9.3.4.1.7 Void

9.3.4.1.8 Interpretation of records

Subclause 8.3.4.1.8 of IEC 60947-1 applies.

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

The contactor or starter and the associated SCPD, or the combination starter, the combination switching device, the protected starter or the protected switching device, shall be subjected to the tests given in 9.3.4.2.1 and 9.3.4.2.2. The tests shall be so conducted that conditions of maximum I_e and of maximum U_e for utilization category AC-3 are covered.

For a magnetically operated contactor or starter, the magnet shall be held closed by a separate electrical supply at the rated control supply voltage U_s. The SCPD used shall be as stated in 8.2.5.1. If the SCPD is a circuit-breaker with an adjustable current setting, the test shall be done with the circuit-breaker adjusted to the maximum setting for the declared type of co-ordination and discrimination.

During the test, all openings of the enclosure shall be closed as in normal service and the door or cover secured by the means provided.

A starter covering a range of motor ratings and equipped with interchangeable overload relays shall be tested with the overload relay with the highest impedance and the overload relay with the lowest impedance together with the corresponding SCPDs.

For type ″1″ co-ordination, a new test sample may be used for each operation stated in 9.3.4.2.1 and 9.3.4.2.2.

For type ″2″ co-ordination, one sample shall be used for the tests at the prospective current ″*r*″ (see 9.3.4.2.1) and one sample for the tests at current I_q (see 9.3.4.2.2).

By agreement of the manufacturer, the tests at *r* and I_q may be carried out on the same sample.

9.3.4.2DV D2 *Modification of 9.3.4.2 by adding Clauses 9.3.4.2DV.1 to 9.3.4.2DV.2.2:*

9.3.4.2DV.1 Selection of SCPD

9.3.4.2DV.1.1 Tests shall be performed with SCPD selected in accordance with Annex DVA, Table DVA.3, Ref. No. 13. When the test is conducted with an SCPD having an ampere rating less than the maximum specified, the product shall be marked to indicate the type and rating of the SCPD as in 6.2DV.2.1.

9.3.4.2DV.1.2 Motor control devices, overload relays, and starters are subjected to a short-circuit test while protected by fuses and a short-circuit test while protected by an inverse-time circuit breaker, except where marked in accordance with 6.2DV.2.1(d).

9.3.4.2DV.1.3 For a contactor or starter marked for group installation, the protective device(s) shall be selected in accordance with 9.3.4.2DV.1.1, except the maximum size of the branch circuit protective device shall not exceed the ampere rating calculated from the following formula:

Amperes = [9,6 x (maximum wire size)] – [2,2 x (minimum motor FLA)]

In which:

Maximum wire size is the ampacity of the largest conductor size for which the device terminals have been evaluated. The conductor ampacity is from Annex DVA, Table DVA.3, Ref. No. 11; and

Minimum motor FLA is the smallest rated FLA (or equivalent FLA from horsepower rating per Annex G) marked on the device.

9.3.4.2DV.1.4 A motor control device capable of being used with protective devices having ratings above and below 600 amperes shall be tested with a 600 ampere one-time, nonrenewable fuse at 10 000 amperes in addition to the tests with the maximum rated fuse.

9.3.4.2DV.1.5 Testing with class RK5 fuses is considered representative of tests using Class H and K fuses.

9.3.4.2DV.2 Sample selection for overload relay

9.3.4.2DV.2.1 An overload relay furnished as part of a particular motor control device shall be tested with that motor control device. A shunt or current transformer that is used to reduce the current in the current element of the overload relay shall be considered to be a part of the relay.

a) For an overload relay provided with a current transformer, when the overload relay current transformer saturates at less than the specified short-circuit current, the short-circuit test specified may be conducted at the level at which the current transformer saturates.

b) An overload relay not provided with a current transformer shall comply with the short-circuit test using the maximum current that can be applied to the input of the overload relay as specified by the manufacturer.

9.3.4.2DV.2.2 Overload relays do not have to be subjected to the test described in 9.3.4.2DV.2.1 if supplied by current transformers that limit the current to a level that the overload relay has already been evaluated.

9.3.4.2.1 Test at the prospective current ″*r*″

The circuit shall be adjusted to the prospective test current corresponding to the rated operational current I_e according to Table 13.

