.

Test characteristics:

- Number of operations: refer to table 8, clause 7.2.4.2 of the standard.
- Recovery voltage: Ue max. (0, + 5 %).
- Power factor = 0.8 ± 0.05, L/R = 2 ms (0, + 15 %).
- Icc source: ³ 10 x Itest but limited to 50 kA.
- Loads must be on load side of the circuit-breaker.

For current values lower than 5 A, as obtaining inductive circuits is very difficult to carry out in practice, LOVAG authorises the use of iron reactance's. In this case, the test circuit will not be damped and a visual check is made that the current is sinusoidal.

- The prospective fault current and the diameter of the fuse wire between the ground of the device and the neutral of the source, shall be specified in the test report (refer to G 8.3.3.5.2 g).

- The number of operations is counted according to the number of times the current passes. Out of the total number of operations, a few non-executed and spurious orders are acceptable. In this case, a few additional operations shall be carried out, whilst observing the mechanical and electrical operating conditions.

Non-opening within the specified time limits is not acceptable.

- It should be recalled that precautions shall be taken to insure that the temperature-rises of the electrical components do not exceed the values indicated in Table 7. This can be carry out, for instance, in decreasing the "ontime".

For practical reasons, LOVAG allows the test to be divided up over several 8-hour periods.

For the operation of manual devices, refer to the last sub-paragraph of clause 8.3.3.3.3 of this Test Instruction.

#### 8.3.3.3.5 Additional test of operational performance capability without current for withdrawable circuit-breakers

Refer to standard.

#### 8.3.3.4 Overload performance

Refer to standard.

Test is mandatory if In max. ≤630 A, and is optional above this value.

Test conditions: (refer to tables 8, 11 and 13 of the standard):

- I = 6 x In max. for A.C. or 2.5 x In for D.C. (0, + 5 %).
- Current values balanced in all three phases: for each phase, ± 10 % of the average of all three.
- Recovery voltage: 1.05 x Ue max. (0, + 5 %).
- Power factor: 0.5 ± 0.05, L/R: 2.5 ms (0, + 15 %).

For current values lower than 5 A, as obtaining inductive circuits is very difficult to carry out in practice, LOVAG authorizes the use of iron reactances. In this case, the test circuit will not be damped and a visual check is made that the current is sinusoidal.

- Number of operations: 12 (9 manual and 3 automatic).
- "Opening to be carried out manually" means an operation carried out on the component which is normally operated by hand (handle or push-button for normal shut-down) ... Manual operations can also be carried out by using a remote control device, or any other appropriate means supplied at 0.85 $U_S$ (refer to paragraph 8.3.2.1).
- During each of the manual operating cycles, the circuit-breaker must remain closed for a period less than 2 seconds but greater than the time taken to establish a permanent current condition, i.e. approximately 50 ms.
- "Automatic opening" means an opening caused directly by the operation of the release (in its maximum setting position).
- The purpose of the overload test is to make sure that the device is capable of making and breaking the current equal to 6 (or 2.5) x $I_n$ max. at 1.05 x $U_e$, and also of withstanding the thermal stresses causes by the current during the time necessary for the tripping of the device. If, due to the time during which the current has to flow, the facilities of the platform are not suitable for carrying out the automatic opening operations as specified, it is possible to proceed as follows:
- carry out the total number of operations (12) manually, at 1.05 x $U_e$ and 6 (or 2.5) x $I_n$max., with an on-time between 50 and 100 ms,
- then carry out the 3 automatic operations at a reduced voltage, but at the same current of 6 (or 2.5) x $I_n$ max., in order to obtain the corresponding thermal effect.

The time between the manual and automatic operations shall be as short as possible.

- Rate: refer to table 8.
- For all other conditions, refer to the standard and paragraph G 4.3.4.3.

