LOVAG

TEST INSTRUCTION IEC EN 60947-5-2

CONDITIONS FOR TESTING TYPE-TESTED PROXIMITY SWITCHES

This test instruction is based on the following standards:

General Rules:

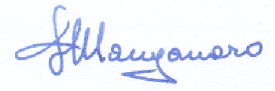
IEC 60947-1 (2007-06) Ed. 5.0
EN 60947-1: 2007
and
IEC 60947-5-2 (2007-10) Ed. 3.0
EN 60947-5-2: 2007

Specific Requirements:

As above

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.

Valid from: 05/03/2009



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LTI IEC/EN 60947-5-2
Edition 3.0
August 2008
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For convenience of use of this test instruction the paragraphs are numbered according to the clauses of the referred standard (IEC and/or EN as indicated).

Tests must be carried out according to the standard; the test instruction only adds a few specific details.

Overview of all test sequences see appendix 1 on page 15

1. to 6. Refer to standard: No tests are described in these sections.

7.4.1 Shock withstandability

cf. EN / IEC 60068-2-27

Pulse shape: half - sine
peak acceleration: 30 g
Duration of the pulse: 11 ms

The test shall be performed in each direction of the specimen along three mutually perpendicular axes
(6 shocks along each axis, 3 shocks in both directions).

7.4.2 Vibration withstandability

cf. EN / IEC 60028-2-6

Frequency range: 10 Hz to 550 Hz
Amplitude: 1 mm for inductive, capacitive and ultrasonic proximity switches
0,5mm for photoelectric proximity switches
Sweep cycle duration: 5 min
Duration of endurance at resonance frequency or at 55 Hz: 30 min in each of the three axes (90 min in all)
The test shall be performed a long three mutually perpendicular axes.

8 Tests

The tests are performed in five test sequences listed in 8.3.1 and a special sequence for class II equipment only. For a survey of this sequences see the appendix

8.2.4 Mechanical properties of terminals

Refer to standard EN 60947-1, 8.2.4.1 and 8.2.4.2 only. It is not required, that the test shall be made terminals in a clean and new condition. Flat copper conductors are not applicable in this case.

8.3.3.2 Operating limits

In the sub-clause 8.3.3.2, Operating limits, there are summarised the following operations These five tests are not part of the test sequences 8.3.1. Because they cannot be omitted, this test instruction has integrated the operating limits test in test sequence 1 at the very beginning.

8.3.3.2.1 Time delay before availability

The tests should be performed under the following conditions:

- test circuit according to fig. 6
- the target is placed in a position such that the proximity switch is in the ON - state (1/3 sn or 3 sn)
- applied voltage equal to the rated operational voltage or the minimum value of the voltage range U_e
- applied current equal to the minimum operational current I_m
- recording the output signal across the load with an oscilloscope triggered by rising supply voltage
- the measured time delay before availability should not exceed 300 ms (see 7.2.1.7)
- during this time the switching element shall not give any other signal than zero longer than 1 ms.

8.3.3.2.2 Minimum operational current

The test is performed under the following conditions.

- test circuit according to fig. 8 (switch S open)
- only for switches with complementary output: Both output elements have to be checked in the ON - state.
- the target is placed in a position such that the proximity switch is the ON - state
- applied voltage U_e and current I_m
- Starting from current values of $I \approx 5 + I_m$, maximum $I = I_e$, the current is decreased to the minimum current value given by 7.2.1.11 by adjusting resistor R1
- during the test switching element(s) shall not change state

8.3.3.2.3 OFF - state current

The test is performed under the following conditions:

- test circuit according to fig. 8 (switch S closed).
- the load R_2 is adjusted to obtain the rated operational current I_e with the supply voltage at the highest permitted value of U_e
- the target is moved so that the switching element is the OFF – state
- the OFF - state current is measured witch supply voltage U_e + 10 % or witch the maximum value of the supply voltage specified as a range the OFF – state current I_r shall be within the following limits

2 terminals	$I_r \leq$ 1,5 mA d.c
	$I_r \leq$ 3 mA a.c. r.m.s
3 or 4 terminals	$I_r \leq$ 0,5 mA d.c

8.3.3.2.4 Independent snap action

The test is performed under the following conditions.

