LOVAG

TEST INSTRUCTION IEC/EN 60947-4-1 Ed.3.1

CONDITIONS FOR TESTING

CONTACTORS AND MOTOR-STARTERS

This test instruction is based on the following standards:

General Rules:

Standard IEC 60947-1 Edition 5.1 (2011-03)	EN 60947-1: 2007 + A1 2011

Specific Requirements:

IEC 60947-4-1 Edition 3.1 (2012-07)	EN 60947-4-1:2010 + A1:2012

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

signed by:

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Chairman of LOVAG Technical Committee

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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 60947-4-1 and all references to clauses of the General Rules (standard IEC 60947-1) are preceded by the letter G.

References to clauses in appendices A, B, C of the standard IEC 60947-4-1 are preceded by the letters A, B, C,...

9.2 COMPLIANCE WITH CONSTRUCTIONAL REQUIREMENTS

9.2.2 Electrical performance of screwless-type clamping units

Test according to subclause 9.8 of IEC 60999-1 and 9.8 of IEC 60999-2
A suitable test arrangement is shown in Figure 10 of IEC 60947-4-1
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 suitablemeasurement method on one specimen at a stabilised temperature.
The test current is Ith

9.2.3 Ageing test for screwless-type clamping units

Test according to subclause 9.10 of IEC 60999-1 and 9.10 of IEC 60999-2
The test shall be done on the device equipped with the clamping units
The test current is Ith

9.3 COMPLIANCE WITH PERFORMANCE REQUIREMENTS

9.3.1 Test sequences

These sequences are referred to by the letters "1, 2, 3, 4, 5,", and each one is carried out on one sample. (Refer to appendix 1 of the test instruction, given as an example for utilisation categories AC3 and AC4).

9.3.2 General test conditions

Each type test or each test sequence is carried out on a clean new device, unless otherwise specified.

Before carrying out any test, it is necessary to identify the device according to the documents supplied by the requesting party and to note the markings on the identification plates and, if possible, the markings are concerning the date(s) of manufacture.

For the electrical tests, the tightening torque of the terminals shall be:

- either the torque specified by the manufacturer,
- or, if no torque is specified, the torque given in
Table G 4 of standard IEC 60947-1

The value of the torque used shall be specified in the test report.

Where no tolerances are specified in the standard, this test instruction gives the tolerances to be observed.

9.3.3 Performance under no load, normal load and overload conditions

9.3.3.1 Operation

(this is the second test in sequence I) This paragraph applies only to starters.

For adjustable relays, the following three tests are carried out successively for the maximum and minimum settings of the relay, and at the corresponding currents, according to 8.2.1.1.2.

First test:

The starter, attached to a rigid chassis, is traversed by its rated full load current, which is maintained either until the device reaches thermal equilibrium (measured as the temperature-rise of the accessible terminal assumed to be the hottest), or for a period of 8 hours.

Three contactor "open - close" operating cycles are carried out, at the rate which corresponds to the intermittent service class of the device, with the off-time being kept to the minimum possible; these operations shall not cause the relay to trip.

Second test:

At the end of the previous test, the test current is increased to 1.2 x Ir, and a check is carried out to ensure that the device trips. The source is left set to this value.

Third test:

This test is carried out either after cooling for eight hours, or after accelerated cooling with ventilation, followed by a 15 minute "recovery" period.

The reset mechanism is maintained in reset position, and the current of 1.2 x Ir is injected again: tripping shall not be impeded.

However, this test is not to be carried out when the reset button causes the de-energizing of winding circuit; this particularity shall be mentioned in the test report.

9.3.3.2 Operating limits

(These tests are a part of sequence I.: Refer to appendix 1 of the test instruction, given as an example)

9.3.3.2.1 Power operated equipment

(This test applies to the "contactor" section).

First test:

The contactor is placed in a still-air chamber at 40°C, and the control circuit is energised at its rated voltage Us, either for a maximum of 8 hours, or until thermal steady-state is reached if the temperature of the winding is measured.

The control voltage is decreased to 85 % of Us, and three open - close operation cycles are carried out as quickly as possible, whilst checking that the contactor closes sharply.
The control voltage is then raised to 110 % of Us, and three open - close operation cycles are again carried out.

When a voltage range is specified for Us, the 85 % apply to the lower limit, and the 110 % apply to the upper limit.
Second test:

The contactor is placed in a still-air chamber at -5 C, until thermal steady-state is reached, with the control circuit de-energized. A control supply voltage equal to Us is applied for a very short period, and is progressively reduced within less than 10 seconds until tripping occurs. The drop-out voltage is recorded.

The measured drop-out voltages shall be between 75 and 20 % of Us (or between 75 and 10 % for a DC coil).
It is recalled that where a voltage range is specified, 20 % (or 10 %) applies to the highest value of the range, and 75 % applies to the lowest value of the same range.

Variant of second test: according to clause 9.2.1.2., the test at -5°C can be replaced by an approximate calculation, using the values obtained at normal ambient temperature.

The method shall be as follows:

After obtaining thermal steady-state at Us and at ambient temperature (a), without prior energization, the impedance Z(a) of the winding is measured at control voltage Us (magnetic circuit closed), and its resistance R(a) (the readings being taken over short periods for Z, and at low voltage for R). This yields the value of the inductance X, which is estimated to be invariable.
It is assumed that the winding temperature varies with ambient temperature, and the following are calculated:

$$R(-5) = R(a) \cdot \frac{234.5 - 5}{234.5 + a}$$

With X known, it is possible to deduce Z(-5).

This indicates that the drop-out voltage corresponds to an equal magnetic flux, and therefore to an equal current, for both ambient temperatures (a) and (-5 °C).

