The prospective current shall be applied for at least 0,05 s and its value is the RMS value determined from the calibration record. This value shall be equal to or higher than the specified value in at least one pole.

The average value of all phases shall comply with the tolerances in 9.3.2.2 of IEC 60947-1:2020.

The highest peak value of the prospective current during its first cycle shall be not less than n times the rated short-circuit current, the value of n being as stated in the fourth column of Table 16 of IEC 60947-1:2020.

b) For direct current:

The current shall be applied for the specified time and its mean value, determined from the record, shall be at least equal to the specified value.

If the testing station is unable to make these tests on direct current, they may, if agreed between manufacturer and user, be made on alternating current, provided suitable precautions are taken, for instance, the peak value of current shall not exceed the permissible current.

For equipment having the same rated current for alternating current and direct current. the AC test shall be taken as valid for the DC rating.

9.3.6.3.4 Test procedure

The temporary connections B are replaced by the equipment under test and the equipment shall be closed twice with an interval of approximately 3 min between these operations on a prospective peak current not less than the rated short-circuit making capacity of the equipment. The current or voltage shall be maintained for at least 0,05 s.

The closing mechanism shall be operated so as to simulate service conditions as closely as possible.

9.3.6.3.5 Behaviour of the equipment during the test

The equipment shall perform during the above tests in such a manner as not to endanger an operator or cause damage to adjacent equipment.

There shall not be permanent arcing or flash-over between poles or between poles and frame and no melting of the fuse in the detection circuit.

The equipment shall remain mechanically operable. Contact welding, such as to prevent an opening operation using normal operating means, is not permitted.

9.3.6.3.6 Condition of the equipment after the test

It shall be demonstrated immediately after the test that the equipment will open and close satisfactorily during a no-load open/close operation.

The force required for opening shall not be greater than the test force of 9.2.6.2 of IEC 60947-1:2020 and Table 17 of IEC 60947-1:2020.

A closing operation is considered satisfactory when normal operation of the handle through its full stroke will close the contacts sufficiently for the equipment to be able to carry its rated operational current.

After the test and without maintenance, the equipment shall comply with the dielectric verification of 9.3.6.4.

The contacts shall be in a suitable condition without maintenance to carry the highest rated operational current and shall comply with the temperature-rise verification of 9.3.6.6.

9.3.6.4 Dielectric verification

Subclause 9.3.4.5 applies.

9.3.6.5 Leakage current

Subclause 9.3.4.6 applies, except that the maximum value of leakage current shall not exceed 2 mA per pole for all utilization categories.

9.3.6.6 Temperature-rise verification

Subclause 9.3.4.7 applies.

9.3.7 Test sequence IV: conditional short-circuit current

9.3.7.1 General

This test sequence applies to the types of equipment listed in Table 15 or Table 16, as applicable, and comprises the tests according to the appropriate table.

This test sequence is not mandatory if a value of rated conditional short-circuit current is not stated by the manufacturer and test sequence III (see 9.3.6) is carried out.

For switches, disconnectors and switch-disconnectors the short-circuit protective device of the equipment may be a circuit-breaker or a fuse and shall be arranged on the load side of the equipment under test.

The type of circuit-breaker or fuse shall be that stated by the manufacturer as suitable for the equipment.

Details of the protective device used for the test i.e. manufacturer's name, type designation, rated voltage, current and short-circuit breaking capacity shall be given in the test report.

The type test with the specified protective device shall be deemed to cover the use of any other protective device having a Joule integral (I^2t) and cut-off current at the rated voltage, prospective current and power-factor not exceeding the specified values for the type of protective device used for the test.

The tests are made to verify compliance with 8.2.5.

9.3.7.2 Circuit-breaker protected short-circuit withstand

9.3.7.2.1 Test values and conditions

The circuit-breaker on the load side of the device under test shall be of the rated voltage, rated current and rated breaking capacity deemed suitable by the manufacturer for use with the equipment.

The test voltage to be used shall be equal to 1,05 × U_e, where U_e corresponds to the operational voltage of the device under test.

The test shall be made as follows:

a) withstand test (switches, disconnectors and switch-disconnectors);

   A prospective current corresponding to the rated conditional short-circuit current stated by the manufacturer shall be applied with the equipment in the closed position. The circuit-breaker shall interrupt the current.

b) making test (switches and switch-disconnectors).