### 8.3.3.5 Verification of dielectric withstand

This test shall be conducted as soon as possible after the preceding test but not exceeding 30 minutes and, where possible, without disturbing either the device or the test rig. For safety reasons, for instance, the device under test may be displaced, without disturbance, towards the dielectric generator.

It is recalled that, according to 8.3.3.2.2, the test shall be carried out in three positions:

- closed - open - tripped.

The sequence of dielectric test may be variable to suit the practicality of the test.

For withdrawable devices, the dielectric tests must also be carried out on the corresponding base. After the tests, the base and the device will be examined at the same time.

### 8.3.3.6 Verification of temperature-rise

Refer to clause 8.3.2.5 of this Test Instruction.

This test is carried out either at ambient laboratory temperature, or at the reference temperature which, unless other specified, is equal to 35 °C (refer to paragraph 4.7.3) but which may be outside the range of + 10 °C, + 40 °C defined in paragraph G 8.3.3.3 (refer to also the incidence on verification of overload releases described in paragraph 8.3.3.7 of the Test Instruction).

The temperature measurement points and temperature-rise limits are specified inTable 7 of IEC 947-2.

### 8.3.3.7 Verification of overload releases

Tests on releases dependent on ambient air temperature.

The verification of these releases shall be carried out at the same ambient temperature as that of the temperature-rise tests and immediately after the preceding temperature-rise test:

- either with a test current equal to 1.45 times the current setting $I_r$ (equal to the rated current $I_n$), if the ambient temperature is equal to the reference temperature.
- or with a modified test current in compliance with the temperature/current characteristics supplied by the manufacturer in the case where the ambient temperature is different to the reference temperature (note 2).

With the manufacturer's agreement, and at the laboratory's request, this verification may also be carried out with a delay after the temperature-rise test (note 1) without the device being reconditioned. In this case, the device is therefore in more unfavourable conditions for the release which shall however take place in the conventional time (table 6). These conditions will be recorded in the test sheets.

Tests on releases declared to be independent of ambient air temperature Note 2 also applies to this type of releases. Verification of these releases shall be carried out:

- either immediately after verification of the temperature-rise if this takes place with an ambient temperature equal to the reference temperature. The test current is then equal to 1.45 times the setting current,

- or, with the manufacturer's agreement, and at the laboratory's request, with a delay after verification of the temperature-rise (note 1) if this temperature-rise occurs, for example, at the premises ambient temperature which is different to the reference temperature. In this case, the tests will be carried out with a current equal to 1.45 times the setting current (without applying the correction coefficient given for releases dependent on ambient temperature). These conditions shall be recorded in the test sheets.

For the two types of releases, the tripping-time shall be less than 2 hours if $I_n$ > 63 A and at 1 hour if $I_n \leq 63$ A.

### 8.3.4 Test sequence II: Rated service short-circuit breaking capacity

In the test report, the definition of the characteristics shall include the utilization category and the values of $I_{cu}$ and $I_{cs}$, plus if necessary that of $I_{cw}$. In principle, the ratio between the values of $I_{cu}$ and $I_{cs}$ shall comply with table 1 of clause 4.3.5.2.3, except in the case where the variant with respect to $I_{cw}$ (defined in clause 4.3.5.2.2) is used.

Cabling characteristics: refer to paragraph 8.3.2.1 c of the Test Instruction.

#### 8.3.4.1 Test of rated service short-circuit breaking capacity

Refer to G 8.3.4.1 to 8.3.2.6 of the standard and of this Test Instruction, and 8.3.2.6.4 of the Test Instruction.

Note: For devices whose operation depends on an external source of power, when sequence I and sequence II are requested simultaneously (refer to the table in paragraph 8.3.5.1 of the Test Instruction), verification of the closing time will be measured during this test (refer to paragraph 7.2.1.1.3).

Case of circuit-breakers in category B whose intended time-delay is adjustable.

The standard does not specify the value of the adjustment for the service breaking capacity. LOVAG considers that it should be the same (minimum or maximum, as appropriate) as that of the overload releases.