Let x Us be the drop-out voltage measured at ambient temperature (a), without prior energization,

and let y Us be the drop-out voltage at (-5°C) to be determined, also without prior energization.

At x Us, the current at temperature (a) is:

$$I(a) = \frac{x\ Us}{Z\ (a)}$$

At y Us, the current at (-5 °C) is $I(-5) = \frac{y\ US}{Z(-5)}$

As these two currents are equal, this means that:

$$y\ Us = x\ Us \cdot \frac{Z(-5)}{Z(a)} \quad \text{or} \quad y = x \cdot \frac{Z(-5)}{Z(a)}$$

For a DC coil, this obviously means that:

$$y = x \cdot \frac{R(-5)}{R(a)}$$

The test therefore consists in measuring the drop-out voltage x Us at any convenient ambient temperature, and measuring the impedance and the resistance of the winding, all without prior energization, and then carrying out the above calculation: the value "y" should be within the limits specified above.

9.3.3.2.1.2 Coil power consumption

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
The coil with the lowest rated control supply voltage Us, the coil with the highest rated control supply voltage Us, 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 °C ± 3 °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 Us 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
Sh(i) = Us(i) × I(i) [VA] for a.c. controlled contactor
Pc(i) = Us(i) × I(i) [W] for d.c. controlled contactor
The published value shall be equal to the average value of the 5 tested coils
Sh = Σ (Us(i) × I(i)) / 5 [VA] respectively Pc = Σ (Us(i) × I(i)) / 5 [W]
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
Sp(i) = Us × I(i) [VA] for a.c. controlled contactor
Pp(i) = Us × I(i) [W] for d.c. controlled contactor with separate pick-up and hold windings
The published value shall be equal to the average value of the 5 tested coils
Sp = Σ (Us(i) × I(i)) / 5 [VA] respectively Pp = Σ (Us(i) × I(i)) / 5 [W]

9.3.3.2.1.3 Pole impedance

The pole impedance shall be determined during the test and with the conditions given in 9.3.3.3.4.
The test in an enclosure is not deemed necessary even if the contactor can be used in an individual enclosure
The voltage drop Ud shall be measured between the line and load terminals (terminals
included) of the contactor preferably at the same time the temperature rise is measured
The impedance per pole is defined as follows
Z = Ud / Ith [Ω]

9.3.3.2.2 Relays and releases

(This clause is applicable only to starters).

9.3.3.2.2 a) Operation of under-voltage relays and releases

The requesting party specifies the rated voltage of the release:

- in the general case, an under-voltage release shall open at between 70 and 35 % of its rated value.

  Closing shall be inhibited for any voltage lower than 35 % of Us, and it should occur before reaching 85 % of Us.

  Where a rated voltage range is specified, "35 %" applies to the highest value of the range, and "70 %" (or 85 %) apply to the lowest value.

- in the specific case of "zero-voltage" releases, these shall open at between 35 % and 10 % of their rated voltage value.

Where a voltage range is specified, 10 % applies to the highest value, and 35 % to the lowest.

These tests are carried out at normal laboratory ambient temperature (between 15 and 35 °C), without waiting for thermal steady-state between each operation.

9.3.3.2.2 b) Shunt-coil operated releases

Tripping shall occur at between 70 and 110 % of the control voltage, Us.

Where a voltage range is specified for Us, 70 % applies to the lowest value of the range, and 110 % to the highest.

These tests shall be carried out 3 times at ambient temperature, with no intentional time-delay.

9.3.3.2.2 c) Thermal, electronic and time-delay magnetic overload relays

- These tests are carried out with single-phase power, with the poles in series.

Before each of these tests, it shall be possible to assess if the device has reached thermal steady-state at the required temperatures.

1) Tests with all poles energized

- Test temperatures: table 3 and clause 9.3.3.2.2 c) specifies that the tests shall be carried out successively at three temperatures: -5, +20 and +40°C.

- This means that, taking table 3 into account for compensated relays, coefficients A, B, C and D become:

	A	B	C	D
- at 20°C	1.05	1.2	1.5	7.2
- at 40°C	1	1.2	1.5	-*
- at -5°C	1.05	1.3	-*	-*

- This means that, taking table 3 into account for electronic relays, coefficients A, B, C and D become:

	A	B	C	D
at -5°C ;at +20°C;at +40°C-	1.05	1.2	1.5	7.2

*The standard does not give coefficients for these temperatures. Consequently LOVAG does not specify test except on special request with the values stated by the requesting party.

If the temperature range is more extensive than that specified by the standard, complementary tests are performed for A and B coefficients at range limits according to manufacturers data.
When tested at the declared minimum and maximum temperatures and the current values are in compliance with the limits specified for -5°C and/or +40°C in fig. 7 of standard, the characteristics at -5°C and/or +40°C need not be verified.

- For non-compensated relays, the tests at 40°C are carried out with the values of table 3 and those at temperatures of -5°C and +20°C are carried out using the coefficients specified by the requesting party, checking that the current/temperature characteristic is less than 1.2 %/K.

  For example, if the specified characteristic is equal to this maximum value, we would have:

	A	B	C	D
- at 40°C	1	1.2	1.5	7.2
- at 20°C	-	1.49	-	-
- at -5°C	1.85	-	-	

Test details:

- Test at current A for 2 hours (or until thermal steady-state is reached), then at current B which shall cause tripping within less than 2 hours.

- Obtainment of thermal equilibrium at the setting current Ir, followed by a test at current C: tripping shall occur within less than 2, 4, 8 or 12 minutes, depending on whether the overload relay is in class 10A, 10, 20 or 30.

- Cooling with no current, followed by a test at current D: refer to tripping times in table 2 of clause 5.7.3.

- Test D can be carried out before the others, on the initiative of the platform.