- minimum and maximum operating load currents and minimum and maximum rated operating voltages (4 measurements)
- target moving from a position where the switching element is in the OFF - state to a position where the switching element is in an ON – state
- observing the output signal on an oscilloscope
- the switching element function should be independent from the velocity of the target and the output shall switch between the ON an OFF state without oscillating or holding at any intermediate level

8.3.3.2.5 Voltage drop (U_d)

The test is performed under the following conditions:

- test circuit according to fig. 8 (switch closed).
- the voltage drop is measured across the active output of the proximity switch
- switching element in the ON – state
- current equal to the rated operational current
- at 23 $\pm$ 5° C ambient temperature
- voltages: U_e +10 % and U_e -15 % or
  $U_{e\ max}$ +10 % and $U_{e\ min}$ -15 % or
  $U_{B\ max}$ and $U_{B\ min}$

- the voltage drop U_d should be within the following limits

2 terminals	$U_d \leq$ 8 V d.c.

	$U_d \leq$ 10 V a.c. r. m.s
3 or 4 terminals	$U_d \leq$ 3,5 V d.c.

8.3.3.3 Temperature rise

See also EN / IEC 60947 - 1, 7.2.2 and 8.3.3.3

The ambient temperature should be between 10° C and 40° C and should not change more than 10K during the test. The air around the test specimen should be at rest during the test. If the ambient temperature changes more than 3K during the last third of the test, a suitable correcting factor should be taken into account.

The applied voltage should be equal to rated operational voltage (or the maximum of the voltage rage) and the applied current should be equal to the rated operational current.

Before and after test, the ambient temperature and the maximum temperature of the test specimen has to be measured. From this dates the maximum temperature rise cab be calculated.

Measures have to be taken that the surrounding air is at rest and the mounting of the sample does not provide additional cooling.

The temperature - rise should not exceed 50K.

8.3.3.4 Dielectric Properties

If the manufacturer has declared a value of the rated impulse withstand voltage U_{imp} see sub - clause 8.3.3.4 of EN / IEC 60947 - 1. The verification of the dielectric properties has to be performed with an impulse test voltage U 1,2/50 according to tab. 12 of EN / IEC 60947 - 1 and according to the height to the test laboratory.

If no value for U_{imp} has been declared, the dielectric properties test has to be carried out with a test voltage according to table V II of 947 - 5 - 2, applied for 1 minute. The test voltage is selected according to Ui. If no Ui is specified, Ue max. has to be taken. The test voltage should be applied between live parts of the switching elements and the surface of the proximity switch likely to be touched in service. The external surface of all insulating parts shall be made conducting by being closely covered by a metal foil.

The proximity switch has passed the test if there if there is no unintentional disruptive, discharge during the test.

8.3.3.5 Making and breaking capacities of switching elements under abnormal and normal conditions

See also 7.2.4.1, Tab. 4 and 5

For utilisation categories see 4.4 Tab 2

For DC - proximity switches the inductance L has to be determined so that the current reaches 95 % of is stationary value after a time of

1 ms for DC - 12
6 Pms for DC - 13

6 P (ms) means six times the steady - state power consumption $P = U_e \times I_e$ measured in ms (Ue in Volt and Ie in Amperes), with a maximum of 300 ms.

The inductance L can also be calculated from

$L = 1/3 \times R \times t$

with t = 1 ms or 6 Pms respectively and R the resistive load, measured in Ohms.

For AC-Proximity switches the inductance has to be determined that

$$\cos \varnothing = \frac{R}{\sqrt{(R^2 + (\omega L)^2}}$$

R = 0,3 for AC 140 normal conditions
= 0,9 for AC 12
= 0,7 for AC 140 abnormal conditions

The inductance L can be calculated from

$L \approx 10^{-2} R\ (s)$ for AC 140

$L \approx 1{,}53 \times 10^{-3} \times R\ (s)$ for AC 12

The number of operations should be at least 6050, the first 50 operations shall be run at $U = 1{,}1\ U_e$ with the loads set at U_e.
The number of operations is specified in the standard as 6 per minute. This number can be increased to shorten time. Also the ON - time can be raised, because the specified values don't take into account the time delay before availability.
After the test, the effective operating distance of the proximity switch shall be measured and be within the limits given in sub-clause 7.2.1.3.1