Table 15 – Test sequence IV: conditional short-circuit current – circuit-breaker protected

Tests	Sub-clause No.	Sample[c]	Types of equipment and order of tests		
			Switch[a]	Disconnector[a]	Switch-disconnector[a]
Circuit-breaker protected short-circuit withstand	9.3.7.2.1 a)	A, B	1	1	1
Circuit-breaker protected short-circuit making	9.3.7.2.1 b)	A, B	2	-	2
Dielectric verification	9.3.7.4	A, B	3	2	3
Leakage current [b]	9.3.7.5	A, B	-	3	4
Temperature-rise verification	9.3.7.6	A, B	4	4	5

[a] Test sequence IV is not mandatory if test sequence III is carried out (see Table 14).

[b] Test required only for U_e greater than 50 V.

[c] "A" is a sample from each fundamental design, chosen from the highest rated conditional short-circuit current, or if applicable, "A" are samples of each type according to 9.3.3.4 d).
"B", if applicable, are samples to verify as many combinations of U_e, I_{cc}, AC or DC voltage ratings, to be tested.

After the withstand test of item a), all equipment according to Table 15 shall withstand operation "close". The circuit-breaker shall be closed, then the device under test shall be closed. The circuit shall be opened by the circuit-breaker.

9.3.7.2.2 Test circuit

Subclause 9.3.6.2.2 applies.

9.3.7.2.3 Test circuit calibration

Subclause 9.3.6.2.3 applies.

9.3.7.2.4 Test procedure

The closing mechanism of the switch shall be operated according to 8.2.1.1.

The temporary connections are replaced by the equipment under test and the test current applied according to 9.3.7.3.1. The recovery voltage shall be maintained for at least 0,05 s after interruption of the test current by the circuit-breaker.

9.3.7.2.5 Behaviour of the equipment during the test

Subclause 9.3.6.3.5 applies.

9.3.7.2.6 Condition of the equipment after the test

Subclause 9.3.6.3.6 applies.

9.3.7.3 Fuse protected short-circuit withstand

9.3.7.3.1 Test values and conditions

The fuse-links shall be of the rated maximum current and rated breaking capacity deemed suitable by the manufacturer for use with the equipment.

The equipment manufacturer shall supply the fuse-links (see appropriate part of the IEC 60269 series) to be used for the test. Details of the fuse-links used shall be recorded in the test report.

The test voltage to be used shall be equal to 1,05 × U_e, where U_e corresponds to the operational voltage of the device under test.

The test shall be made as follows:

a) Withstand test

A prospective current corresponding to the rated conditional short-circuit current stated by the manufacturer shall be applied with the equipment in the closed position.

b) Making test

After the withstand test of item a), all equipment according to Table 16 shall be fitted with new fuse-links and closed on to the rated conditional short-circuit current.

Table 16 – Test sequence IV: conditional short-circuit current – fuse protected

Tests	Sub-clause No.	Samples[c]	Types of equipment and order of tests					
			Switch[a]	Fuse-switch and switch-fuse	Discon-nector [a]	Discon-nector-fuse and fuse-discon-nector	Switch-discon-nector [a]	Switch-discon-nector-fuse and fuse-switch-discon-nector
Fuse protected short-circuit withstand	9.3.7.3.1 a)	A, B	1	1	1	1	1	1
Fuse protected short-circuit making	9.3.7.3.1 b)	A, B	2	2	–	–	2	2
Dielectric verification	9.3.7.4	A, B	3	3	2	2	3	3
Leakage current [b]	9.3.7.5	A, B	–	–	3	3	4	4
Temperature-rise verification	9.3.7.6	A, B	4	4	4	4	5	5

[a] Test sequence IV is not mandatory if test sequence III is carried out (see Table 14).

[b] Test required only for U_e greater than 50 V.

[c] "A" is a sample from each fundamental design, chosen from the highest rated conditional short-circuit current, or if applicable, "A" are samples of each type according to 9.3.3.4 d).
"B", if applicable, are samples to verify as many combinations of U_e, I_{cc}, AC or DC voltage ratings, to be tested.

9.3.7.3.2 Test circuit

Subclause 9.3.6.2.2 applies.

9.3.7.3.3 Test circuit calibration

Subclause 9.3.6.2.3 applies.

9.3.7.3.4 Test procedure

For fuse-switches, fuse-disconnectors and fuse-switch-disconnectors, the closing mechanism shall be operated according to 8.2.1.1.