- The order in which the tests are carried out as a function of the temperatures is indifferent.

  Adjustable relays

- For adjustable relays, the test is to be carried out at the maximum setting and at the minimum setting.

2) Tests on three-pole thermal overload relays with two poles energized:

- In view of the application of table 4, the requesting party shall specify whether or not the thermal relay is sensitive to phase loss.

- The test is carried out only at the temperatures specified in Table 4.

- For adjustable relays, the test is carried out for each of the two extreme settings.

- The test is repeated for each combination of three poles.

9.3.3.2.2.d) Instantaneous magnetic overload relays

The value of the current is established at a value of less than 60 % of the specified IR value (to avoid tripping when an asymmetric making wave occurs), and it is then rapidly increased whilst recording the current wave.

The rms value of the tripping current is taken to be equal to the peak value of the last complete half-cycle of the recording, divided by $\sqrt{2}$.

This rms value shall be equal to the specified I_R value, to within $\pm$ 10 %.

If the relays are adjustable, the test is carried out for the two extreme settings, allowing the thermal relays (if any) to cool down.

9.3.3.2.2.e) Under-current relays in automatic change-over

(This test applies only to star-delta starters and to auto-transformer starters).

This under-current relay shall be associated with an overload relay operating in starting position. The following are checked:

1 - The drop-out current of the under-current relay shall not be greater than or equal to 1.5 times the setting current of the overload relay.

2 - The two relays, connected together in series, are traversed by a current equal to twice the setting current of the overload relay. The under-current relay must not be degraded.

Consequently, test 2 is carried out first, followed by test 1 which is considered to be both a check and a result.

In the case of adjustable relays, the under-current relay is set to its minimum position, and the overload relay to its maximum position.

9.3.3.4 **Dielectric properties**

Refer to standard

9.3.3.4.1 **Type tests**

Refer to standard

G 8.3.3.4.1.2)c) **Application of the test voltage**

Refer to standard IEC 60947-1

G 8.3.3.4.2 c)
and
G 8.3.3.4.3 c)
i) ii) **Main circuit**

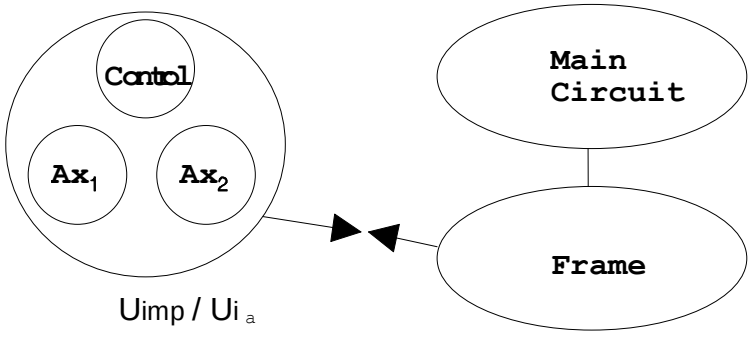
The conditions are defined in the standard for all control circuits and all auxiliary circuits normally connected to the main circuit.

All control and auxiliary circuits normally connected to the main circuit shall be considered as a main circuit.

iii) **Control and auxiliary circuits**

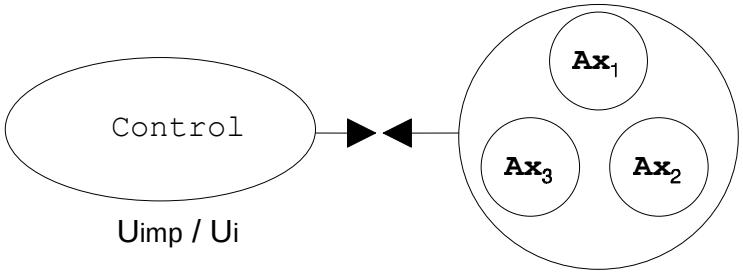
1) The standard provides for cases in which the control circuits and auxiliary circuits are not connected to the main circuit (if these are normally connected to the main circuit, refer to a).

The test is performed by applying the test voltage across all the control and auxiliary circuits and the frame, the latter being connected to the main circuit, which is possible only if there is a single auxiliary circuit or if all these circuits have the same Uimp or Ui.



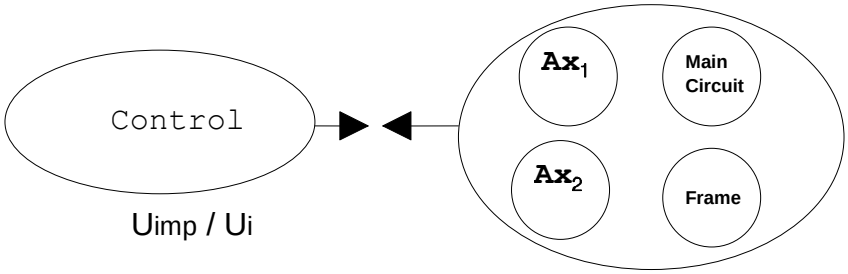
2) Test between each circuit which may be isolated from the others in normal operation and all the other circuits interconnected.

This test is to be performed if there are several circuits having:
- either the same Uimp or Ui; in this case, the circuits are tested with respect to each other (this test had not been performed before).



- or different Uimp's or Ui's.

In this case, all other circuits must also be connected to the frame since it was impossible to perform test 1.



For each of the tests, the test voltage depends on the insulation voltage of corresponding control and auxiliary circuits.

9.3.3.5 Making and breaking capacities

This test is a part of sequence "2", and is carried out on sample N° 2.

Refer to standard and to Tables 7, 7a and 7b.

For the test of categories AC3 and AC4, the breaking and making capacities (at the top of table 7) shall be preceded by the making capacity test (at the bottom of table 7).

