

8.3.3.2 Electrostatic discharge

The test values and procedures are given in 9.3.5.2.1.

8.3.3.3 Radio-frequency electromagnetic field

The test values and procedures are given in 9.3.5.2.2.

8.3.3.4 Fast transients (common mode) (5/50 ns)

The test values and procedures are given in 9.3.5.2.3.

8.3.3.5 Surges (1,2/50/μs-8/20/μs)

The test values and procedures are given in 9.3.5.2.4.

8.3.3.6 Harmonics and commutation notches

The test values and procedures are given in 9.3.5.2.5.

8.3.3.7 Voltage dips and short time interruptions

The test values and procedures are given in 9.3.5.2.6.

8.3.3.8 Power frequency magnetic field

Tests are not required. Immunity is demonstrated by the successful completion of the operating capability test (see 9.3.3.6).

9 Tests

9.1 Kinds of tests

9.1.1 General

Subclause 8.1.1 of IEC 60947-1 applies.

9.1.2 Type tests

Type tests are intended to verify compliance of the design of controllers and starters of all forms with this standard. They comprise the verification of:

- a) temperature-rise limits (9.3.3.3);
- b) dielectric properties (9.3.3.4);
- c) operating capability (9.3.3.6);
- d) operation and operating limits (9.3.3.6.3);
- e) rated making and breaking capacity and conventional operational performance of series mechanical switching devices of hybrid equipment (9.3.3.5);
- f) performance under short-circuit conditions (9.3.4);
- g) mechanical properties of terminals (8.2.4 of IEC 60947-1 applies);
- h) degrees of protection of enclosed controllers and starters (annex C of IEC 60947-1 applies);
- i) EMC tests (9.3.5).

9.1.2DV D2 Modification by replacing 9.1.2 with the following:

See 9.3.1DV for type test information.

9.1.3 Routine tests

Subclause 8.1.3 of IEC 60947-1 applies where sampling tests (9.1.4) are not made instead.

Routine tests for controllers and starters comprise:

- operation and operating limits (9.3.6.2);
- dielectric tests (9.3.6.3).

9.1.3DV D2 Deletion of 9.1.3:

This Clause does not apply.

9.1.4 Sampling tests

Sampling tests for controllers and starters comprise:

- operation and operating limits (9.3.6.2);
- dielectric tests (9.3.6.3).

Subclause 8.1.4 of IEC 60947-1 applies, with the following amplification:

A manufacturer may use sampling tests instead of routine tests at his own discretion. Sampling shall meet or exceed the following requirements, as specified in IEC 60410 (see table II-A of IEC 60410).

Sampling is based on $AQL \leq 1$:

- acceptance number $Ac = 0$ (no defect accepted);
- rejection number $Re = 1$ (if 1 defect, the entire lot shall be tested).

Sampling shall be made at regular intervals for each specific lot.

Alternative statistical methods that ensure compliance with the above IEC 60410 requirements can be used, for example statistical methods controlling continuous manufacturing or process control with capability index.

Sampling tests for clearance verification according to 8.3.3.4.3 of IEC 60947-1 are under consideration.

9.1.4DV D2 Deletion of 9.1.4:

This Clause does not apply.

9.1.5 Special tests

Special tests for controllers and starters comprise:

- verification of coordination at the crossover current between the starter and the SCPD (see Annex B).

9.2 Compliance with constructional requirements

Subclause 8.2 of IEC 60947-1 applies (however, see note to 8.1).

9.3 Compliance with performance requirements

9.3.1 Test sequences

Each test sequence is made on a new sample.

NOTE 1 With the agreement of the manufacturer, more than one test sequence, or all sequences, may be conducted on one sample. However, the tests are to be conducted in the sequence given for each sample.

NOTE 2 Some tests are included in the sequences solely to reduce the number of samples required; the results have no significance for the preceding or following tests in the sequence. Therefore, for convenience of testing and by agreement with the manufacturer, these tests may be conducted on separate new samples and omitted from the relevant sequence. This only applies to the following tests when called for:

8.3.3.4.1 item 5) of IEC 60947-1: *Verification of creepage distance;*

8.2.4 of IEC 60947-1: *Mechanical properties of terminals;*

annex C of IEC 60947-1: *Degrees of protection of enclosed equipment.*

The test sequence shall be as follows:

a) Test sequence I

- i) Verification of temperature rise (9.3.3.3)
- ii) Verification of dielectric properties (9.3.3.4)

b) Test sequence II: Operating capability verification (9.3.3.6)

- i) Thermal stability test (9.3.3.6.1)
- ii) Overload capability test (9.3.3.6.2)
- iii) Blocking and commutating capability test (9.3.3.6.3), including verification of operation and operating limits

c) Test sequence III

- i) Performance under short-circuit conditions (9.3.4)

d) Test sequence IV

- i) Verification of mechanical properties of terminals (8.2.4 of IEC 60947-1)
- ii) Verification of degrees of protection of enclosed equipment (annex C of IEC 60947-1)

e) Test sequence V

EMC tests (9.3.5)