The temporary connections are replaced by the equipment under test and the test current applied according to 9.3.7.3.1.

The recovery voltage shall be maintained for at least 0,05 s after interruption of the test current by the fuse.

9.3.7.3.5 Behaviour of the equipment during the test

Subclause 9.3.6.3.5 applies.

9.3.7.3.6 Condition of the equipment after the test

Subclause 9.3.6.3.6 applies.

9.3.7.4 Dielectric verification

Subclause 9.3.4.5 applies.

9.3.7.5 Leakage current

Subclause 9.3.4.6 applies.

9.3.7.6 Temperature-rise verification

Subclause 9.3.4.7 applies.

9.3.8 Test sequence V: overload performance capability

9.3.8.1 General

This test sequence applies to the types of equipment listed in Table 17 and comprises the tests according to the table.

9.3.8.2 Overload test

The equipment shall first be temperature conditioned at room temperature. The test current is 1,6 × I_{the} or 1,6 × I_{th} for a period of 1 h, or until one or more of the fuses blow. If the time is less than 1 h, the time shall be recorded in the test report.

The equipment manufacturer shall supply the fuse-links (see appropriate part of the IEC 60269 series) to be used for the test. Details of the fuse-links used shall be recorded in the test report.

Subclause 9.3.4.2 applies with the exception that no temperatures have to be measured.

Within 3 min to 5 min after the fuse(s) has (have) operated or the period of 1 h is over, the equipment shall be operated once, i.e. opened and closed. The equipment shall not have undergone any impairment hindering such operation. The force to open the equipment shall not be greater than the actuator test force of 9.2.6.2 of IEC 60947-1:2020 and Table 17 of IEC 60947-1:2020.

The time duration of the overload test shall be measured and given in the test report.

9.3.8.3 Dielectric verification

Subclause 9.3.4.5 applies.

9.3.8.4 Leakage current

Subclause 9.3.4.6 applies.

9.3.8.5 Temperature-rise verification

Subclause 9.3.4.7 applies with the addition of the following.

Fuse-links aged during the overload test according to 9.3.8.2 shall be replaced by new fuse-links of the same type and rating.

Table 17 – Test sequence V: overload performance capability

Tests	Sub-clause No.	Samples [b]	Types of equipment and order of tests		
			Fuse-switch and switch-fuse	Disconnector-fuse and fuse-disconnector	Switch-disconnector-fuse and fuse-switch-disconnector
Overload test	9.3.8.2	A	1	1	1
Dielectric verification	9.3.8.3	A	2	2	2
Leakage current [a]	9.3.8.4	A	–	3	3
Temperature-rise verification [c]	9.3.8.5	A	3	4	4

[a] Test required only for U_e greater than 50 V.

[b] "A" is a sample from each fundamental design, chosen from the highest rated current I_e, and if applicable, having the maximum temperature-rise according to 9.3.3.4 d).

[c] By agreement with the manufacturer, the test sequence may be changed so that the temperature-rise verification test follows directly after the overload test, followed by dielectric verification and the leakage current tests, as applicable.

9.3.9 Test sequence VI: critical load current performance of equipment with a DC rating

9.3.9.1 General

This test sequence applies to the equipment listed in Table 20 and comprises the tests according to Table 20.

9.3.9.2 Determination of critical load current

9.3.9.2.1 Test values and conditions

The test to determine the critical load current need not be repeated if it has been determined at a higher time constant.

The test shall be made at the maximum operational DC voltage, U_e, assigned by the manufacturer.

The time constant of the test circuit shall be as given in Table 19.

At the discretion of the manufacturer, a higher value of time constant may be used. The same value of time constant should be used for all tests carried out to determine the critical load current. When a higher value of time constant is used it shall be stated in the report.

The test current values shall be: 1 A, 2 A, 4 A, 8 A, 16 A, 32 A, 63 A, with ±10 % tolerance, up to and including the rated operational current at the highest rated operational voltage. If necessary, the range of the test current shall be extended upwards by applying a 2 times ratio.

The switches, switch-disconnectors and fuse-combination units shall be opened seven times, manually or mechanically at the manufacturer's discretion. During each cycle, the switches, switch-disconnectors and fuse-combination units shall remain closed for a time sufficient to ensure that the full current is established, but not exceeding 2 s.