For the latter making test, the standard accepts a tolerance of ± 20 % on the voltage, and also accepts the fact of "combining" the two series of tests (refer to note 9 in Table 7).

For this closing test, and for the "combined" test, the control supply voltage shall be 110 % of Us for half the number of operations, and 85 % for the other half. If the manufacturer specifies a control voltage range, 110 % applies to the highest value of the range and 85 % to the lowest.

9.3.3.5.1 **General test conditions**
and
9.3.3.6 **Operational performance capability**

The standard applying to the types of equipment which can have a total bounce time in the order of 50 ms, LOVAG specifies that the on-time shall not be less than 50 ms for the ac. tests, or, for dc. tests, shall be at least 3 times the time-constant or 50 ms.

Except for the make only test, if a control voltage range is specified, the supply voltage shall be equal to the minimum value specified.

9.3.4 **Performance under short-circuit conditions**

Note: According to clause 8.2.5 of the standard, the co-ordination of a starter with an SCPD is checked by carrying out this operating test under short-circuit conditions (refer to paragraph 8.2.5.1), and a discrimination test between overload relays and SCPDs (refer to paragraph 8.2.5.2. and to Annex B4).

9.3.4.1.1 **General requirements for short-circuit tests**

The control circuits of the contactors or starters are energized by a separate source at Us (refer to 9.3.4.2). If a control voltage range is specified, the supply voltage shall be equal to the minimum value specified.

9.3.4.1.2 **Test circuit for the verification of short-circuit ratings**

All parts of the equipment which are normally connected to the ground during operation, including the enclosure on the screens, shall be isolated from the ground and connected to one point as specified in Figures G9, G10, G11 and G12.

For type 1 co-ordination, it seems essential for this point to be the neutral of the source, since the fuse connected to the ground is replaced by a 6 mm² copper wire, in order to assess the failures if a fault occurs.

However, if the platform only has a delta source with a low power artificial neutral (fault current less than 1500 A), the standard accepts, with the agreement of the requesting party, for the ground of the device to be connected to a phase conductor by a 6 mm² wire. If used, this configuration shall be specified in the test report, along with the approval of the requesting party.

9.3.4.1.5 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 time 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 testing stations 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.

Only the full voltage calibration shall be recorded in the test report, and the check at the reduced voltage shall be recorded on the test sheets, with a reminder of the periodic calibration values.

The instant of making should be chosen in that way at maximum current value corresponding to the power factor and table G 16,clause G 8.3.4.1.3

9.3.4.1.8 Interpretation of records

a) Determination of the applied voltage and power frequency recovery voltage

It is recalled that the recovery voltage between phases (or the average between the three voltages in the case of a three - phased circuit) shall be equal to 105 % of the operational voltage, with the tolerance of + 5%, - O% specified in clause G 8.3.2.2 (the recovery voltage and the applied voltage are expressed and measured between phases, between the supply terminals).

b) Determination of the prospective breaking current

Figure G 13 shows the calibration of the circuit (Fig. G 13a), and the making breaking of a non limiting device (Fig. 13b).

The latter figure represents the voltage variations as a function of time.

Note 2 of Figure G 13 concerns only operation "O".

c) Determination of the prospective peak making current

The peak value of the prospective making current is measured according to the recording of the circuit calibration.

9.3.4.2 Conditional short-circuit current of contactors, starters, combination starters and protected starters

The manufacturer shall declare the rated type of co-ordination :1 or 2.

The verification includes two series of tests:

. one series of tests at current "r", where r = f(Ie.AC3) (clause 9.3.4.2.1.)

. one series of tests at current "Iq", if the manufacturer has assigned a value of "Iq" higher than "r" (clause 9.3.4.2.2).

The details of these tests are given in Appendix 2 to this test instruction, for both types of device. This appendix specifies the moments at which it is acceptable to change the starter, and possibly the SCPD.

Furthermore, the standard requires the tests to be carried out in such a way as to obtain the maximum values of Ie and Ue for category AC 3. This can be carried out:

- either by using two relays, one tested at Ue max with the corresponding Ie, and the other at Ie max with the corresponding Ue.

- or by using only one relay, tested at Ue max and at Ie max, but only with the manufacturer's approval.

This possibility is recalled in Appendix 3 to this test instruction.

In the first case, it is possible to use two SCPDs, either similar or different. Furthermore, the standard provides for the case of starters which can be fitted with interchangeable overload relays; the test is carried out using the relay with the highest impedance and the relay with the lowest impedance in conjunction with the corresponding SCPDs.

The different possibilities are summarised in Appendix 3 of this test instruction.

Note: Discrimination between overload relays and SCPDs

This is a special test. It is considered in appendix B, part B4 of the standard, and will therefore be considered here in B.4

9.3.4.2.1. Test at prospective current "r"

Refer to standard, and to Appendix 2 of the test instruction.

The prospective current "r" is specified in Table 11.

The test comprises an "O-t-CO" cycle, in which closing is carried out by the contactor.

9.3.4.2.2 Test of the rated conditional short-circuit current Iq

Current Iq is the conditional short-circuit current assigned by the manufacturer for the association, when Iq is greater than "r".

In the case of interchangeable relays, the variants studied in Appendix 3 can be used as a guide.

The test includes the following (refer to Appendix 2 of the test instruction):

1 - one SCPD breaking operation, with all devices in make configuration prior to the test,

2 - one SCPD breaking operation, with the current established by the closing of the contactor or the starter on the short-circuit.

If the short-circuit making capacity - see note 1 - of the manually controlled connecting device of a combination starter or a protected starter is less than the peak current value "Iq", taking into account the asymmetry of switching-on current - and therefore the power-factor, the following additional test shall be carried out on a new sample.