9.3.1DV D2 Modification by replacing 9.3.1 with the following:

The sequence of tests for solid state motor controllers shall be as follows:

Table 9.3.1DV.1 – Sequence of tests for solid state motor controllers

Clause Reference	Test	Sample Number ^a							
		1	2 ^b	3	4	5 ^c	6 ^c	7 ^c	8 ^c
		Seq.	Seq.	Seq.	Seq.	Seq.	Seq.	Seq.	Seq.
9.3.3.3	Temperature	1							
9.3.3.4	Dielectric	3	3			3	2	2	
9.3.3.3	Overvoltage and Undervoltage	2							
9.3.3.5DV	Overload		1						
9.3.3.5DV	Endurance		2						
9.3.4DV	Short Circuit			1					
Annex DVB, Table DVB.3, Ref. No. 15	Breakdown of Components				1				
Annex DVE	Controller Overload					1			
Annex DVE	Single Phasing					2			
Annex DVE	Inoperative Blower Motor						1		
Annex DVE	Clogged Filter							1	
Annex DVE	Current Limiting Control								1
^a Any or all combinations of sequences may be conducted on a single sample if agreeable to those concerned. More than one sample may be used if more than one rating is being tested. One sequence need not be completed as a prerequisite to the starting of another. ^b This sequence is not required for reduced voltage starters. ^c This sequence applicable to reduced voltage starters only.									

9.3.2 General test conditions

Subclause 8.3.2 of IEC 60947-1 applies, with the following addition:

Unless otherwise specified in the relevant test clause, the clamping torque for connections shall be that specified by the manufacturer or, if not specified, the torque given in table 4 of IEC 60947-1.

In the case where several heat sinks are specified, the one which has the higher thermal resistance shall be used.

True r.m.s. voltage and current measuring means shall be used.

9.3.3 Performance under no load, normal load, and overload conditions

9.3.3.1 Vacant

9.3.3.2 Vacant

9.3.3.3 Temperature rise

9.3.3.3.1 Ambient air temperature

Subclause 8.3.3.3.1 of IEC 60947-1 applies.

9.3.3.3.2 Measurement of the temperature of parts

Subclause 8.3.3.3.2 of IEC 60947-1 applies.

9.3.3.3.3 Temperature rise of a part

Subclause 8.3.3.3.3 of IEC 60947-1 applies.

9.3.3.3.4 Temperature rise of the main circuit

For semiconductor switching devices connected in the main circuit (see 8.2.2.4), temperature sensing means shall be attached to the outer surface of the case of the semiconductor switching device that is most likely to produce the highest temperature rise during this test. The final case temperature, C_f , and the final ambient temperature, A_f , shall be recorded for use in the test of 9.3.3.6.2.

For mechanical switching devices (see 8.2.2.4.2 and 8.2.2.4.4), temperature sensing means shall be attached in accordance with the requirements of 8.3.3.3 of IEC 60947-1.

The main circuit shall be loaded as stated in 8.2.2.4.

All auxiliary circuits which normally carry current shall be loaded at their maximum rated operational current (see 5.6), and the control circuits shall be energized at their rated voltages.

Starters shall be fitted with an overload relay, complying with 5.7, and selected as follows:

- non-adjustable relay:

the current setting shall be equal to the maximum operational current of the starter, and the test shall be at this current;

– adjustable relay:

the maximum current setting shall be that which is nearest to, but not greater than, the maximum operational current of the starter.

For starters, the test shall be made with that overload relay for which the current setting is nearest to the maximum of its scale.

NOTE – The selection method described above is designed to ensure that the temperature rise of these field wiring terminals of the overload relay, and the power dissipated by the starter, are not less than those that will occur under any combination of relay and controller. In cases where the effect of the overload relay on these values is insignificant (as in solid-state overload relays), the test current shall always be the maximum operational current of the starter.

9.3.3.3.5 Temperature rise of control circuits

Subclause 8.3.3.3.5 of IEC 60947-1 applies, with the following addition:

The temperature rise shall be measured during the test of 9.3.3.3.4.

9.3.3.3.6 Temperature rise of coils and electromagnets

Subclause 8.3.3.3.6 of IEC 60947-1 applies with the following addition:

Electromagnets of contactors or starters intended for duty within semiconductor controllers or for mechanical bypass switching means shall comply with 8.2.2.6 with rated current flowing through the main circuit for the duration of the test. The temperature rise shall be measured during the test of 9.3.3.3.4.

9.3.3.3.7 Temperature rise of auxiliary circuits

Subclause 8.3.3.3.7 of IEC 60947-1 applies, with the following addition:

The temperature rise shall be measured during the test of 9.3.3.3.4.

9.3.3.4 Dielectric properties

9.3.3.4.1 Type tests

1) General conditions for withstand voltage tests

Subclause 8.3.3.4.1 1) of IEC 60947-1 applies except the last note. See also 8.2.3.

2) Verification of impulse withstand voltage

a) General

Subclause 8.3.3.4.1 2) a) of IEC 60947-1 applies.

b) Test voltage

Subclause 8.3.3.4.1 2) b) of IEC 60947-1 applies with the following sentence added.