The contactor or starter and the associated SCPD, or the combination starter, the combination switching device, the protected starter or the protected switching device, shall then be connected in the circuit. The following sequence of operations shall be performed:

a) one breaking operation of the SCPD shall be performed with all the switching devices closed prior to the test (“O” operation);

b) one breaking operation of the SCPD shall be performed by closing the contactor or starter on to the short-circuit (“CO” operation).

Table 13 – Value of the prospective test current according to the rated operational current

Rated operational current I_e (AC-3)a A	**Prospective current ″*r*″ kA**
$0 < I_e \leq 16$	1
$16 < I_e \leq 63$	3
$63 < I_e \leq 125$	5
$125 < I_e \leq 315$	10
$315 < I_e \leq 630$	18
$630 < I_e \leq 1\,000$	30
$1\,000 < I_e \leq 1\,600$	42
$1\,600 < I_e$	Subject to agreement between manufacturer and user
[a] If the contactor or starter is not specified according to utilization category AC-3, the prospective current “*r*” shall correspond to the highest rated operational current for any utilization category claimed by the manufacturer.	

The power factor or the time-constant shall be according to 8.3.4.1.4 of IEC 60947-1.

9.3.4.2.1DV D2 ***Modify 9.3.4.2.1 by replacing with Clauses 9.3.4.2.1DV.1 to 9.3.4.2.1DV.1.2 and Tables 9.3.4.2.1DV.1.1.1 and 9.3.4.2.1DV.1.2.1:***

9.3.4.2.1DV.1 Standard fault current circuits

9.3.4.2.1DV.1.1 The test circuit shall be capable of delivering the current specified in Table 9.3.4.2.1DV.1.1.1 for a given rating.

9.3.4.2.1DV.1.2 The equipment shall be subjected to the number and type of operations in accordance with Table 9.3.4.2.1DV.1.2.1. Successive operations shall be conducted by alternately closing the circuit on the equipment (″O″ OPERATION) by means of any appropriate switching device, using random closing and closing the device on the circuit (″CO″ operation).

Table 9.3.4.2.1DV.1.1.1 – Short-circuit test values (9.3.4.2.1DV.1.1 and 9.3.4.2.2DV.1)

Maximum horsepower rating, hp 600 V or less	Maximum rating, kW	Maximum ampere rating, 601 – 1 500 V	Test current, symmetrical rms amperes	Power factor
0 – 1	0 – 0,746	–	1 000	0,7 – 0,8
Over 1 – 50	Over 0,746 – 38	0 – 50	5 000	0,7 – 0,8
Over 50 – 200	Over 38 – 149	Over 50 – 200	10 000	0,7 – 0,8
Over 200 – 400	Over 149 – 298	Over 200 – 400	18 000	0,25 – 0,30
Over 400 – 600	Over 298 – 441	Over 400 – 600	30 000	0,20 or less
Over 600 – 900	Over 441 – 671	Over 600 – 850	42 000	0,20 or less
Over 900 – 1 600	Over 671 – 1 193	Over 850 – 1 500	85 000	0,20 or less
Over 1 600	Over 1 193	Over 1 500	100 000	0,20 or less
NOTE – For a manual motor controller additionally intended for use as a motor disconnecting means the minimum short-circuit current rating shall be 5 kA for motor ratings less than 50 hp, and the power factor of the test circuit shall be 0,5 or less for short-circuit current ratings of 10 kA or less.				

Table 9.3.4.2.1DV.1.2.1 – Required number of short-circuit test operations (Standard fault) (9.3.4.2.1DV.1.2)

Rating		Number of poles for a device	Number of current elements[a]	Type of branch circuit protection and number of poles provided		Number of operations[b,c]
kW	(Horsepower)			Fuse	Circuit breaker	
0 – 149	(0 – 200)	1 phase, single pole	1	1	Single pole Inverse time	3 “O” operations
		1 phase, 2 poles	2[d]	2	2 pole Inverse time	3 “O” operations
		3 phase, 3 pole	3	3	3 pole Inverse time	2 “O” operations
150 – 1 193	(201 – 1 600)	3 phase, 3 pole	3	3	3 pole Inverse time	1 “O” operations

[a] Applies to devices provided with or incorporating a thermal overload relay. See 9.3.4.2DV.2.1 and 9.3.4.2DV.2.2.