3 - one SCPD breaking operation, with the current established by the closing of the switching device.

The purpose of the latter operation is to check that the making capacity of the switching device is sufficient.

However, if by construction (for example in an item of equipment), the switching device cannot switch on the on-load circuit, this operation shall not be carried out. This particularity shall be specified in the test report.

Note:

In the case of a circuit-breaker, the making capacity associated with the ultimate short-circuit breaking capacity is taken into account, as checked during sequence 3 of standard 947-2; this is because it is merely necessary to compare current Iq with the ultimate breaking capacity, since both are expressed as rms values: if Iq > Icu, it is necessary to carry out test 3.

Conversely, in the case of a fused-combination, it is necessary to take the short-circuit making capacity with fuse to be taken into account, which is expressed as a peak value and compare it with the asymmetric peak of Iq. It is recalled that all fuses must be replaced for each operation.

9.3.4.2.3 Results to be obtained

The results to be obtained are recalled in Appendix 2 of the test instruction.

Note 1:

Replacement of the entire contactor is not accepted if welding occurs, and if the contacts cannot be easily separated.

Note 2:
for type 2 only
If the contacts have become welded, but were separated in accordance with manufacturer's instruction, this fact shall be recorded in the test report.

Note 3:
for type 2 only
Since it is difficult to appreciate a "significant deformation", (see paragraph J of standard), with the agreement of the client, the standard requires in the case of welding contacts have to be separated, to carry out 10 operating cycles under the conditions of table 8 for the applicable utilization category. The results shall be mentioned in the test report, there shall be no permanent arcing, no flashover between poles, no blowing of the fusible element used for the control of safety clearance and no welding of contacts.

ANNEX B TO STANDARD SPECIAL TESTS

B.1 General

According to the standard, these special tests are carried out at the manufacturer's discretion.

B.4 Discrimination between overload relays and SCPDs

(This test is discussed here, and may be requested as an addition to the "performance under short-circuit conditions" tests specified in paragraph 9.3.4, and using the same SCPD. However, the tests are carried out on new devices, unless otherwise agreed by the manufacturer).
The overload relay or release can be included in the SCPD (protected manual starters for instance).
In that case, after the test at the lower current (0,75 I_C), LOVAG admits that the relay, which shall be in conformity with IEC 60947-4-1 and which shall have operated, opens the SCPD.

B.4.4.1 Test procedure

The test currents are actual "through" currents, as opposed to "prospective" currents. This means that the calibration of the test circuit is effected by replacing the starter by an impedance equal to this device, measured under cold conditions (or by using components with analogous characteristics). The SCPD shall be replaced by a negligible impedance, to allow the measurement of the breaking current. The overload relay may be rendered inoperant for the same reason.

In the case of small relays with a high internal resistance, it may be impossible to obtain the required power factor. In this case, the load circuit shall therefore be made up only of inductances, in order to obtain the lowest possible power factor.

The separate power supply of the control circuit shall use the normal operating circuit, i.e. it shall at least pass through the contact of the relay and, on express demand, it may also pass through other auxiliary contacts of the assembly being tested (strikers, etc. ...).

The test includes a breaking test for each of the specified currents.

B 4.4.2 Results to be obtained

At the end of the tests, refer to clause 9.3.4.2.3 of the standard and of this test instruction for inspection of the devices.

The purpose of the latter operation is to check that the making capacity of the switching device is sufficient.

However, if by construction (for example in an item of equipment), the switching device cannot make the circuit when it is loaded, this operation shall not be carried out. This particularity shall be mentioned in the test report.

Appendix 1

SUMMARY OF TEST PROGRAMME FOR CONTACTORS OR STARTERS IN CATEGORIES AC-3 OR AC-4 ACCORDING TO IEC/EN 60947-4-1

TYPE OF TEST (PER SEQUENCE)		CONTACTOR	STARTER
CLAUSE IN STANDARD	TITLE		
	Sequence I	Device N°1	Device N°1
9.3.3.3	Verification of tempera-ture-rise	YES	Adjustment or Ie max
9.3.3.1	Operation	Not applicable	YES
9.3.3.2	Operating limits		
9.3.3.2.1	Power-operated equipment	YES	(unnecessary if test already carried out for contactor part) YES
9.3.3.2.2	Relays and releases	Not applicable	YES
9.3.3.4	Dielectric properties	YES	
	Sequence II	Device N°2	Device N°2
9.3.3.5	Verification of making and breaking capacities See 9.3.3.5.5c) if AC-3 See 9.3.3.5.5d) if AC-4	50"C"then 50"C-O" with 110% of Us for 50% of operations, and 85% of Us for the rest, in each group	ditto, but: -the overload relays can be short-circuited -the test is purpose-less if already carried out on the contactor alone
9.3.3.6	Operation performance capacity, dielectric test	YES	as above
	Sequence III	Device N°3	Device N°3
9.3.4	Verification of performance under short-circuit conditions	YES Refer to appendices 2	YES and 3 of test instruct.
	Sequence IV	Device N°4	Device N°4
9.3.5	Ability of contactor to withstand overload currents	YES	YES applicable to contactors only
	Sequence V	Device N°5	Device N°5
8.2.4 of Part 1	Mechanical and electrical properties of terminals	YES	YES
Appendix C of Part 1	Verification of degree of protection of devices in enclosures	YES	YES

Appendix 2

CO-ORDINATION TESTS BETWEEN A CONTACTOR OR A STARTER AND A SHORT-CIRCUIT PROTECTION DEVICE (SCPD)

Clause 8.2.5. of the standard specifies that the co-ordination includes:

- short-circuit operating tests, according to clause 9.3.4.2

- the discrimination tests according to annex B4.