For any part for which the dielectric properties are not sensitive to altitude (e.g. opto-coupler, potted parts, etc.) the correction factor for altitude is not applicable.

c) Application of test voltage

With the equipment mounted and prepared as specified in item 1) above, the test voltage is applied as follows:

- i) between all the terminals of the main circuit connected together (including the control and auxiliary circuits connected to the main circuit) and the enclosure or mounting plate, with the contacts, if any, in all normal positions of operation;
- ii) for poles of the main circuit declared galvanically separated from the other poles: between each pole and the other poles connected together and to the enclosure or mounting plate, with the contacts, if any, in all normal positions of operation;
- iii) between each control and auxiliary circuit not normally connected to the main circuit and
 - the main circuit;
 - the other circuits;
 - the exposed conductive parts;
 - the enclosure or mounting plate, which, wherever appropriate, may be connected together;
- iv) for equipment suitable for isolation, across the poles of the main circuit, the line terminals being connected together and the load terminals connected together. The test voltage shall be applied between the line and load terminals of the equipment with the contacts in the isolated open position and its value shall be as specified in item 1) b) of 7.2.3.1 of IEC 60947-1.

d) Acceptance criteria

Subclause 8.3.3.4.1 2) d) of IEC 60947-1 applies.

3) Power-frequency withstand verification of solid insulation

a) General

Subclause 8.3.3.4.1 3) a) of IEC 60947-1 applies.

b) Test voltage

Subclause 8.3.3.4.1 3) b) of IEC 60947-1 applies with the following sentence added at the end of the first paragraph.

If an alternating test voltage cannot be applied due to the EMC filter components, which cannot easily be disconnected, a direct test voltage may be used having the same value as the crest value of the projected alternating test voltage.

c) Application of test voltage

Subclause 8.3.3.4.1 3) c) of IEC 60947-1 applies with the two last sentences modified as follows:

The test voltage shall be applied for 5 s, with the following conditions:

- in accordance with items i), ii) and iii) of 2) c) above;
- for hybrid semiconductor controller or starters, across the poles of the main circuit, the line terminals being connected together and the load terminals connected together.

d) Acceptance criteria

Subclause 8.3.3.4.1 3) d) of IEC 60947-1 applies.

4) Power-frequency withstand verification after switching and short-circuit tests

a) General

Subclause 8.3.3.4.1 4) a) of IEC 60947-1 applies.

b) Test voltage

Subclause 8.3.3.4.1 4) b) of IEC 60947-1 applies.

c) Application of test voltage

Subclause 8.3.3.4.1 4) c) of IEC 60947-1 applies with the following sentence added at the end of the paragraph.

The use of a metal foil, as mentioned in 8.3.3.4.1 1) of IEC 60947-1, is not required.

d) Acceptance criteria

Subclause 8.3.3.4.1 4) d) of IEC 60947-1 applies.

5) Power-frequency withstand verification after humidity treatment

Subclause 8.3.3.4.1 5) of IEC 60947-1 applies.

6) Verification of d.c. withstand voltage

Subclause 8.3.3.4.1 6) of IEC 60947-1 applies.

7) Verification of creepage distances

Subclause 8.3.3.4.1 7) of IEC 60947-1 applies.

8) Verification of leakage current of equipment suitable for isolation

The maximum leakage current shall not exceed the values of 7.2.7 of IEC 60947-1.

9.3.3.4.2 Vacant

9.3.3.4.3 Sampling tests for verification of clearances

1) General

Subclause 8.3.3.4.3 1) of IEC 60947-1 applies.

2) Test voltage

The test voltage shall be that corresponding to the rated impulse withstand voltage.

Sampling plans and procedure are under consideration.

3) Application of test voltage

Subclause 8.3.3.4.3 3) of IEC 60947-1 applies.

4) Acceptance criteria

Subclause 8.3.3.4.3 4) of IEC 60947-1 applies.

9.3.3.5 Making and breaking capacity of mechanical switching devices

9.3.3.5DV D2 Modification by replacing 9.3.3.5 and all subclauses with the following:

9.3.3.5DV.1 In the United States, this test is not required for a motor controller with a reduced voltage starting feature.

9.3.3.5DV.2 Overload test, General – Line and load terminals of industrial control equipment having clearances in accordance with Annex DVB, Table DVB.3, Ref. No. 6, shall be monitored for overvoltages during the overload test. Generated voltages shall not be greater than the lowest impulse withstand voltage rating specified in Annex DVB, Table DVB.3, Ref. No. 7.

9.3.3.5DV.3 The overload test or tests shall cover the conditions of maximum interrupted values of voltage, power, and current.

9.3.3.5DV.4 Tests on equipment having an alternating-current rating shall be conducted using a circuit having a frequency in the range of 25 – 60 hertz.

9.3.3.5DV.5 Equipment shall close and open a test circuit connected as shown in Figure 9.3.3.5DV.5.1 and having the current and power factor as described in Table 8.2.4.2DV.1.1.