#### 8.3.4.2 Verification of dielectric withstand

Refer to standard, and to clause 8.3.3.5 of this Test Instruction.

#### 8.3.4.3 Verification of temperature-rise

Refer to paragraph 8.3.3.6 of the Test Instruction.

Only the temperature-rise of the main circuit terminals shall be checked. The test is carried out on the samples mentioned in table 10.

During this test, the device shall not trip.

#### 8.3.4.4 Verification of overload releases

Refer to paragraphs 8.3.3.7 of the standard and the Test Instruction.

The test is carried out at 1.45 times the current $I_r$ used for each of the devices with the single-phase poles in series or three-phase.

### 8.3.5 Test sequence III: Rated ultimate short-circuit breaking capacity

Refer to the table in paragraph 8.3.1 of the Test Instruction.

In the test report, the definition of the characteristics shall include the utilization category and the values of $_{Icu}$ and $I_{cs}$ are well as $I_{cw}$, where appropriate. In principle, the ratio between the values of $I_{cu}$ and $I_{cs}$, should comply with table 1 except in the case where the variant with respect to I is used as defined in clause 4.3.5.2.2.

The rated short-circuit making capacity, $I_{cm}$ (which is related to $I_{cu}$, ) shall also be specified.

The note in 8.3.5 introduces the term "instantaneous override" used by certain manufacturers for category B circuit-breakers in which $I_{cu}$, is greater than $I_{cw}$; in this case, this term is used in the definition of the characteristics of the device.

Cabling characteristics: refer to paragraph 8.3.2.1 of the Test Instruction.

### 8.3.5.1 Verification of overload releases

Test pole by pole at 2 x $I_r$ at the laboratory ambient temperature taking into account, for releases dependent on ambient temperature, the correction factor to be applied to the test current, in the case where this temperature is different from the reference temperature.

The connection conditions for the device shall be defined in the test report, and shall be the same for both tests 8.3.5.1 and 8.3.5.4 The requesting party shall specify, before the test, the maximum value of the tripping time at 2 x $I_r$, on one pole, at the reference temperature, as well as any correction coefficient to be used for the test.

### 8.3.5.2 Test of rated ultimate short-circuit breaking capacity

For four-pole devices, refer to paragraph 8.3.2.6.4 The additional operating sequence to be carried out on one or more new samples is only to be performed if the four poles are not all identical.

Note: For devices whose operation depends on an external source of power, when sequence I and sequence III are requested simultaneously, verification of the closing time will be measured during this test (refer to paragraph 7.2.1.1.3).

### 8.3.5.3 Verification of dielectric withstand

Refer to 8.3.3.5 of this Test Instruction.

### 8.3.5.4 Verification of overload releases

Refer to standard, and refer to 8.3.5.1 of the standard and of Test Instruction.

Testing of one pole at a time, at 2.5 x $I_r$.

### 8.3.6 Test sequence IV: Verification of rated short-time withstand current

For the four-pole devices, refer to paragraph 8.3.5.2 of the Test Instruction.

Cabling characteristics : refer to paragraph 8.3.2.1 of the Test Instruction.

#### 8.3.6.1 Verification of overload releases

Refer to 8.3.5.1 of the standard and of the Test Instruction.

#### 8.3.6.2 Test of rated short-time withstand current

According to G 8.3.4.3

- the test can be carried out at any convenient voltage. If a momentary separation of the contacts longer than 2 ms occurs, the test must be repeated at the operational voltage.

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.

The calibration current is the real test current.

- when this test is carried out at the rated operational voltage, the calibration current is the prospective current.

Calibration shall produce the rated peak value, and the test time shall insure the corresponding Joule integral).

According to table G VIII and G 8.3.4.3 the test current in each of the phases shall be within the tolerances "0, + 5 %".

These tolerances apply equally to test currents or to currents measured during calibration at reduced voltage.

The duration of this withstand current is set by the manufacturer, according to the values specified in 4.3.5.4 of the standard.