The first group corresponds to sequence "III", whilst the second is a "special test" carried out at the manufacturer's discretion, but both are considered together here since they will frequently be carried out together, in order to check the type of co-ordination declared.

This appendix specifies the procedure for:

- each type of co-ordination given in the standard (types 1 and 2)

- depending on the type of device:

. all devices or combinations of devices, except for "combination starters and protected starters",

. combination starters and protected starters (refer ,to definitions in paragraphs 3.2.7 and 3.2.8).

Note that, for these types of devices, it is possible to have Iq > Icu, depending on the instructions given in 9.3.4.2. of this test instruction. If this is the case, test 3 according to 9.3.4.2.2. of the standard shall be carried out.

Each of the cases is considered on its own here, which means that repetitions are necessary, but this avoids cross-referencing and facilitates the use of this appendix.

During the course of the text, it is sometimes deemed acceptable to replace the starter during a sequence, and to replace the starter and the SCPD between two sequences. This replacement may not be necessary if the operational condition of these parts is correct, and if the requesting party so wishes. In this case, if a fault occurs in the test sequence, the complete set of tests shall be repeated and the accepted replacements made as appropriate.

For combination starters and protected starters, when the standard accepts a "replacement of starter", it is acceptable to replace only a part of the starter, for example the overload relay on its own or the contactor on its own, provided that this replacement can be easily carried out by an operator.

For the meaning of the different currents (r, Iq, Ic, Icu), refer to the standard and to the test instruction.

For the meaning of symbols "A, B, C, D, etc. ..." in the verifications to be carried out after the tests, refer to clause 9.3.4.2.3 of the standard.

1 CO-ORDINATION TYPE 1: ALL DEVICES EXCEPT COMBINATION STARTERS AND PROTECTED STARTERS

1.1 Discrimination tests

- New devices (SCPD + contactor or starter),

- "O" operation at 0.75 x Ic.

prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform closing device,
- the SCPD shall not operate,
- the overload release or relay shall operate;

after test:

- inspection of the SCPD,
- reset the overload relay;

- "O" operation at 1.25 x Ic.

prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform closing device,
- the SCPD shall operate before the starter (to be checked by recording the voltage across the terminals of each device or, if this is not possible, check according to the operating time);

after test:

- inspection of the starter,
- inspection of the SCPD,
- the starter shall comply with conditions A, B, C, D and H of clause 9.3.4.2.3.
- the starter may not be in operating condition.

- End of discrimination tests.

1.2 Operation under short-circuit conditions

1.2.1 Tests at prospective current "r":

- New equipment. (SCPD and starter or contactor). Unless the requesting party decides to accept the use of all or part of the devices having been subjected to the discrimination tests. But using new fuses.

- "O" operation at current "r".

prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

after test:

- verifications A, B, C, D and H by visual examination (according to 8.3.4.2.3.);

- the starter may not be in operating condition. Replacement is accepted;

- reset the starter relay (if not replaced following agreement by the requesting party);

- reset the circuit-breaker release;

- replace all fuses.

- "CO" operation at current "r".

prior to test:

- SCPD closed:

test:

- the contactor or starter is closed,

after test:

- verifications A, B, C, D and H by visual examination according to 9.3.4.2.3.;

- the starter may not be in operating condition;

- end of tests at current "r".

1.2.2 Conditional short-circuit current tests Iq:

For these devices, Iq < Icu of SCPD.

- New equipment. Unless the requesting party decides to accept the use of all or part of the devices having been subjected to the tests at current "r". New fuses.

- "O" operation at current "Iq".

prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

after test:

- verifications A, B, C, D and H by visual examination according to 9.3.4.2.3.;

- the starter may not be in operating condition. Replacement is accepted;

- reset the starter relay, if replacement was refused by the requesting party);

- reset the circuit-breaker release, or replace all fuses.

- "CO" operation at current "Iq".

prior to test:

- SCPD closed:

test:

- the contactor or starter is closed,

after test:

- verifications A, B, C, D and H by visual examination according to 9.3.4.2.3.;

- the starter may not be in operating condition;

- end of co-ordination type 1 tests, for all devices except combination starters and protected starters.

- Summary:
. number of devices to be procured for these tests, including accepted replacements:
- contactors or starters : 5
- circuit-breakers : 3
- sets of fuses : 5

2 CO-ORDINATION TYPE 1; COMBINATION STARTERS AND PROTECTED STARTERS

2.1 Discrimination tests

- New devices (SCPD + starter or contactor),

- "O" operation at 0.75 x Ic.

. prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch,
- the SCPD shall not operate,
- the overload release or relay shall operate;

after test:

- inspection of the SCPD,
- reset the overload relay;

- "O" operation at 1.25 x Ic.

. prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch,
- the SCPD shall operate before the starter (to be checked by recording the voltage across the terminals of each device or, if this is not possible, check according to the operating time);

after test:

- inspection of the starter, the starter shall comply with conditions A, B, C, D and H of clause 9.3.4.2.3

- inspection of the SCPD: verifications E and F, and verification I (dielectric test across supply-side terminals, with SCPD open);

- the starter may not be in operating condition.

- End of discrimination tests.

2.2 Operation under short-circuit conditions

2.2.1 Tests at prospective current "r":

- New equipment. Unless it is decided to use all or part of the devices having been subjected to the discrimination tests. New fuses.

- "O" operation at current "r".

. prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

after test:

- inspection of the starter: it must comply with conditions A, B, C, D and H of clause 9.3.4.2.3.

- inspection of the SCPD: verifications E and F, and verification I (dielectric test as above, if the starter has been replaced);

- the starter may not be in operating condition: Replacement is accepted (if it is not replaced, following agreement by the requesting party, the relay is reset);

- reset the circuit-breaker release;

- replace all fuses.