[b] Number of operations for each current element selected, when device is provided with or incorporates thermal overload relays.

[c] The poles and contacts may be omitted from the circuit after a sufficient number of tests have been conducted to determine that subsequent malfunction or breakdown of the equipment due to contact arcing is unlikely. Consideration shall be given to contact arcing while testing the intermediate as well as the higher-rated current elements.

[d] For a product rated single phase only:

1) Two poles and two overload relays shall be used when overload relays are provided in each conductor to the motor; and

2) Two poles and one overload relay shall be used for other arrangements.

9.3.4.2.2 Test at the rated conditional short-circuit current I_q

NOTE This test is done if the current I_q is higher than the current *"r"*.

The circuit shall be adjusted to the prospective short-circuit current I_q equal to the rated conditional short-circuit current.

If the SCPD is a fuse and the test current is within the current-limiting range of the fuse, then, if possible, the fuse shall be selected to permit the maximum peak let-through current (I_p) and the maximum let-through energy (I^2t).

The contactor or starter and the associated SCPD, or the combination starter, the combination switching device, the protected starter or the protected switching device, shall then be connected to the circuit.

The following sequence of operations shall be performed:

a) one breaking operation of the SCPD shall be performed with all the switching devices closed ("O" operation) prior to the test.

b) one breaking operation of the SCPD shall be performed by closing ("CO" operation) the contactor or starter on to the short-circuit.

c) in the case of a combination starter or a protected starter, with the switching device of the SCPD having a short-circuit breaking capacity or rated conditional short-circuit current less than the rated conditional short-circuit current of the combination starter or protected starter the following additional test shall be made. One breaking operation of the SCPD shall be performed by closing ("CO" operation) the switching device (switch or circuit-breaker) on to the short-circuit, the contactor or starter already being closed. This operation may be performed either on a new sample (starter and SCPD) or on the first sample with the agreement of the manufacturer. After this operation only conditions a) to g) of 9.3.4.2.3 shall be verified.

9.3.4.2.2DV D2 ***Modify 9.3.4.2.2 by replacing with Clauses 9.3.4.2.2DV.1 to 9.3.4.2.2DV.3.1 and Table 9.3.4.2.2DV.3.1.1:***

9.3.4.2.2DV.1 High available fault current circuits (Optional) – The optional requirements in this section cover use on circuits having available short-circuit currents in excess of the minimum levels specified in Table 9.3.4.2.1DV.1.1.1, and not more than 200 000 amperes rms symmetrical.

9.3.4.2.2DV.2 Protective devices

9.3.4.2.2DV.2.1 Circuit breakers – The protective devices used for the test shall be selected as follows: for noncombination controllers, the circuit breaker shall be selected from commercially available units of the molded case type having essentially the same characteristics with respect to peak let-through current and a clearing I^2t without current limiting features, unless specific circuit breakers are marked for use with the controller.

9.3.4.2.2DV.2.2 Fuses – The protective devices used for the test shall be selected as follows:

a) When tested on a single-phase circuit, it will permit a peak let-through and clearing I^2t not less than the maximum value established for the fuse class intended to be used with the controller being tested.

b) For a fuse with I_p and I^2t limits established for several different short-circuit current levels, the test fuse shall be selected to have at least the maximum values of the current corresponding to the marked short-circuit current rating of the motor control device.

9.3.4.2.2DV.3 Procedure

9.3.4.2.2DV.3.1 The equipment shall be subjected to the number and type of operations in accordance with Table 9.3.4.2.2DV.3.1.1.

Table 9.3.4.2.2DV.3.1.1 – Required number of short-circuit test operations (high fault current) (9.3.4.2.2DV.3.1)

Disconnecting means provided	Type of test	Number of test operations
Yes	Disconnecting means closed on the circuit (″CO″ operation)	1
Yes	Motor control device closed on the circuit (″CO″ operation)	1
Yes	Circuit closed on the equipment (″O″ operation)	1
No	Motor control device closed on the circuit (″CO″ operation)	1
No	Circuit closed on the equipment (″O″ operation)	1
Notes 1) If complete physical closure of the switching contact (e.g. current flow in all poles) is established during closing tests (“CO”shots), the withstand test (“O” shot) is not required. 2) When a motor control device and its control circuit are supplied from the same source (common control), the closing test on the disconnect switch is not required.		