8.3.4 Performance under short - circuit current condition

Test circuit see fig. 10 of sub - clause 8.3.4
Test performed under the following condition:

- mounted as in service, in free air
- connected to the test circuit with the same size wire as used in service
- output element of proximity switch in ON – state
- Before short - circuit the rated operational current and 1.1 times the rated operational voltage has to be adjusted.
- When the short - circuit switch is closed a prospective short - current of 100 A has to be supplied by the source.
- The short - circuit current must be maintained until the SCPD or the internal short circuit protection in the proximity switch has operated.
- Three tests should be carried out. The interval between the tests shall be not less than 3 minutes. The actual time has to be documented in the test - report.
- After short - circuit test, the operating distance shall be measured and be within the limits given in sub - clause 7.2.1.3

8.4 Testing of operating distance
for inductive, capacitive and ultrasonic switches

The effective operational distance (s_r) and the differential travel (H) are measured at the following conditions:

- mounted as in service
- rated voltage or any other voltage within the voltage range
- the load shall be adjusted to provide 0,2 I_e
- 23 $\pm$ 5° C ambient air temperature
- the target is square shaped having a thickness of 1 mm and made of steel of a rolled finish. The length of the side of the square is equal to the diameter of the circle inscribed on the active surface of the sensitive face, or three times of the rated operating distance s_n whichever is greater (see fig. 5 of EN / IEC 60947-5-2)
- For capacitive proximity switches the target shall be connected to earth
- For photoelectric proximity switches of type R (type T) the standard target is the reflector (the emitter) which is either supplied or specified by the manufacturer. For photoelectric proximity switches of type D the standard target is
    1. 100 x 100 mm white paper with 90 % reflectivity
    2. 200 x 200 mm white paper with 90 % reflectivity
- ambient light for photoelectric proximity switches is 1000 to 2000 Lux (for practical reasons not 0 Lux as in EN / IEC 60947-5-2, 8.4.2.1 and following sub-clauses)
- The target is moved, not faster than 1 mm per sec towards and away from the sensing face of the proximity switch in an axial direction(see fig. 3 and 4 of EN / IEC 60947-5-2)

- The measured value for the effective operational distance s_r shall be within

  90 % an 110 % of the rated operating distance (s_n)

  $0,9\ s_n \leq s_r \leq 1,1\ s_n$

- For ultrasonic proximity switches the operational distance s_r shall within the minimum and maximum operating distance

  $s_{min} \leq s_r \leq s_{max}$

8.4.1.3 Hysteresis

The differential travel (H) is defined as a percentage of the effective operating distance (s_r). The measured value shall be less than 20 % of the effective operating distance (s_r)

8.4.1.4 usable operating distance

The usable operating distance Su is measured over the -25° C and +70° C ambient temperature range and the supply voltage at 85% and 110% of their rated voltage.
For inductive and ultrasonic proximity switches the usable operating distance s_u shall be within the following limits

$0,9\ s_r \leq s_u \leq 1,1\ s_r$

For capacitive proximity switches the usable operating distance s_u shall be between

$0,8\ s_r \leq s_u \leq 1,2\ s_r$

8.4.1.5 Repeat accuracy

The repeat accuracy has to be measured only in test sequence 4/5. It is measured at the following condition:

- first measurement after 5 min of power on
- over an eight hour period
- an enclosure temperature of 23 $\pm$ 5° C
- during the measurement the relative humidity shall not change more than $\pm$ 5 %
- supply voltage U = U_e $\pm$ 5 % or at any voltage $\pm$ 5 % within the rated operational voltage range
- the measured value shall not exceed 10 % of the effective operating distance s_r

  $R \leq 0,1\ s_r$

8.5 Testing for the frequency of operating cycles

The frequency of operating cycles can be measured by two different methods described in fig. 12. The teeth of the rotating disc should pass the front of the sensing face of the proximity switch at a distance equal to half of the rated operating distance. For ultrasonic proximity switches the method is described in fig. 13 . The output signal of the proximity

switch and the determination of the frequency is illustrated in fig. 14.
The minimum frequency of operating cycles is stated in the specification or is given by manufacturer declaration.