- "CO" operation at current "r".

. prior to test:

- SCPD closed:

test:

- the contactor or starter is closed;

after test:

- verifications A, B, C, D and H by visual examination according to 9.3.4.2.3.;

- inspection of the SCPD, verifications E and F:

. dielectric test I (see above),

. verification "G" of circuit-breaker, in the case where Iq > Icu:

- for an instantaneous release, test at 120 % of Ir, 2 poles in series, with no asymmetry;

- for an overload release, test at 250 % of In, one pole at a time,

- the starter may not be in operating condition;

- end of tests at current "r".

2.2.2 Conditional short-circuit current tests "Iq":

For these devices, Iq < Icu of SCPD.

- New equipment. Unless the requesting party decides to accept the use of all or part of the devices having been subjected to the tests at current "r". New fuses.

- "O" operation at current "Iq".

. prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

after test:

- inspection of starter: verifications A, B, C, D and H by visual examination;

- inspection of the SCPD: verifications E and F, and verification I (dielectric test: as above, if the starter has been replaced);

- the starter may not be in operating condition: Replacement is accepted (its relay is reset if, following refusal by the requesting party, the starter is not replaced);

- reset the circuit-breaker release, or replace all fuses.

- "CO" operation at current "Iq".

. prior to test:

- SCPD closed:

test:

- the starter is closed,

after test:

- examination of starter: verifications A, B, C, D and H;

- inspection of the SCPD: verifications E and F, and verification I (dielectric test);

- the starter may not be in operating condition;

- end of tests if Iq < Icu

- Additional "CO" test with current Iq, if Iq > Icu:

. for this test, replacement of the previous starter is accepted, as is replacement of the SCPD: (reason: the purpose of this test 3 of clause 9.3.4.2.2 is to show that the making capacity of the SCPD is sufficient, and not to exert a further constraint on the devices. This explains why replacement is authorised).

New fuses

. prior to test:

- starter closed; (refer to exception in test instruction, clause 9.3.4.2.2.).

test:

- the SCPD is closed:

after test:

- examination of starter: visual verifications A, B, C, D and H;

- inspection of the SCPD: verifications E and F, and verification I (dielectric test);

- the starter may not be in operating condition;

- verification G of circuit-breaker (see "r" above).

- End of co-ordination tests, type 1, for combination starters and protected starters.

- Summary:
. number of devices to be procured for these tests, including accepted replacements:

	Iq < Icu	Iq > Icu
- contactors or starters :	5	6
- circuit-breakers or switches :	3	4
- sets of fuses :	5	6

3 CO-ORDINATION TYPE 2: ALL DEVICES EXCEPT COMBINATION STARTERS AND PROTECTED STARTERS

3.1. Discrimination tests

- New devices (SCPD + contactor or starter),

- Preliminary verification "K" of 9.3.4.2.3.

. Overload relay test at ambient temperature, at a known current value, such as 2, 2.5 or 3 x Ir max at which the subsequent verifications are to be carried out.

- "O" operation at 0.75 x Ic.

. prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

- the SCPD shall not operate;

- the overload release or relay shall operate;

after test:

- inspection of the SCPD,

- reset the overload relay;

- "O" operation at 1.25 x Ic.

. prior to test:

- starter and SCPD closed:

test:

- the SCPD shall operate before the starter (to be checked by recording the voltage across the terminals of each device or, if this is not possible, by checking to the operating time);

after test:

- verifications A, B, C, D of the assembly:

- verification J: welding of the contacts is acceptable if they can be easily separated;

- verification K of the overload relay (see above);

- verification L: dielectric test of contactor or of starter, at 2 x Ue (min: 1000 V) according to G 8.3.3 4.1, item 4);

- if the contacts have become welded and are easily separated according to clause 8.3.4.2.3 of the test instruction, additional test: 10 "CO" operations according to Table 8 for category AC-3 (2 x Ie), after resetting the circuit-breaker or replacing the fuses. The contacts shall not become welded again, or shall be easy to separate.

- End of discrimination tests.

3.2. Operation under short-circuit conditions

3.2.1. Tests at prospective current "r":

- New equipment. Unless the requesting party decides to accept the use of all or part of the devices having been subjected to the discrimination tests. New fuses.

- Preliminary verification "K" (see above in 3.1).

- "O" operation at current "r".

. prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

after test:

- verifications A, B, C and D of 9.3.4.2.3.;

- verification J: welding of the contacts is acceptable, if they can be easily separated;

- "CO" operation at current "r".

- same devices as in previous operation.

. prior to test:

- SCPD closed:

test:

- making by contactor or starter;

after test:

- verifications A, B, C and D of 9.3.4.2.3.;

- verification J: welding of the contacts is acceptable, if they can be easily separated;

- verification K (as above, in 3.1):

- verification L: dielectric test of contactor or of starter, at 2 x Ue (min: 1000 V) according to G 8.3.3.4.1, item 4);

- if the contacts have required separation, additional test: 10"CO" operations according to Table 8 for category AC-3 (2 x Ie). The contacts shall not become welded again.

- end of tests at current "r".

3.2.2 Conditional short-circuit current tests "Iq":

For these devices, Iq $\leq$ Icu of SCPD.

- New equipment. Unless the requesting party decides to accept the use of all or part of the devices having been subjected to the tests at current "r".

- Preliminary verification "K" (see above in 3.1).

- "O" operation at current "Iq".

prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

after test:

- verifications A, B, C and D of 9.3.4.2.3.;

- verification J: welding of the contacts is acceptable, if they can be easily separated;

- reset the circuit-breaker, or replace all fuses.