9.3.4.2.3 Results to be obtained

The contactor, starter, or the combination starter, the combination switching device, the protected starter or the protected switching device, shall be considered to have passed the tests at the prospective current *"r"* and, where applicable, the prospective current I_q, if the following conditions are met for the claimed type of co-ordination.

Both types of co-ordination (all devices):

a) The fault current has been successfully interrupted by the SCPD, the combination starter or the combination switching device and the fuse or fusible element or solid connection between the enclosure and supply shall not have melted.

b) The door or cover of the enclosure has not been blown open and it is possible to open the door or cover. Deformation of the enclosure is considered acceptable provided that the degree of protection by the enclosure is not less than IP2X.

c) There is no damage to the conductors or terminals and the conductors have not been separated from the terminals.

d) There is no cracking or breaking of an insulating base to the extent that the integrity of mounting of a live part is impaired.

Both types of co-ordination (combination starters, combination switching devices, protected starters and protected switching devices only):

e) The circuit-breaker or the switch is capable of being opened manually by its operating means.

f) Neither end of the SCPD is completely separated from its mounting means to an exposed conductive part.

g) If a circuit-breaker with rated ultimate short-circuit breaking capacity less than the rated conditional short-circuit current assigned to the combination starter, the combination switching device, the protected starter or the protected switching device is employed, the circuit-breaker shall be tested to trip as follows:

1) circuit-breakers with instantaneous trip relays or releases: at 120% of the trip current.

2) circuit-breakers with overload relays or releases: at 250% of the rated current of the circuit-breaker.

Type "1" co-ordination (all devices):

h) There has been no discharge of parts beyond the enclosure. Damage to the contactor and the overload relay is acceptable. The starter may be inoperative after each operation. The starter shall therefore be inspected and the contactor and/or the overload relay and the release of the circuit-breaker shall be reset if necessary and, in the case of fuse protection, all fuse-links shall be replaced.

Type "1" co-ordination (combination and protected starters only):

i) The adequacy of insulation in accordance with 8.3.3.4.1, item 4), of IEC 60947-1 is verified after each operation (at currents "*r*" and "I_q") by a dielectric test on the complete unit under test (SCPD plus contactor/starter but before replacement of parts) using a power frequency withstand voltage of twice the rated operational voltage U_e but not less than 1 000 V. The test voltage shall be applied to the incoming supply terminals, with the switch or the circuit-breaker in the open position, as follows:

– between each pole and all other poles connected to the frame of the starter;

– between all live parts of all poles connected together and the frame of the starter;

– between the terminals of the line side connected together and terminals of the other side connected together.

For equipment suitable for isolation, the leakage current shall be measured through each pole, with the contacts in the open position, at a test voltage of 1,1 U_e and shall not exceed 6 mA.

Type "2" co-ordination (all devices):

j) No damage to the overload relay or other parts has occurred, except that welding of contactor or starter contacts is permitted, if they are easily separated (e.g. by a screwdriver) without significant deformation, but no replacement of parts is permitted during the test, except that, in the case of fuse protection, all fuse-links shall be replaced.

In the case of welded contacts as described above, the functionality of the device shall be verified by carrying out 10 operating cycles under the conditions of Table 10 for the applicable utilization category.

k) The tripping of the overload relay shall be verified at a multiple of the current setting and shall conform to the published tripping characteristics, according to 5.7.5, both before and after the short-circuit test.

l) The adequacy of the insulation in accordance with 8.3.3.4.1, item 4), of IEC 60947-1 shall be verified by a dielectric test on the contactor, the starter, the combination starter, the combination switching device, the protected starter or the protected switching device, using a power frequency withstand voltage of twice the rated operational voltage U_e but not less than 1 000 V.

In the case of combination starters, combination switching devices, protected starters and protected switching devices, additional tests according to 8.3.3.4.1, item 3), of IEC 60947-1 shall be made across the main poles of the device with the contacts of the switch or of the circuit-breaker open and the contacts of the starter closed.