When the proximity switch frequency of operating cycles exceeds the limit of the measuring method described, another test method has to be selected which must be indicated in the test-report.
The operating characteristics shall remain as given in sub-clause 4 of
EN / IEC 60947-5-2 according to test sequences and 2 and 3.

8.6 Electromagnetic compatibility

In all EMC-tests, except 8.6.4 surge test, the proximity switches are connected to the rated operational voltage (or the maximum voltage of its voltage range)
$U = U_e$ and a load corresponding to the rated operational current $I = I_e$. The proximity switch housing shall be grounded, when made of conducting material.

The connecting leads shall be 2 m +0,1m, -0

The test shall be performed with a target set at a position such that the switching element is both in OFF - and in ON - state. For inductive and capacitive proximity switches the target shall be positioned at 1/3 s_n or 3 s_n
Electrically the target shall be grounded for inductive and capacitive sensors.

During the test the state of the switching element shall not change for more than 1 ms.

8.6.1 Electromagnetic field withstandability
cf. 7.2.6.1
Frequency band: 80 MHz to 1000 MHz

8.6.2 Electrostatic discharge (ESD) withstandability

cf. 7.2.6.2
The following methods should be applied:
- contact discharges: the tip of the discharge electrode shall touch the EUT before the discharge switch is operated
- air discharge: the round discharge tip of the discharge electrode shall be approaches as fast as possible (without causing mechanical damage) to touch the EUT
- indirect application of the discharge:
  discharges of objects played or installed near the EUT shall be simulated by applying the discharges of the ESD generator to a coupling plane in the discharge mode.

The contact discharge method shall be preferably used. The air discharge method shall be used at insulating surfaces and non-accessible points.

8.6.3 Fast transient withstandability (burst)

cf. 7.2.6.3
The connecting leads shall be placed in the capacitive coupling clamp

8.6.4 Impulse voltage withstandability

cf. 7.2.6.4

Annex B Protection against electrical shocks constructional requirements and tests for class II equipment insulated by encapsulation

The following test sequence is performed for encapsulated proximity switches with insulation of class II according EN / IEC 60536

- dielectric test in new conditions
- cable test (if applicable)
- rapid change of temperature test
- impact test
- cyclic damp heat test
- dielectric test after ageing

B.8.1.2.1 Dielectric test in new conditions

The test performed under the following conditions

- test voltage applied between the stripped joined ends of the cable or the terminals connected together and any point of the surface (or a metal foil on the surface) of the encapsulated device

- Test voltage
  U_{imp} + 1 step higher (or 1,6 U_{imp} step) if the manufacturer declares U_{imp} or
  AC power frequency Ui + 1000 V (r.m.s) if the manufacturer declares no U_{imp}
- The specimen has passed the test when there is no breakdown of the insulation and no flashover

B.8.1.2.2 Cable integrity test

C.8.1.1 Pull Test

the cable shall be subjected to a steady force applied in the axes of the cable entrance.

- the force value (in N) shall be 20 times the external cable diameter (in mm) with a maximum of 160 N
- the test shall be performed three times with a duration of 1 min for each time and witch 1 min pause between applications

B.8.1.2.2 Torque test

C.8.1.2

- the cable shall be subjected to a torque of 0,1 Nm or limited at the value given an angle of torque of 360 °
- the torque shall be applied clockwise and then counter - clockwise to the cable at a distance of 10 cm from the device cable entrance
- the test shall be performed three times with a duration of 1 min for each time with 1 min pause between applications

B.8.1.2.2 Push Test

C.8.1.3

- the push force shall be performed three times with a duration of 1 min for each time and witch 1 min pause between applications

B.8.1.2.2 Bend Test

C.8.1.4

The cable shall be subjected to the stresses resulting from the following test sequence:

a) initially suspend a 3 kg mass by attaching it to the cable 1 m from the cable entrance and with the axis of the sable entrance vertical,
b) tilt the device 90° to cause a 90° bend in the cable maintaining that position for 1 minute.
c) tilt the switch 90° in its opposite orientation relative to vertical so as to cauce an opposite 90° bend in the cable maintaining the position for a duration of one minute.

After the tests no visible damage of the cable entrance sealing means and no displacement of the cable shall be observed.