- "CO" operation at current "Iq".

same devices as above.

prior to test:

- SCPD closed:

test:

- making by contactor or starter;

after test:

- verifications A, B, C and D of 9.3.4.2.3.;

- verification J: welding of the contacts is acceptable, if they can be easily separated;

- verification K (as above, in 3.1):

- verification L: dielectric test of contactor or of starter, at 2 x Ue (min: 1000 V) according to G 8.3.3.4.2, item 4);

- If the contacts have required separation, additional test: 10 "CO" operations according to Table 8 for category AC-3 (2 x Ie), after resetting the circuit-breaker or replacing the fuses. The contacts shall not become welded again.

- End of co-ordination type 2 tests, for all devices concerned.

- Summary: number of devices to be procured, including all accepted replacements:

- contactors or starters: 3
- circuit-breakers: 3
- sets of fuses: 5

4. CO-ORDINATION TYPE 2. COMBINATION STARTERS AND PROTECTED STARTERS

4.1. Discrimination tests

- New devices (SCPD and starter),

- Preliminary verification "K":

overload relay test at ambient temperature, at a known current value, such as 2, 2.5 or 3 x Ir max at which the subsequent verifications are to be carried out.

- "O" operation at 0.75 x Ic.

. prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

- the SCPD shall not operate;

- the overload release or relay shall operate;

after test:

- inspection of the SCPD,

- reset the overload relay;

- "O" operation at 1.25 x Ic.

. prior to test:

- starter and SCPD closed:

test:

- the SCPD shall operate before the starter (to be checked by recording the voltage across the terminals of each device or, if this is not possible, by checking to the operating time);

after test:

- verifications A, B, C, D of 9.3.4.2.3.

- verification J: welding of the contacts is acceptable if they can be easily separated;

- verifications E and F;

- verification K (see 4.1. above);

- verification L: dielectric test at 2 x Ue (min: 1000 V);

- according to G 8.3.3.4.1., item 4);

- then according to G 8.3.3.4.1., item 3);

. SCPD open and starter closed,

- if the contacts have become welded and are easily separated according, additional test consisting of 10 "CO" operations according to Table 8 for category AC-3 (2 x Ie), after resetting the circuit-breaker or replacing the fuses. The contacts shall not become welded again .

- End of discrimination tests.

4.2. Operation under short-circuit conditions

4.2.1 Tests at prospective current "r":

- New equipment. Unless the requesting party decides to accept the use of all or part of the devices having been subjected to the discrimination tests. New fuses.

- Preliminary check "K" (see 4.1. above).

- "O" operation at current "r".

. prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

after test:

- verifications A, B, C and D;

- verification J: welding of the contacts is acceptable, if they can be easily separated;

- verifications E and F;

- "CO" operation at current "r".

- same devices as in "O" operation.

. prior to test:

- SCPD closed:

test:

- starter closes;

after test:

- verifications A, B, C and D;

- verification J: welding of the contacts is acceptable, if they can be easily separated;

- verifications E and F;

- verification K (refer to procedure in 4.1):

- verification L: dielectric test (refer to procedure above);

- verification G if Icu < Iq:

. for an instantaneous release, test at 120 % of Ir, 2 poles in series, with no asymmetry;

. for an overload release, test at 250 % of In, one pole at a time.

- if the contacts have required separation, additional test (LOVAG): 10"CO" operations according to Table 8 for category AC-3 (2x Ie), after resetting the circuit-breaker or replacing the fuses. The contacts shall not become welded again.

- end of tests at current "r".

4.2.2 Conditional short-circuit current tests "Iq":

For these devices, Iq can be > Icu of the SCPD. New fuses.

- New equipment. Unless the requesting party decides to accept the use of all or part of the devices having been subjected to the tests at current "r".

- Preliminary verification "K" (refer to procedure above, in 4.1).

- "O" operation at current "Iq".

. prior to test:

- starter and SCPD closed:

test:

- the circuit is closed by the platform making switch;

after test:

- verifications A, B, C and D;

- verification J: welding of the contacts is acceptable, if they can be easily separated;

- verifications E and F;

- reset the circuit-breaker and overload relay. Replace fuses.

- "CO" operation at current "Iq".

. same devices as above.

prior to test:

- SCPD closed:

test:

- making by starter;

after test:

- verifications A, B, C and D;

- verification J: welding of the contacts is acceptable, if they can be easily separated;

- verifications E and F;

- verification K: test of overload relay (refer to procedure above, in 4.1);

- verification L: dielectric test refer to procedure above, in 4.1;

- If the contacts have required separation, additional test: 10"CO" operations according to Table 8 for operating category AC-3 (2 x Ie);

- End of co-ordination tests if Iq $\leq$ Icu.

- If Iq > Icu, additional "CO" test at Iq

- New devices. The use of new devices is accepted here, because the purpose of this test is to show that the short-circuit making capacity of the SCPD is sufficient, and not to exert a further constraint on the devices.

- Preliminary verification K of overload relay: (refer to procedure above, in 4.1).

prior to test:

- starter closed; (see exception in 9.3.4.2 of the test instruction);

test:

- the SCPD is closed;

after test:

- verifications A, B, C and D.

- verification J: welding of the contacts is acceptable, if they can be easily separated.

- verifications E and F.

- verification G: see procedure in "r" tests.

- verification K (see procedure in 4.1.).

- verification L: dielectric test; see procedure above.

- If the contacts have required separation, additional test (LOVAG): 10"CO" operations according to Table 8 for utilization category AC-3 (2 x Ie);

- End of co-ordination tests.

- Summary: number of devices to be procured, including all accepted replacements:

		Iq ≤ Icu	Iq ≥ Icu
- contactors or starters	:	3	4
- circuit-breakers	:	3	4
- sets of fuses :		5	6