The number of operating cycles per hour shall be in accordance with Table 18.

In the case of a device where the line and load terminals are identified, all the operations shall be with the supply connected in accordance with the line and load markings. Tests on equipment where the line and load terminals are not marked shall be carried out as follows:

a) with the supply connected to the terminals as determined by the manufacturer, when the manufacturer demonstrates the equipment has a symmetrical contact system and arc control arrangement in respect of the current flow in each pole; or

b) with the first four operations with the supply connected in one direction followed by three operations in the opposite direction on the same sample, when the equipment does not have symmetrical contacts system and arc control arrangement in respect of current flow in each pole.

For each test current, the average arcing time is calculated. If two current flow directions are permitted, the maximum of the two values for this test current is used for further evaluation. If an average arcing time exceeds 1,3 time the value of the average at the rated operational current at the highest rated operational voltage, this is considered a critical current.

NOTE When searching for the critical current, if the value of test current is lower than the previous value of current, a new sample can be used to avoid the effects of remnant magnetism.

If several critical currents are found in this way, the one with the highest arcing time shall be tested.

If no critical value of current is found within these criteria, no further test according to 9.3.9.2.1 is required. At the manufacturer's discretion, the test at each value of current may be carried out on a new sample.

9.3.9.2.2 Test circuit

Subclause 9.3.5.2.2 applies.

9.3.9.2.3 Value of critical load current

The time of the arc extinction during the test shall be recorded and it shall not exceed 1 s.

When all operations are carried out with the current flow in the same direction, for each value of test current the average extinction time for the last six operations is calculated. When the operations are carried out with the current flow in both directions, the average extinction time of the last three operations in each direction shall be calculated. I_{crit} is the current corresponding to the maximum average extinction time. If no critical load current is identified below the rated operational current, the remaining tests in this sequence shall not be carried out.

9.3.9.3 Critical load current performance

The test may be carried out on a new sample. This test sequence is identical to test sequence II (see 9.3.5), except existing Table 5, Table 6 and Table 13 are replaced by Table 18, Table 19 and Table 20, respectively. The test supply shall be connected in accordance with the line-load and polarity markings where applicable. For switches capable of current flow in both directions, the supply shall be connected so as to provide the longest arc duration at the critical load current, as determined in 9.3.9.2.3.

The arcing time during each breaking operation shall not exceed 1 s.

Table 18 – Number of operating cycles corresponding to the critical load current

Category	Rating of the product A	Number of operating cycles per hour [a]	Number of operating cycles at I_{crit}
DC-21, DC-22 and DC-23	$I_e \leq 315$	120	100
	$315 < I_e \leq 630$	60	100
	$630 < I_e \leq 2\,500$	20	100
	$I_e > 2\,500$	10	100
[a] With the agreement of the manufacturer, the number of operating cycles per hour can be increased.			

Table 19 – Test circuit parameters for Table 18

Utilization category	Rated operational current	Making and breaking		
		I	U/U_e	L/R ms
DC-21A, DC-21B	All values	I_{crit}	1	1
DC-22A, DC-22B	All values	I_{crit}	1	2
DC-23A, DC-23B	All values	I_{crit}	1	7,5

Table 20 – Test sequence VI: critical load current performance of equipment with a DC rating

Tests	Sub-clause No.	Samples[b]	Types of equipment and order of tests			
			Switch	Fuse-switch and switch-fuse	Switch-disconnector	Switch-disconnector-fuse and fuse-switch-disconnector
Determination of critical load current	9.3.9.2	A, B	1	1	1	1
Critical load current performance	9.3.9.3	C, D	2	2	2	2
Dielectric verification	9.3.5.3	C, D	3	3	3	3
Leakage current [a]	9.3.5.4	C, D	–	–	4	4
Temperature-rise verification	9.3.5.5	C, D	4	4	5	5

[a] Test required only for U_e greater than 50 V.

[b] "A" and "C" are samples from each fundamental design, chosen from the highest rated current I_e, and if applicable, having the maximum temperature-rise according to 9.3.3.4 d).
"B" and "D", if applicable, are samples to verify as many combinations of U_e, I_e, DC voltage ratings, to be tested.

9.4 Electromagnetic compatibility tests

9.4.1 General

Subclause 9.4 of IEC 60947-1:2020 applies with the following addition.

During tests, the following performance criterion applies:

– unintentional separation or closing of contacts shall not occur.