B.8.1.2.3 Rapid change of temperature test

Spec: EN / IEC 60068-2-14

For inductive, capacitive and ultrasonic proximity switches (clause 6.1.1.1):

lower temperature T_A = -25°C

upper temperature T_B = +70°C

For photoelectric proximity switches (clause 6.1.1.2)

lower temperature T_A = - 5°C

upper temperature T_B = +55°C

transfer time: 2 - 3 min or 0,5 min for automatic transfer

duration time: 3h

number of cycles: 5

B.8.1.2.4 Impact test

the test is performed under the following conditions:

- sample put on a riding support
- three impacts of 0,5 J near the centre of one of the largest surfaces of the encapsulated device
- impacts provided by the dropping of steel, sphere of 0,25 kg from a height of 0,2 m
- after test no visible damge shall be observed

B.8.1.2.5. Cyclic damp heat

Spec: EN / IEC 68-2-30

Upper temperature: 55° C

number of cycles: 6 (1 cycle ≡ 24h)

The test method 1 or 2 can be selected and must be indicated in the test - report

B.8.1.2.6 Dielectric test after stresses

This test is performed with test voltages according table 7
During the tests no breakdown of insulation or any other manifestation of disruptive discharge shall occur: the leakage current shall not exceed 2 mA.

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Appendix 1: Test sequences according to EN / IEC 60947-5-2

Test sequence 1
DUT 1

- Operating limits 8.3.3.2
  - Time delay before availability 8.3.3.2.1
  - Minimum operational current 8.3.3.2.2.
  - OFF-state current 8.3.3.2.3
  - Independent snap-action 8.3.3.2.4
  - Voltage drop 8.3.3.2.5
- Temperature rise 8.3.3.3
- Mechanical properties of terminals 8.2.4
- Dielectric properties 8.3.3.4
- Visual inspection

Test sequence 2
DUT 2

- Cable tests C.8.1 *Only for devices with integrally connected cable!*
  - Pull test C.8.1.1
  - Torque test C.8.1.2
  - Push test C.8.1.3
  - Bend test C.8.1.4
  - Visual inspection
- Degree of protection C.8.2
- Vibration 7.4.2
- Frequency of operating cycles 8.5
- Rated operational distance 8.4
- Dielectric properties 8.3.3.4
- Visual inspection

Test sequence 3
DUT 3

- Cable tests C.8.1 *Only for devices with integrally connected cable!*
  - Pull test C.8.1.1
  - Torque test C.8.1.2
  - Push test C.8.1.3
  - Bend test C.8.1.4
  - Visual inspection
- Degree of protection C.8.2
- Shock 7.4.1
- Frequency of operating cycles 8.5
- Rated operational distance 8.4
- Dielectric properties 8.3.3.4
- Visual inspection

Test sequence 4
DUT 4

- Making and breaking capacities 8.3.3.5
- Dielectric properties 8.3.3.4
- Visual inspection
- Rated operational distance and hysteresis 8.4
- Independent snap-action 8.3.3.2.4
- Usable operational distance 8.4.1.4
- Repeat accuracy 8.4.1.5

Test sequence 5
DUT 5

- EMC 8.6
  - Radiated electromagnetic field immunity 8.6.1
  - Electrostatic discharge immunity 8.6.2
  - Fast transient immunity 8.6.3
  - Emission requirements 8.6.5
- Performance under short circuit current conditions 8.3.4
- Dielectric properties 8.3.3.4
- Visual inspection
- Rated operational distance and hysteresis 8.4
- Independent snap-action 8.3.3.2.4
- Usable operational distance 8.4.1.4
- Repeat accuracy 8.4.1.5

Test sequence 6
DUTs 6.1 .. 6.3
Only for Class-II-devices!

- Dielectric properties in new conditions B.8.1.2.1
- Cable tests C.8.1 *Only for devices with integrally connected cable!*
  - Pull test C.8.1.1
  - Torque test C.8.1.2
  - Push test C.8.1.3
  - Bend test C.8.1.4
- Rapid changes of temperature B.8.1.2.3
- Impact test B.8.1.2.4
- Cyclic damp heat B.8.1.2.5
- Dielectric properties after stresses B.8.1.2.6
- Visual inspection