For D.C. circuit-breakers, the standard accepts that the D.C. test may be replaced by a single-phase A.C. test, provides that the peak value is at the most equal to the value specified for D.C. In order to obtain the thermal stress, the duration of the test must be at least doubled. The requesting party should be warned that this variant is far more constraining from the electrodynamic stress point of view.

For this test, the tripping relays must be inoperative: this operation consists either in annihilating the mechanical action of the release, or annihilating the relay control signal (by short-circuiting the secondary winding of the current transformers for example, if the device is fitted with these).

After the test, a check is made that the device can be operated using its normal control components.

#### 8.3.6.3 Verification of temperature-rise

Refer to paragraph 8.3.4.3 of the Test Instruction.

The inoperative releases for the test in paragraph 8.3.6.2 are put back into service.

The test is carried out on all the devices without modifying the setting of the releases.

During this test, the device shall not trip.

**8.3.6.4 Test of short-circuit capacity at the maximum short-time withstand current**

The test current is the maximum value of the short-time current, and the test voltage is the highest voltage corresponding to this current. On the oscillograms, check that the circuit-breaker has remained closed during the maximum time specified by the manufacturer for the corresponding current.

The calibration of the test circuit, at the prospective current shall show that the prospective current is at least equal to the rated short-time withstand current, at the instant specified for separation of the contacts.
The recovery voltage shall be equal to 105 % (0, + 5 %) of the highest voltage applicable to the rated short-time withstand current.
For several *Icw*/*Ue* values, refer to table 10.
The second paragraph of clause 8.3.6.4 of the standard means that, if a value of *Icw* corresponds to a voltage range, the breaking capacity test at current *Icw*, shall be carried out for the maximum voltage in this range (x 1.05). The attention of the party requesting the test is therefore drawn to the fact that sequence IV mandatorily includes a breaking capacity test at the same specified current *Icw*, and for the maximum declared voltage for this value.

**8.3.6.5 Verification of dielectric withstand**

Refer to standard and 8.3.3.5 of the Test Instruction.

**8.3.6.6 Verification of overload releases**

Refer to paragraphs 8.3.5.1 in the standard and the Test Instruction.

### 8.3.7 Test sequence V: Performance of integrally fused circuit-breaker

Cabling characteristics: refer to paragraph 8.3.2.1 of the Test Instruction.
For the four-pole devices, refer to paragraph 8.3.5.2 of the Test Instruction.
The temperature-rise test 8.3.7.2 is necessary if *Ics* < *Is* (since if *Ics* > *Is*. The temperature-rise has already been carried out in sequence II). However, if sequence V is the only sequence requested, the temperature-rise test must be carried out whatever the relative values of *Is* and *Ics*.
The party requesting the test must specify the essential characteristics of the fused circuit-breakers used:

- rated current
- rated voltage
- maximum breaking capacity
- fuse pre-arcing characteristic curve
- fuse operation characteristic curves and circuit-breaker operation characteristic curves, i.e. either the mean curve with tolerances or, preferably, the set of curves defining a tolerance area.

Note: It is recalled that the phase-to-phase recovery voltage for the test is
1.05 x *Ue* (0, + 5 %).

#### 8.3.7.1 Short-circuit at selectivity limit current

Refer to standard.
The test current Is can be deduced from the characteristics curves according to Figure below, which provides further and additional details with respect to Figure A1 of the standard.