For equipment suitable for isolation, the leakage current shall be measured through each pole, with the contacts in the open position, at a test voltage of 1,1 U_e and shall not exceed 2 mA.

Fuse-links, if any, are shorted.

9.3.4.2.3DV.1 D2 *Modification to item (b):*

Replace IP2X with Annex DVA, Table DVA.3, Ref. No. 5.

9.3.4.2.3DV.2 D2 *Modification to item (g)(1):*

Replace 120% with 130%.

9.3.5 Overload current withstand capability of contactors

For the test, the contactor shall be mounted, wired and operated as specified in 9.3.2.

All poles of the contactors are simultaneously subjected to one test with the overload current and duration values stated in 8.2.4.4. The test is performed at any convenient voltage and it starts with the contactor at room temperature.

After the test, the contactor shall be substantially in the same condition as before the test. This is verified by visual inspection.

NOTE The I^2t value (Joule integral) calculated from this test cannot be used to estimate the performance of the contactor under short-circuit conditions.

9.3.6 Routine tests and sampling tests

9.3.6.1 General

The tests shall be carried out under the same conditions as those specified for type tests in the relevant parts of 9.1.2 or under equivalent conditions. However, the limits of operation in 9.3.3.2 may be verified at the prevailing ambient air temperature and on the overload relay alone, but a correction may be necessary to allow for normal ambient conditions.

9.3.6.2 Operation and operating limits

For electromagnetic, pneumatic and electro-pneumatic contactors or starters, tests are carried out to verify operation within the limits specified in 8.2.1.2.

For manual starters, tests are carried out to verify the proper operation of the starter (see 8.2.1.2, 8.2.1.3 and 8.2.1.4).

NOTE 1 In these tests it is not necessary to reach thermal equilibrium. The lack of thermal equilibrium may be compensated by using a series resistor or by appropriately decreasing the voltage limit.

Tests shall be made to verify the calibration of relays. In the case of a time delay overload relay, this may be a single test with all poles equally energized at a multiple of the current setting, to check that the tripping time conforms (within tolerances) to the curves supplied by the manufacturer; in the case of an instantaneous magnetic overload relay, the test shall be carried out at 1,1 times the current setting. For under-current relays, stall relays and jam relays, tests shall be carried out to verify the proper operation of these relays (see 8.2.1.5.4, 8.2.1.5.5 and 8.2.1.5.6).

NOTE 2 In the case of a time-delay magnetic overload relay comprising a time-delay device working with a fluid dashpot, calibration may be carried out with the dashpot empty, at a percentage of the current setting indicated by the manufacturer and capable of being justified by a special test.

9.3.6.3 Dielectric tests

Subclause 8.3.3.4.2 of IEC 60947-1 applies with the following addition.

In the case of a rheostatic rotor starter, all the poles of the rotor switching devices will normally be connected through the starting resistors; the dielectric test is therefore confined to the application of the test voltage between the rotor circuit and the frame of the starter.

The use of the metal foil is not necessary.

NOTE The combined test of 8.3.3.4.2 of IEC 60947-1 is permitted.

9.4 EMC Tests

9.4DV D2 *Modify 9.4 and all subclauses by replacing with the following:*

Clause 9.4 does not apply.

9.4.1 General

Subclauses 8.3.2.1, 8.3.2.3 and 8.3.2.4 of IEC 60947-1 apply with the following additions.

With the agreement of the manufacturer, more than one EMC test or all EMC tests may be conducted on one and the same sample, which may initially be new or may have passed test sequences according to 9.3.1. The sequence of the EMC tests may be any convenient sequence.

The test report shall include any special measures that have been taken to achieve compliance, for example the use of shielded or special cables. If auxiliary equipment is used with the contactor or starter in order to comply with immunity or emission requirements, it shall be included in the report.

The test sample shall be in the open or closed position, whichever is the worse, and shall be operated with the rated control supply.

9.4.2 Immunity

The tests of Table 14 are required. Special requirements are specified in 9.4.2.1 to 9.4.2.7.

If, during the EMC-tests, conductors are to be connected to the test sample, the cross-section and the type of the conductors are optional but shall be in accordance with the manufacturer's literature.