9.4.2 Immunity

9.4.2.1 Equipment incorporating electronic circuits

The requirements of 8.3.2 of IEC 60947-1:2020 apply. To verify compliance with these requirements, the tests contained in Table 7 shall be conducted.

9.4.3 Emission

9.4.3.1 Equipment not incorporating electronic circuits

No tests are necessary (see 8.3.3.1).

9.4.3.2 Equipment incorporating electronic circuits

The requirements of 8.3.3.2 apply. The limits contained in Table 8 shall be verified by tests.

Measurements shall be made in the operating mode, including grounding conditions, producing the highest emission in the frequency band being investigated which is consistent with normal service conditions (see Clause 6).

Each measurement shall be performed in defined and reproducible conditions.

9.5 Special tests

9.5.1 Mechanical and electrical durability

Resistance to mechanical and/or electrical wear is demonstrated by the operational performance test detailed in 9.3.5.2.

Where abnormal service conditions are expected (see also note to 8.2.4.3.1 of IEC 60947-1:2020), the following tests detailed in 9.5.2 and 9.5.3 may be necessary.

9.5.2 Mechanical durability

The mechanical durability test (see 8.2.4.3 and 9.1.5), where required, is made in accordance with the appropriate requirements of 9.3.5.2, except that for equipment suitable for isolation, the maximum value of leakage current shall not exceed 6 mA per pole for all utilization categories.

The total number of operating cycles shall be as declared by the manufacturer.

9.5.3 Electrical durability

The electrical durability test (see 8.2.4.4 and 9.1.5), where required, is made in accordance with the appropriate requirements of 9.3.5.2, except that for equipment suitable for isolation, the maximum value of leakage current shall not exceed 6 mA per pole for utilization categories AC-21, AC-22, AC-23, AC-23e, DC-21, DC-22 and DC-23.

Equipment of utilization categories AC-20A, AC-20B, DC-20A and DC-20B is not submitted to this test.

The total number of operating cycles shall be as declared by the manufacturer.

9.5.4 Damp heat, salt mist, vibration and shock

These special tests shall be made either at the discretion of the manufacturer or according to an agreement between the manufacturer and user (see 3.8.4 of IEC 60947-1:2020). As special tests, unless specifically called for, these additional tests are not mandatory, and it is not necessary for a switch, disconnector, switch-disconnector or fuse combination unit to satisfy any of these tests to conform to this document.

Annex Q of IEC 60947-1:2020 applies.

Product verification and operational capability after the test shall be demonstrated by compliance with the relevant requirements of 9.3.4.7.

Annex A
(normative)

Equipment for direct switching of a single motor

A.1 General

Switches, switch-disconnectors and fuse-combination units normally intended for direct switching of individual motors shall comply with the additional requirements of Annex A. These requirements are essentially the same as the appropriate subclauses of IEC 60947-4-1:2018 and equipment complying with this annex may state on the nameplate the appropriate utilization category according to Table A.1.

A.2 Rated

A.2.1 Intermittent periodic duty or intermittent duty

Subclause 5.3.4.3 of IEC 60947-1:2020 applies with the following additions.

According to the number of operating cycles, which they shall be capable of carrying out per hour, equipment is divided into the following classes:

– class 1: up to 1 operating cycle per hour;
– class 3: up to 3 operating cycles per hour;
– class 12: up to 12 operating cycles per hour;
– class 30: up to 30 operating cycles per hour;
– class 120: up to 120 operating cycles per hour.

A.2.2 Temporary duty

Subclause 5.3.4.4 of IEC 60947-1:2020 applies.

A.3 Making and breaking capacities

An equipment is defined by its making and breaking capacities, in accordance with utilization categories as specified in Table A.2 (see Clause A.4).

A.4 Utilization category

The utilization categories as given in Clause A.2 are considered standard in this annex. Any other type of utilization category shall be based on agreement between manufacturer and user but information given in the manufacturer's catalogue or tender may take the place of such an agreement.

Each utilization category is characterized by the values of the currents and voltages, expressed as multiples of the rated operational current and of the rated operational voltage, and by the power-factors or time-constants as shown in Table A.2 and other test conditions used in the definitions of the rated making and breaking capacities.

For equipment defined by their utilization category, it is therefore unnecessary to specify separately the rated making and breaking capacities as these values depend directly on the utilization category as shown in Table A.2.