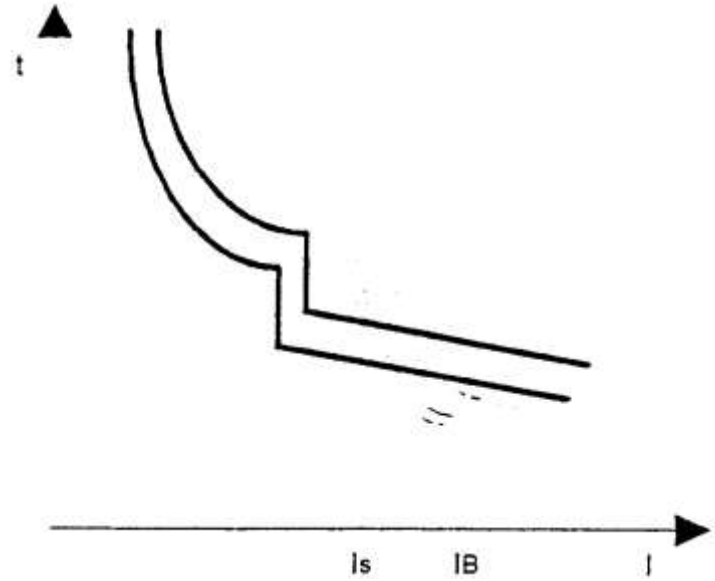



Fig.1 - Determination of currents $I_s$ and $I_B$
Curves defining the operating area of the circuit breaker
Curves defining the fuse pre-arc area
Curves defining the fuse operating area

Note: For the definition of $I_s$ and $I_B$, refer to 2.17.4 and 2.17.6 of the standard.
Also refer to G 2.5.25.

The tolerances on the test current Is are – 5 %, 0 of the calculated value of Is (by analogy with the other selectivity tests on contactors and fuses).

**8.3.7.2 Verification of temperature-rise**

Refer to paragraphs 8.3.7 and 8.3.2.5 and of the Test Instruction.
The test shall be carried out using the same fuses as in the previous test.
The fuses shall not melt and the circuit-breaker shall not trip.

**8.3.7.3 Verification of dielectric withstand**

Refer to paragraph 8.3.3.5 of the Test Instruction.
It is recalled that this test is omitted if the entire sequence V is carried out on the same no-maintenance device (refer to 8.3.7).

**8.3.7.4 Verification of overload releases**

Refer to paragraph 8.3.5.1 of the standard and the Test Instruction.

**8.3.7.5 Short-circuit at 1.1 times the take-over current**

To determine the take-over current $I_B$, refer to Figure 1 above.
The tolerance on the test current is 0,+ 5 % of 1.1 times current $I_g$ determined above.
The recovery voltage is 1.05 x Ue (0, + 5 %).

**8.3.7.7 Verification of dielectric withstand of circuit-breaker**

Refer to paragraph 8.3.3.5 of the Test Instruction.

**8.3.7.8 Verification of overload releases**

Refer to standard and to 8.3.5.1 of this Test Instruction.

**8.3.8 Combined test sequence**
Cabling characteristics: Refer to paragraph 8.3.2.1. of the Test Instruction.

**8.3.8.1 Verification of overload releases**
Refer to standard, and to 8.3.5.1 of standard and of this Test Instruction.

**8.3.8.2 Test of rated short-time withstand current**
Refer to standard, and to 8.3.6.2 of this Test Instruction.
The time specified by the standard (subclause 4.3.5.4) is, at least, that of the release with the maximum setting(s) (whether or not it is incorporated).

**8.3.8.3 Test of rated service short-circuit breaking capacity**
Refer to standard.
The text of the standard specifies that if a value of $I_{cw}$ corresponds to a voltage range, the breaking test must be carried out for the maximum voltage in this range (x 1.05).

**8.3.8.4 Verification of dielectric withstand**
Refer to 8.3.3.5 of this Test Instruction.

**8.3.8.5 Verification of temperature-rise**
Refer to standard.
During this test the device shall not trip.

**8.3.8.6 Verification of overload releases**
Refer to paragraph 8.3.3.7 of the standard and the Test Instruction.
Test at 1.45 x $I_r$. after allowing all parts to have cooled down to the ambient temperature used for test to clause 8.3.8.5.
Additional test on each pole individually at 2.5 times Ir

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

## A.5 Verification of discrimination

The standard indicates that "in certain cases, tests at *Is* are necessary on theassociation", and specifies two of them.
These tests will be carried out at the request of the manufacturer, who shall indicate:

- the type of discrimination: total or partial,
- the conditions of discrimination:
  - rating and setting of the releases of C1
  - rating and setting of the releases of C2, time-delay if any, or rating and type of the fuses,
  - $I_s$ value (if partial discrimination), or the different values of $I_s$ in accordance with the different operational voltages,
  - tripping characteristics of C1 and C2 or pre-arcing characteristics of the fuses.

1st case: Verification of the total discrimination in short-circuit

In this case, C1 shall operate alone up to its rated short-circuit breaking capacity ($I_{cu}$ or $I_{cs}$, in accordance with the level of discrimination required).
The circuit-breaker C1 and its SCPD are set in accordance with figure A.6, especially for the connecting cables (for cross-sections see the paragraph 8.3.2.1 of the Test Instruction)
For calibration, temporary connections of negligible impedance take place of the SCPD and C1. The test current is equal to $I_{cu}$ or $I_{cs}$ (tolerance 0, + 5 %) of the circuit-breaker C1 for the required voltage.
If C2 is a circuit-breaker, the delay, if any, is set at the value indicated by the manufacturer.
The test sequence is O-t-CO, the CO operation being made by C1.
Results to be obtained:

- refer to standard, paragraph G 8.3.4.1.7,
- if C2 is a circuit-breaker, it shall not open during the test,
- if C2 is a set of fuses, they shall not melt.

The circuit-breaker C1 being in accordance with the sequence II or the sequence III, it is not necessary to verify the overload releases and the dielectric withstand.

2nd case: Verification of the partial discrimination

In this case, the circuit-breaker C1 only shall trip up to the value of the selectivity limit current $I_s$.
The test conditions are identical with the previous one except for the test circuit which is set at $I_s$ value in accordance with the concerned voltage, with a tolerance of ± 5 %. The results to be obtained are identical with the previous case.

## A.6 Verification of the back-up protection

A.6.1 Determination of the take-over current
Under the responsibility of the manufacturer, the standard does not provide test.

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 (it is, then, under the responsibility of the manufacturer), or by tests in accordance with the paragraph A.6.3.

A.6.3 Tests for verification of back-up protection

Test conditions:
- refer to standard, paragraphs A.6.3 and A.6.2 a).
- the manufacturer shall indicate the value of rated conditional short circuit current of the association C1 C2.

Tests to carry out:
- a first test shall consist of a O-t-CO sequence of operations made at the rated conditional short-circuit current,
- a second test shall consist of a O-t-CO sequence of operations made at $I_{cu}$ or $I_{cs}$, according to the manufacturer demand.

Unless otherwise specified by the manufacturer, both tests are carried out on two different samples for C1 and C2 (if this latter is a circuit-breaker).
If C2 is a circuit-breaker, the record of its possible momentary opening with its duration shall be provided by the test station.
If additional tests are necessary (see paragraph A.6.3 a) to determine the lowest current at which C1 trips and contacts of C2 open momentarily (the restoration of supply being provided by C2), these tests wilt be carried out on new samples unless otherwise stated by agreement with the manufacturer.

The number of samples tested will be indicated in the test report.

# Appendix C
# Individual pole short-circuit test sequence

Additional sequence for circuit-breakers used on networks where one phase is earthed.

Cabling characteristics: Refer to paragraph 8.3.2.1. of the Test Instruction.

**C2. Test of individual pole short-circuit breaking capacity**

$I_{SU}$ ≥25 % $I_{cu}$

The test will be carried out following table 10. The inversion of the connections of the unmarked terminals are not necessary being in single phase.

**C3. Verification of dielectric withstand**

Refer to paragraph 8.3.5.3 of the Test Instruction.

**C4. Verification of overload releases**

Refer to paragraph 8.3.5.4 of the Test Instruction.